2016-2018

Massachusetts
Joint Statewide Three-Year
Electric and Gas Energy Efficiency Plan

October 30, 2015

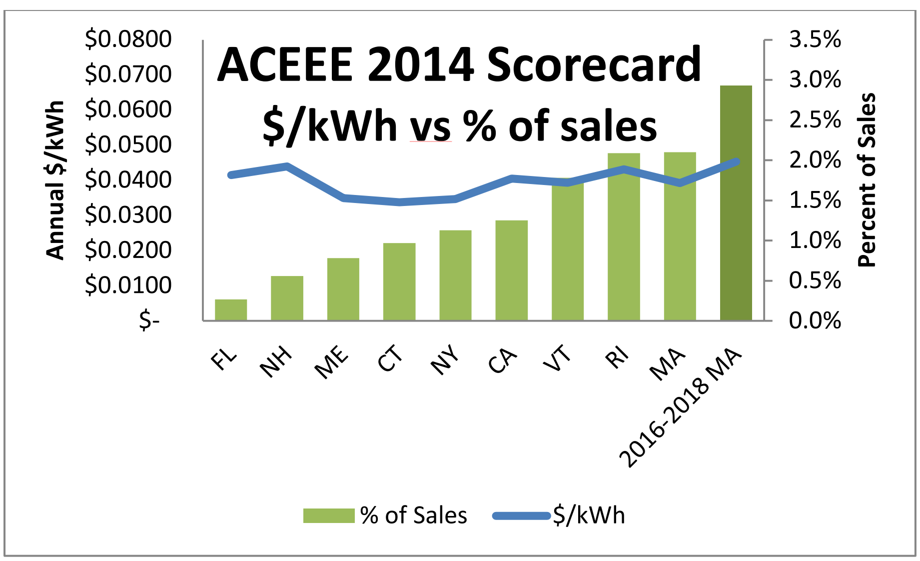
2016-2018 MASSACHUSETTS JOINT STATEWIDE THREE-YEAR ELECTRIC & GAS ENERGY EFFICIENCY PLAN

I. EXECUTIVE SUMMARY

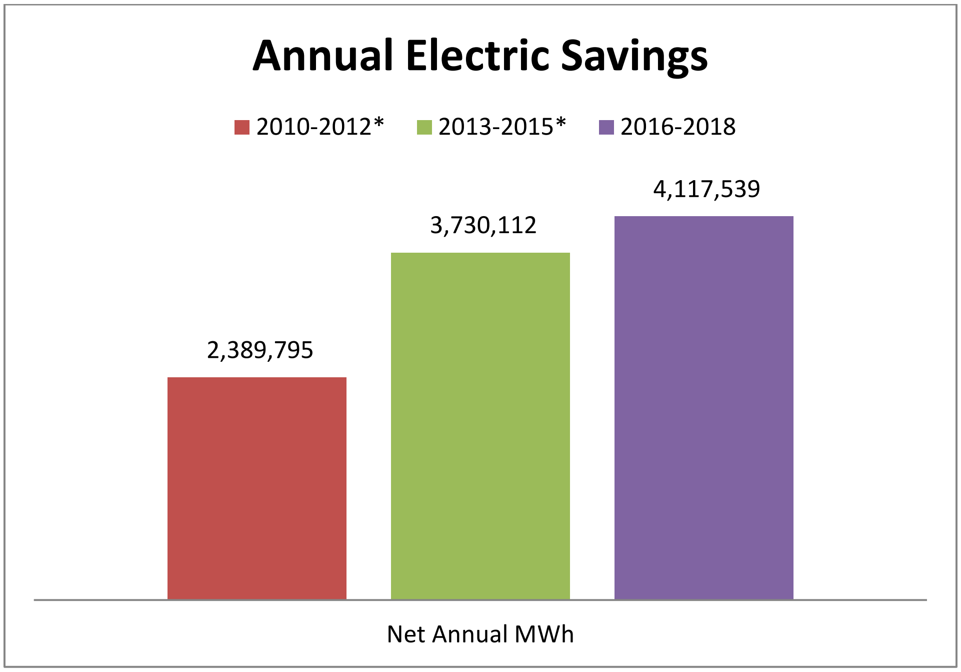
A. Context for the Program Administrators' Energy Efficiency Efforts Under the GCA

The Program Administrators' energy efficiency efforts under the Green Communities Act reflect an unprecedented collaborative undertaking with long-lasting multi-billion dollar benefits for Massachusetts. The magnitude of the success and accomplishments of the Program Administrators in implementing energy efficiency programs and services, with the support and aid of the Energy Efficiency Advisory Council and stakeholders, can be hard to conceptualize. Energy efficiency benefits are not always visible to the naked eye, taking the form of insulation in walls, deferred construction of generating facilities, reduced greenhouse gas emissions and improved comfort or industry profitability. The energy savings and benefits of energy efficiency programs, however, are real and measurable. With rigorously quantified total dollar benefits of over $12.5 billion since 2008 (many times greater than costs), energy efficiency under the Green Communities Act is truly a historic achievement, making Massachusetts a model of energy efficiency success for the rest of the nation.

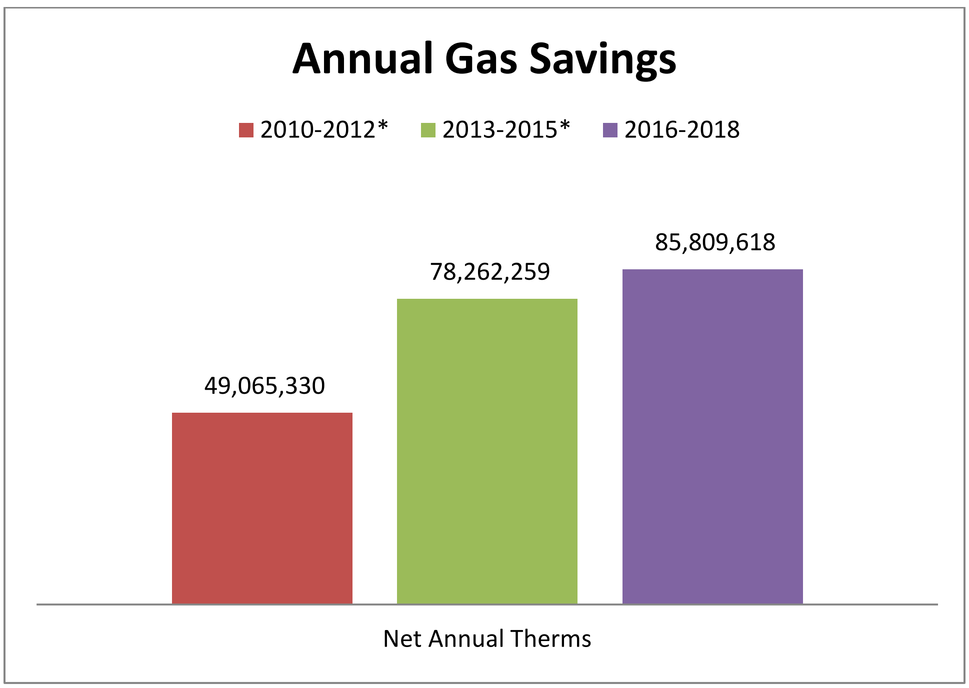
The Program Administrators have increased their savings achievements significantly since the 2008 passage of the Green Communities Act, with electric savings almost tripling between 2008 and 2014. These achievements have resulted in Massachusetts continuing to be the Number 1 ranked state in the nation for energy efficiency by the American Council for an Energy Efficiency Economy ("ACEEE"). Additionally, Massachusetts attained a perfect score on the ACEEE 2015 State Energy Efficiency Scorecard for its program administrator-operated energy efficiency programs and its policies to support the development of combined heat and power ("CHP") facilities.[1] In the 2016-2018 Plan, the PAs are proposing aggressive savings goals at levels even higher than the 2013-2015 Plan, despite increased challenges.



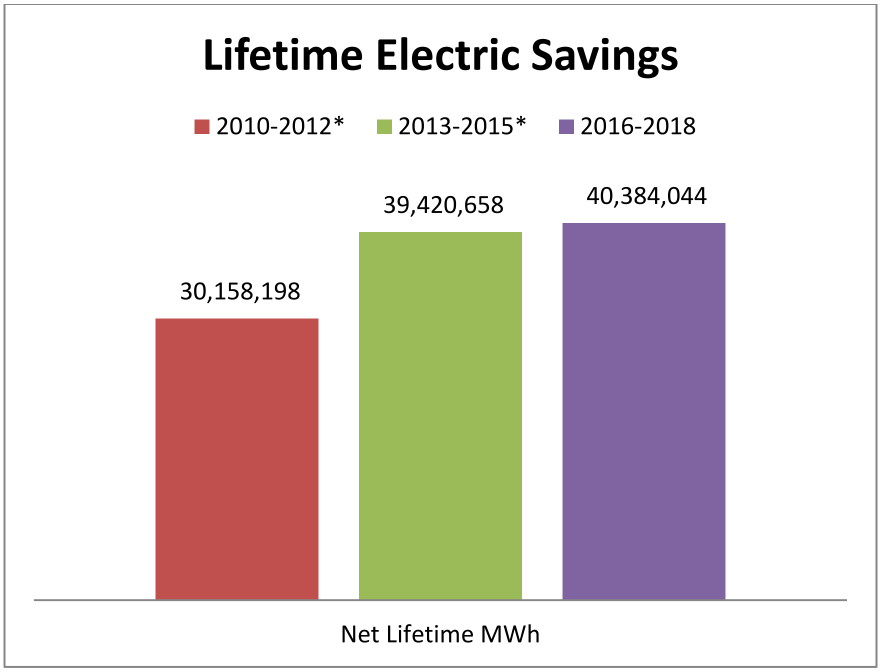
[1] ACEEE, "The 2015 State Energy Efficiency Scorecard," October 2015, Report Number U1509.

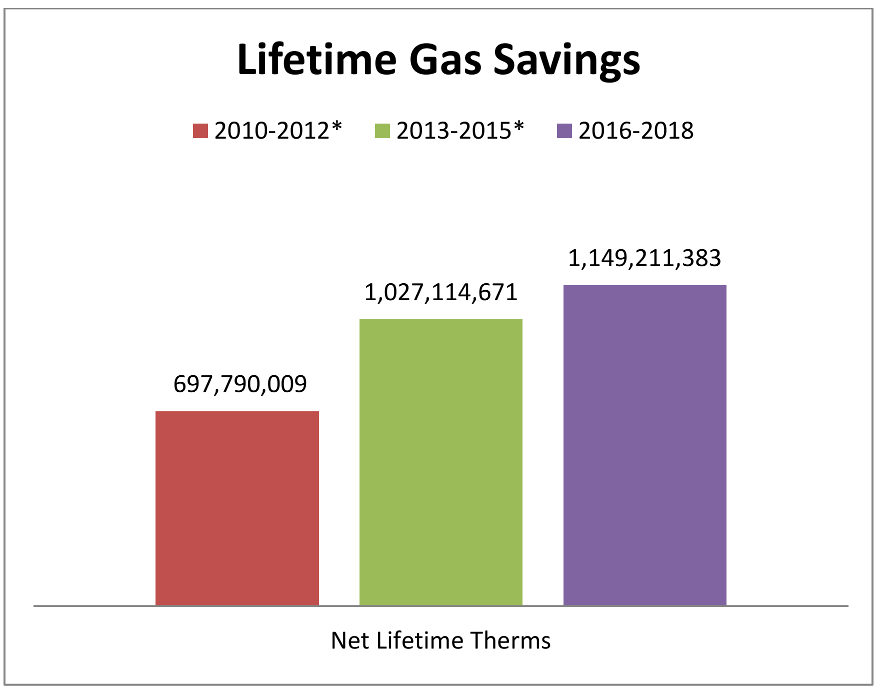


* 2010 - 2014 represent actual savings; 2015 - 2018 represent planned.

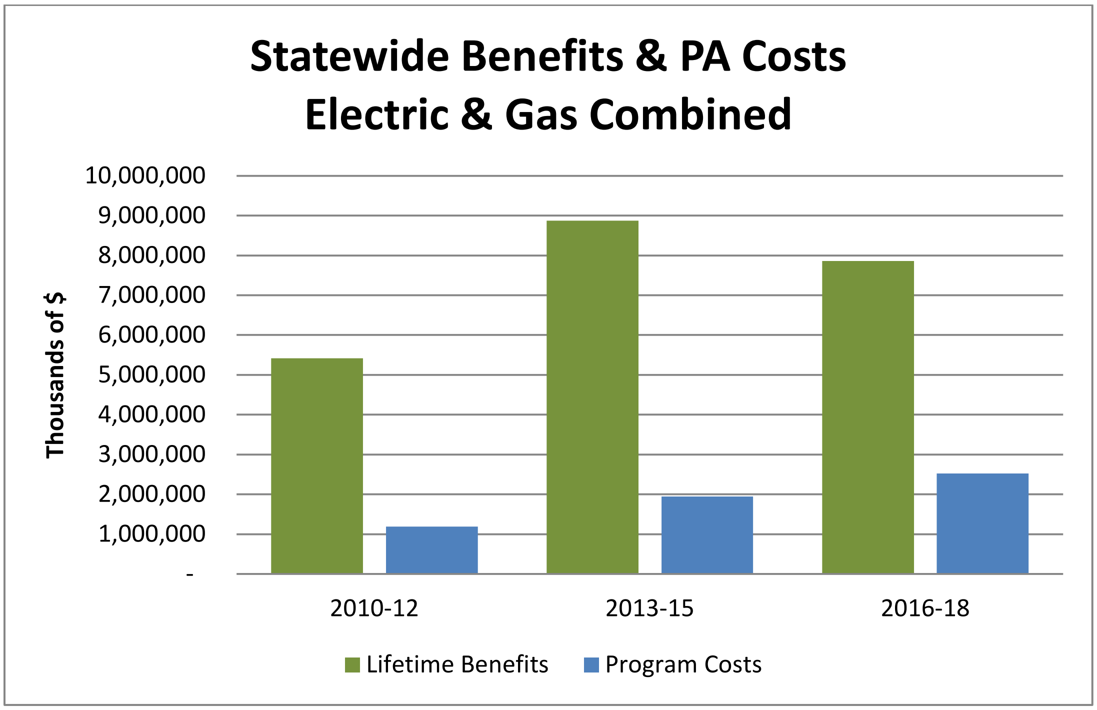


* 2010 - 2014 represent actual savings; 2015 - 2018 represent planned.



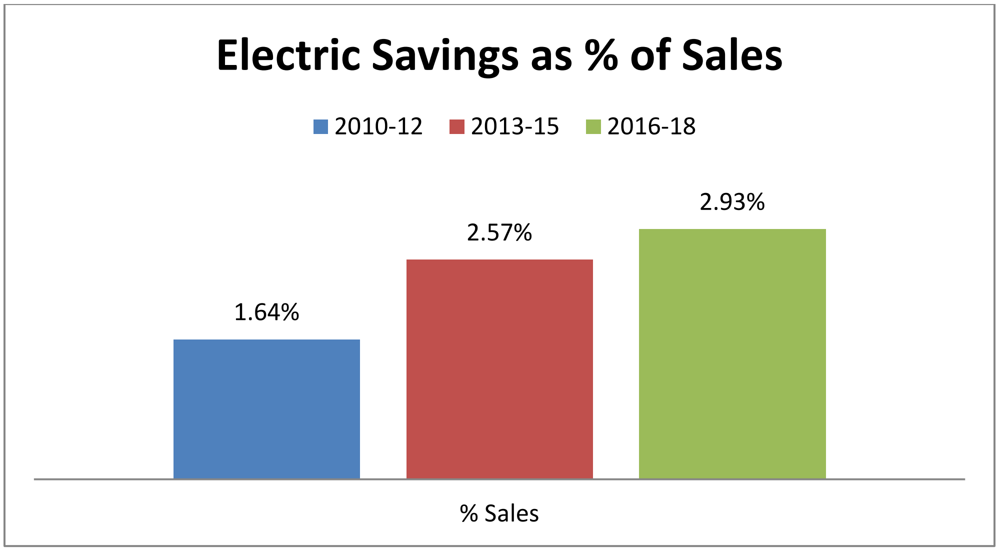


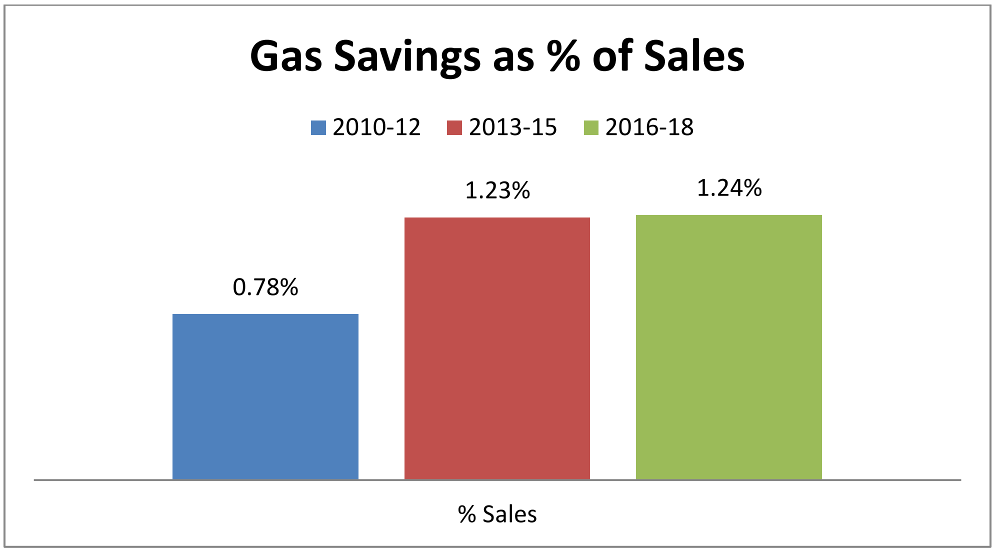
While delivering these unprecedented savings, the Program Administrators have carefully managed expenditures to keep costs as low as possible. The PAs strive to maximize the value of each dollar spent. The majority of energy efficiency expenditures are delivered to customers in the form of incentives that are intended to overcome the financial barrier to investment. For example, in the 2016-2018 Plan, approximately 74 percent of the electric budget and approximately 71 percent of the gas budget are dedicated to **participant incentives**, the biggest driver of savings. The next largest category of expenditures, approximately 15-18 percent, will go to payments for contractors, installers and training. Approximately 3 percent of the statewide budget is dedicated to the rigorous Massachusetts Evaluation, Measurement and Verification process. Other administrative functions like Program Planning and Administration and Marketing and Advertising combined make up approximately 8-9 percent of the statewide budget. These percentages are in line with the budget allocations previously approved by the Department of Public Utilities, demonstrating that the Program Administrators have been able to provide direct benefits to customers and contractors and grow the energy efficiency portfolios while minimizing costs. Due to avoided costs declining, despite increasing savings, dollar benefits are lower in the 2016-2018 Plan then they were in 2013-2015 (but greenhouse gas reductions increase in the Plan).



The Plan being filed today fully reflects the provisions of the Term Sheet dated September 23, 2015 (supplemented on October 26, 2015) agreed upon by the Program Administrators, the Executive Office of Energy and Environmental Affairs, the Department of Energy Resources, and the Office of the Attorney General, which is included in Appendix D. The Term Sheet is the result of extensive collaboration among the agreeing parties following the PAs' submission of their April 30, 2015 draft Plan and the July 27, 2015 Resolution of the Energy Efficiency Advisory Council. Further, the Plan gathered the broad support of the Energy Efficiency Advisory Council which led to the October 26, 2015 Resolution. The October 26th Resolution was approved by an overwhelming 14 to 1 vote of the Energy Efficiency Advisory Council, which is attached as Appendix I. In this Resolution, after extensive review and collaboration the Council respectfully requested that "the Commissioners of the Department of Public Utilities . . . approve the 2016-2018 Massachusetts Joint Statewide Three-Year Electric and Gas Energy Efficiency Investment Plan and the Individual Plans of the [program administrators], to the degree that the Individual Plans are fully consistent with the Statewide Plan."

The Plan provides for the most aggressive savings goals ever in the Commonwealth, and to the PAs' knowledge, in the United States. The Plan provides for an annual savings goal of 2.93 percent of retail sales (electric) and of 1.24 percent of retail sales (gas) at costs-to-achieve that are materially lower than those set forth in the April 30th draft. Moreover, the Plan prioritizes: (1) new demand reduction/peak reduction efforts; (2) continued commitment to innovation and technology; and (3) the creation of a new residential contractor engagement effort. All tables and values in this Plan are consistent with the Term Sheet. The PAs express their appreciation for the extensive efforts and diligent work of the Executive Office of Energy and Environmental Affairs, the Department of Energy Resources, the Office of the Attorney General, the Energy Efficiency Advisory Council, its consultants, and other interested stakeholders.





B. Moving Forward and Sustaining Excellence in 2016-2018

This Plan represents the Program Administrators' collective efforts – informed by in-the-field Program Administrator experiences, Evaluation, Measurement and Verification results, and outstanding input from and collaboration with the Energy Efficiency Advisory Council and stakeholders – to build upon and sustain Massachusetts' historic effort. Going forward, a key challenge to navigate is the danger of "over-promising and under-delivering." Sustaining very high savings goals becomes increasingly difficult in each subsequent year as markets become saturated, "easy" savings no long exist, and rising baselines continue to reduce claimable savings. Over the next three years, the Program Administrators will need to find ways to mine savings from more difficult, costly, and challenging projects and market segments. Extensive details addressing these challenges are set forth in the multiple sections and tables contained in this Plan.

In order to meet this challenge, the PAs have developed a number of innovations for the 2016-2018 Plan:

Residential and Low-Income

- 2016 initial implementation of an innovative new **Renter-Specific Offer**, including a special renter visit, installation of *instant savings measures* such as light bulbs, power strips, gas/water saving aerators and showerheads, and collection of information to use in following up with landlords.
- **Multi-family Initiative Enhancements**, creating a *project-level lead* to ensure optimal customer experience, tracking and reporting of commercial and residential meter savings *separately*.
- Continued driving of the **LED Revolution**, with LED offerings adapting to the changing lighting market.
- 2016 initial implementation of a new **Moderate-Income Offer**, with the Program Administrators working on a new *61-80 percent of median income opt-in approach* for those with weatherization opportunities.
- Continuation of the Program Administrators' historic **Low-Income Services Partnership with the Low-Income Energy Affordability Network (LEAN)** to ensure that the Commonwealth's most economically vulnerable citizens participate in specially tailored programs; PAs acknowledge and thank LEAN for its collaboration with the PAs and commitment to low-income populations across the Commonwealth.

Commercial and Industrial

- Broadening the **Upstream Program Delivery Mechanism** to encompass additional, appropriate equipment types and end-uses for the purpose of advancing the ongoing market transformation effort; implementation of a new upstream approach targeting water heating technologies will begin in late 2015.
- **Segment-specific Outreach and Implementation Strategies** (marketing strategies and materials, partnerships, campaigns) to advance energy efficiency implementation and

customized to overcome unique participation barriers of each segment; this Plan provides more details on sector-specific areas of focus for each PA.

- Comprehensive review/analysis of the very successful **Small Business Initiative** to advance participation and comprehensiveness at all customer sizes and energy usage ranges.
- Deployment of an exciting new online incentive application portal, with a menu drive interface enabling the creation and submission of customer applications for incentives; this portal will materially enhance the overall customer experience, especially for mid-sized customers.

Evaluation, Measurement & Verification and Data

- A high level **Strategic Evaluation Planning** document is included with this Plan. The development of this document was guided by an Evaluation Planning Summit held in February 2015. The Summit provided a forum for the PAs, Council consultants, and evaluation contractor teams to identify emerging evaluation topics and activities.
- A wealth of quantitative data is now readily available to stakeholders and the public (www.masssavedata.com). The **Mass Save Data** website has been developed to improve the transparency of and access to reported energy efficiency data. Currently this website includes data regarding program participation, annual and lifetime savings, benefits, cost to deliver, expenditures, greenhouse gas emissions reductions that result from energy efficiency efforts, and forecasted sales for the years 2010 through 2015. The PAs are also planning to add geographic and measure level data to the website, and will strive to continue to improve the functionality of this database while minimizing its costs.
- The Customer Profile Studies will provide **Customer Based Analysis**, including detailed geographic analysis across fuels and service territories. This information will also be used to populate the Mass Save Data geographic tab, which is under development.
- There will be renewed emphasis on enhancing the value of evaluation by producing **Real Time Evaluation Results** to the extent possible, shortening the feedback loop between evaluation and implementation, and making recommendations more actionable.
- Undertaking, through the Council's highly successful independent EM&V process, a new study to verify more precisely the emissions reductions resulting from the PAs' energy efficiency efforts, and potentially also looking at impacts from other efforts that interrelate with the PAs' efforts.

Marketing

- Implementation of **Spanish and Portuguese versions of the comprehensive Mass Save® website**, helping to ensure even greater access for customers to energy efficiency programs.

Savings, Benefits and Infrastructure

- Continuation of the **Aggressive Savings Goals** (2.93 percent of sales for electric and 1.24 percent of sales for gas). Based upon ACEEE data, the Program Administrators believe that these are the most aggressive goals for an integrated gas and electric energy effort in the nation.[2]

- Consistent with the Term Sheet and in response to the Council's comments, electric savings goals have increased from the April 30th draft by approximately 17 percent (annual) and 21 percent (lifetime). Gas savings have increased by 15 percent (annual) and 14 percent (lifetime); while savings have increased, per unit costs-to-achieve have decreased.
- Total Benefits of approximately **$8 billion** for customers; Net Benefits of approximately **$4.4 billion**.
- Clear and strong commitment to the support of the robust Massachusetts **Energy Efficiency Delivery Infrastructure and Contractor Network**, with a stable level of investment of over $2.5 billion in energy efficiency in 2016-2018.
- Environmental benefits equivalent to removing 410,162 cars from the road through annual electric and gas savings in 2016-2018.

The PAs have also sought stakeholder input and insights in the preparation of this Plan. The PAs have received constructive input from Councilors, government officials, stakeholders, energy experts and consultants, and participants in the Council workshops. This 2016-2018 Plan has benefited from this extensive input. The PAs appreciate their team; every Program Administrator contributes, every Program Administrator leads, and every Program Administrator learns.

C. <u>Cost to Achieve</u>

In addition to the challenges of meeting higher savings goals, PAs face increasing challenges to minimize increases in the cost to achieve these savings. The PAs have materially reduced their projected cost-to-achieve savings from the projections in the April 30th draft, as reflected in the Plan, with a reduction in electric cost-to-achieve per kWh of approximately 13 percent and in gas cost-to-achieve per therm of approximately 7 percent.

Cost to achieve looks at the PAs' total costs per unit of net savings attributable to the programs. Market penetration, increasing costs for key measures, and decreasing levels of claimable savings due to changes in federal standards and the application of results from the impact evaluations are all significant factors that can drive up the cost per kWh or therm saved. Two areas that are particularly impacted by these factors in the 2016-2018 Plan are the Residential Lighting initiative and Low-Income programs.

- The Residential Lighting initiative is facing a number of concurrent challenges that are increasing the cost to achieve. Federal Energy Independence and Security Act ("EISA") standards are eliminating inefficient bulbs from the market, raising the baseline and decreasing the savings that Program Administrators can claim. At the same time, programs are increasingly incentivizing a greater number of LEDs than CFLs, and the cost per kWh for an LED is significantly higher than that of a CFL. Additionally, recent

[2] ACEEE, "The 2015 State Energy Efficiency Scorecard," October 2015, Report Number U1509.

evaluation results have increased the free ridership rate for LEDs, further reducing the net savings that Program Administrators can claim. All of these factors have led to increases in the cost to achieve of 10 to 20 percent for the residential lighting initiative compared to previous three-year plans.

- Historically, the Program Administrators have partnered with the federal Weatherization Assistance Program to deliver programs to income-eligible customers and have been able to leverage federal funding. Going forward, however, the availability of federal funding will be sharply reduced due to national program cuts, and the Program Administrators will need to fund a greater portion of each project. For gas energy efficiency programs, the lack of available federal funding results in a greater than 50 percent increase in the cost per therm saved in the low-income sector. In addition, the Program Administrators must dedicate at least 20 percent of their gas budgets to low-income programs, which substantially impacts the portfolio cost to achieve. These costs have increased so significantly that if 2016-2018 costs were applied to 2014 programs, the cost per therm in 2014 would have been 20 percent higher. While the Program Administrators remain committed to finding efficiencies in program design and delivery and controlling costs to the maximum extent possible, these types of funding shifts are not the result of actual cost increases, are beyond the control of the Program Administrators, and must be taken into account when comparing across program years.

Despite these challenges, the Program Administrators have set aggressive goals (indeed, they believe, the most aggressive goals for any integrated gas and electric energy efficiency plan in the country) that are realistic, achievable and deliver unprecedented benefits to all customers. Setting unrealistic goals can reduce the PAs' flexibility to adjust to a changing market, risking missed targets and loss of the broad-based public support for energy efficiency that is a crucial component of the success achieved to date in Massachusetts. This Plan will allow the Program Administrators to achieve all cost-effective energy savings and continue to enjoy the broad-based public support for energy efficiency that will allow for continued success in delivering energy efficiency in Massachusetts.

II. INTRODUCTION

Bay State Gas Company d/b/a Columbia Gas of Massachusetts ("CMA"), The Berkshire Gas Company ("Berkshire"), Blackstone Gas Company ("Blackstone"), Boston Gas Company, Colonial Gas Company, Massachusetts Electric Company and Nantucket Electric Company, each d/b/a National Grid ("National Grid"), Fitchburg Gas and Electric Light Company d/b/a Unitil ("Unitil"), Liberty Utilities (New England Natural Gas Company) Corp. d/b/a Liberty Utilities; ("Liberty"), Cape Light Compact ("Compact" or "CLC"),[3] and NSTAR Electric Company, NSTAR Gas Company and Western Massachusetts Electric Company, each d/b/a Eversource Energy ("Eversource") (collectively, "Program Administrators" or "PAs") developed and prepared this 2016-2018 Energy Efficiency Plan ("2016-2018 Plan" or "Plan") pursuant to the mandates of An Act Relative to Green Communities, Acts of 2008, c. 169, codified at G.L. c. 25 §§ 19, 21-22 ("Green Communities Act" or "GCA"). The Program Administrators take great pride in planning and administering energy efficiency programs pursuant to the GCA's statutory framework for energy efficiency, which has resulted in nation-leading, award-winning programs with savings goals and delivery that are unprecedented.

This Plan reflects an extensive collaborative effort among the PAs. The PAs express their appreciation for the work of all stakeholders and, in particular, the members of the Energy Efficiency Advisory Council ("Council" or "EEAC"), led by the Council chair, the Department of Energy Resources ("DOER"). This Plan has also benefitted from suggestions and discussions made during stakeholder workshops facilitated by Raab Associates, Ltd., on behalf of the Council in February, March and June of 2015. Since the filing of the initial draft plan on April 30, 2015 the PAs have engaged in positive and constructive dialogue with the Council on the 2016-2018 Plan, culminating with the Council passing a resolution in support of the Plan.

The GCA and Department of Public Utilities ("Department")[4] precedent require that three-year energy efficiency plans, such as this 2016-2018 Plan, provide for the acquisition of all cost-effective energy efficiency resources in a manner that is sustainable and with consideration of short term customer bill impacts. In this Plan, the Program Administrators set aggressive, sustainable goals that: (1) capture all available cost-effective energy efficiency; (2) maximize net economic benefits; (3) achieve energy, capacity, climate, and environmental goals; and (4) consider both short-term customer bill impacts and longer-term benefits expected from proposed efforts. This Plan includes comprehensive energy efficiency services, large-scale marketing, and education campaigns, and extensive Evaluation, Measurement, and Verification ("EM&V") efforts, all resulting in significant and proven energy savings to customers in the Commonwealth of Massachusetts (the "Commonwealth" or "Massachusetts").

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3 The Cape Light Compact is the only publicly funded, municipal aggregator (as defined by G.L. c. 164, § 134) energy efficiency program administrator in Massachusetts. Since it is a public entity consisting of twenty-one towns and two counties, it does not participate in performance incentives or collect lost-based revenues. As such, any discussion of these topics contained in the Three-Year Plan does not pertain to the Compact and general references to Program Administrators in these topic narratives do not include the Compact.

4 The Department is a regulatory agency subject to G.L. c. 30A that is statutorily responsible for extensive oversight of the Program Administrators in Massachusetts.

The Program Administrators developed and refined the Plan in a collaborative, transparent, and year-long process with the Council, its consultants, the DOER, the Office of the Attorney General (the "Attorney General" or "AG"), the Low-Income Energy Affordability Network ("LEAN"), and other interested stakeholders. The Council guides the development and implementation of Three-Year Plans with monthly meetings of the full Council and its subcommittees.[5] The PAs are active participants in all of these meetings. In addition to its regular meetings noted above, in 2015, the Council conducted a number of sector-focused workshops to help inform the development of the 2016-2018 Plan. The PAs were partners in developing the workshop briefing materials.

In November 2015, after detailed review and input from the Council, the Department will begin an extensive review of the 2016-2018 Plan through a formal investigation that includes standards for filing, discovery, evidentiary hearings, briefing, and careful and extensive analysis informed by the Department's technical expertise. The level of review, collaboration, transparency, and accountability of the current statutory framework ensures that customers are receiving beneficial and cost-effective services. Notably, the data demonstrating the costs and benefits to customers of these services is now more easily accessible to the public in a user-friendly database that provides a single source of both statewide and individual PA information.

In addition to the advice of the Council, the 2016-2018 Plan builds upon the experience of the Program Administrators in developing and implementing two Three-Year Plans pursuant to the GCA, specifically, the 2010-2012 Plan and the 2013-2015 Plan. The Program Administrators routinely share best practices and identify new and innovative strategies through their many working groups and management committees, including the Residential Management Committee ("RMC"), the Commercial & Industrial Management Committee ("C&IMC"), the Evaluation Management Committee ("EMC"), the Low-Income Best Practices committee, the Massachusetts Technical Advisory Committee ("MTAC"), the Planning and Analysis Group ("PAG"), and the Contractor Best Practices Working Group. To track their performance against their Three-Year Plans, each Program Administrator publicly files data tables and benefit-cost screening models that show information at the measure level with each plan and report submitted to the Department. The PAs also submit statewide quarterly reports and monthly data dashboards to the Council, along with many other ad hoc data requests. In 2014, the PAs developed an internet-based database to facilitate public access to statewide energy efficiency data in a more user friendly manner. Extensive planned and reported energy efficiency data for 2010 through 2015 is available at www.MassSaveData.com.

Finally, in advancing the objectives of the Green Communities Act, the 2016-2018 Plan also supports the Commonwealth's broader policy objectives. In a series of legislation enacted in parallel with the GCA, the Commonwealth signaled its commitment to being a worldwide leader in developing a green economy through the Global Warming Solutions Act, St. 2008, c. 298 ("GWSA"), and the Green Jobs Act, St. 2008, c. 307. The GWSA calls for broad statewide

[5] The Council holds monthly, publicly-noticed open meetings of the full Council, with regular presentations from the Program Administrators and the Council's consultants, as well as public comment. The Council's Executive Committee, which is comprised of a smaller group of councilors, conducts monthly meetings to facilitate the business of the Council and management of its consultants.

reductions of greenhouse gas ("GHG") emissions in the Commonwealth, thus spurring innovation and promoting research and development in the area of clean energy. Enacted concurrently, the Green Jobs Act provides a robust funding source for the green technology industry, facilitating economic development and job growth in the clean energy sector. Taken together, these legislative enactments reflect the Commonwealth's commitment to climate protection and its leadership in promoting clean and renewable energy. Reductions in GHG emissions and job creation are important results of energy efficiency programs implemented pursuant to the GCA. Like past plans, the 2016-2018 Plan will continue to fulfill the requirements of the GCA and support the goals of the GWSA and Green Jobs Act, with a focus on minimizing the cost of energy efficiency program design and implementation for the benefit of customers.

A. Core Goals for 2016-2018

In the 2016-2018 Plan, the Program Administrators seek to build on the lessons learned from their two previous Three-Year Plans, including both their successes and challenges, take advantage of new technologies and market opportunities, and continue to foster a sustainable energy efficiency infrastructure in the Commonwealth. The Program Administrators will pursue all available cost-effective energy efficiency, subject to reasonable short-term customer bill impacts, as mandated by the GCA, and will seek to maximize benefits to the Commonwealth and its citizens.

Statewide Electric Summary

	Units	2016	2016-2017	2016-2018
Forecasted Annual Retail Energy Sales	*MWh*	46,908,188	93,745,319	140,331,922
Average Annual Savings Over Three Years	*% of sales*	2.93%		
Cumulative Annual Savings Goals	*MWh*	1,371,584	2,744,075	4,117,539
Cumulative Lifetime Savings Goals	*MWh*	12,812,171	26,205,273	40,384,043
Cumulative Budget: Program Costs	*millions of $*	$ 598.8	$ 1,220.0	$ 1,857.6
Cost per Annual kWh Saved	*$/kWh*	$0.451		
Summer Demand Savings	*MW*	203	404	598
Winter Demand Savings	*MW*	222	440	649
Benefits	*millions of $*	$ 2,041.2	$ 4,105.9	$ 6,214.6
Cumulative Performance Incentive Pool at Design	*$*			$ 100,000,000
Performance Incentive Levels				
Threshold	*%*			75%
Design	*%*			100%
Exemplary - Cap	*%*			125%

Statewide Gas Summary

	Units	2016	2016-2017	2016-2018
Forecasted Annual Retail Energy Sales	*Therms*	2,270,659,323	4,576,164,520	6,915,678,418
Average Annual Savings Over Three Years	*% of sales*		1.24%	
Cumulative Annual Savings Goals	*Therms*	28,094,852	56,599,232	85,809,618
Cumulative Lifetime Savings Goals	*Therms*	376,308,950	757,115,763	1,149,211,383
Cumulative Budget: Program Costs	*millions of $*	$ 216.9	$ 438.0	$ 665.6
Cost per Annual therm Saved	*$/Therm*		$7.76	
Benefits	*millions of $*	$ 546.1	$ 1,091.3	$ 1,646.7
Cumulative Performance Incentive Pool at Design	*$*			$ 18,000,000
Performance Incentive Levels				
Threshold	*%*			75%
Design	*%*			100%
Exemplary - Cap	*%*			125%

B. Statutory Context

1. Overview

Each PA is subject to the jurisdiction of the Department and individually bears responsibility for meeting the statutory mandate under the GCA to acquire all available cost-effective energy efficiency. The PAs are responsible for administering energy efficiency programs pursuant to the GCA. G.L. c. 25, § 19(a-b). The GCA also makes them *ex officio* members of the Council. G.L. c. 25, § 22(a).[6] This statutory construct appropriately recognizes that each PA is a distinct entity with a unique service territory, is owned by shareholders and/or governed by a municipal board of directors and has a deep knowledge of its businesses and customers and many years of experience implementing energy efficiency programs.

The GCA requires the PAs to jointly prepare, in coordination with the Council, an energy efficiency plan every three years. G.L. c. 25, § 21(b)(1). This plan "shall provide for the acquisition of all available energy efficiency and demand reduction resources that are cost effective or less expensive than supply and shall be prepared in coordination with the [Council]." G.L. c. 25, § 21(b)(1). As discussed in more detail in subsequent sections, a Three-Year Plan must include the elements set out in detail in the GCA. G.L. c. 25, § 21(b)(2). Every three years, the PAs must submit this plan to the Council for "approval and comment" and "review" on or before April 30. G.L. c. 25, § 21(c). The PAs "may make any changes or revisions to reflect the input of the [Council]." G.L. c. 25, § 21(c). The PAs must submit their plans, "together with the [Council]'s approval or comments and a statement of any unresolved issues, to the [Department] on or before October 31." G.L. c. 25, § 21(d)(1). This statutory context is discussed in more detail below. For a detailed overview of energy efficiency's regulatory background and Department history, please refer to the materials in Appendix B.

6 The dictionary defines "ex officio" as meaning "by virtue of one's position or status." The Oxford English Dictionary (2013). Ex-officio members have exactly the same rights and privileges as do all other members, except as otherwise specified by statute. See http://www.robertsrules.com/faq.html#2.

2. The Green Communities Act

As noted above, energy efficiency in Massachusetts is governed by the statutory framework set out in the GCA. The GCA transformed and institutionalized past practice to achieving energy efficiency savings in Massachusetts. Energy efficiency programs have been offered in Massachusetts since the 1980s and stakeholder working groups and a consensus approach have been the foundation for achieving savings.[7] The enactment of the GCA expanded energy efficiency mandates by requiring the PAs to develop three-year energy efficiency plans that will "provide for the acquisition of all available energy efficiency and demand reduction resources that are cost effective or less expensive than supply." G.L. c. 25, §§ 19(a), 21(a), 21(b)(1), 21(b)(2). It also institutionalized the collaborative, consensus approach to energy efficiency by creating a statewide stakeholder advisory body (the Council) to coordinate with the PAs and the Department on the development and implementation of three-year energy efficiency plans. G.L. c. 25, §§ 21-22.

In view of the GCA's collaborative paradigm, it is important to understand how the Department, Council, and PAs each contribute to ensuring the acquisition of all cost-effective energy efficiency in Massachusetts. Under the GCA, the Department is responsible for approving individual PA Three-Year Plans and determining individual PA plan-related performance. The Department also appoints and convenes the Council. The Council is an advisory body that leverages the expertise of its diverse stakeholder membership and expert consultants to meet its statutory mandates "through a sustained and integrated statewide energy efficiency effort." G.L. c. 25, § 22(b). By design, the Council provides valuable statewide advice and recommendations to the PAs and the Department on the development and implementation of Three-Year Plans. Finally, under the GCA, the PAs must coordinate with each other and the Council to develop Three-Year Plans. As discussed earlier, the PAs are also responsible for implementing Three-Year Plans and are subject to the regulatory authority of the Department.

To date, the GCA's statewide collaborative approach has produced excellent results. The PAs and the Council have a proven track record of reaching consensus on numerous topics. This is a signature success of the efforts of multiple stakeholders in Massachusetts. The roles of the Department, Council and PAs are discussed in more detail below.

3. Department of Public Utilities

The Department is a quasi-judicial regulatory agency with extensive statutory authority over the Program Administrators.[8] The Department is responsible for ensuring that the electric

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[7] Energy efficiency programs have been offered by the electric and natural gas utilities since the 1980s and by the Compact since 2001. Prior to the GCA, the PAs each developed plans with limited budgets and relied on stakeholder working groups and a consensus approach to developing energy efficiency implementation.

[8] The Department's authority extends beyond energy efficiency to all aspects of the operations of electric and gas distribution companies including, but not limited to, rate setting, service quality, customer care, and the operation of a safe and reliable utility. See G.L. c. 164, § 76. Since its establishment by the Legislature in 1919, the Department has comprehensively regulated the operations of electric and gas utility companies

and gas utilities provide safe, reliable, and least-cost service to Massachusetts customers.[9] Under the GCA, the Department is responsible for ensuring that electric and natural gas resource needs are first met through all cost-effective energy efficiency resources as a means to reduce energy costs for all customers. G.L. c. 25, § 21(a).

In expanding energy efficiency and requiring the PAs to coordinate with the Council, the GCA subjects both the Council and the PAs to the Department's jurisdiction with respect to final plan approval, cost-effectiveness, rates, and cost recovery. G.L. c. 25, §§ 19, 21-22. The GCA requires the Department to convene and appoint the members of the Council and to conduct the final review and approval of each Three-Year Plan.[10] The GCA also requires the Department to ensure that each PA acquires all cost-effective energy efficiency resources, delivers energy efficiency programs while minimizing administrative costs, and complies with the other requirements of the GCA.[11] If a PA has not reasonably complied with its Three-Year Plan, the Department may open an investigation into the PA's performance. G.L. c. 25, § 21(e).

In sum, pursuant to G.L. c. 164, and the GCA, the Department has oversight authority over the PAs and the Council and is responsible for final administrative review of energy efficiency determinations. G.L. c. 25, §§ 19, 21-22. The GCA's grant of authority to the Department is consistent with the Department's enabling and comprehensive statutory regulation of utility companies and municipal aggregators under c. 164 and particularly its regulatory supervisory authority over the electric and natural gas distribution companies pursuant to G.L. c. 164 § 76. Having the resources, technical expertise, and the statutory obligation to regulate in the public interest, the Department is uniquely structured to ensure that energy efficiency funds are spent cost-effectively, that customers are receiving energy efficiency services, and that energy savings are being achieved. The Department conducts its review of Three-Year Plans and PA performance through individual adjudicatory proceedings consistent

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in Massachusetts pursuant to General Laws Chapter 164 to ensure that electric and gas services are provided pursuant to just and reasonable rates.

9 In exercising its authority, the Department does not micromanage utility decisions or substitute its judgment for that of utility management. See New England Telephone and Telegraph Company v. Department of Public Utilities, 327 Mass. 81, 90 (1950) ("a public regulatory board cannot assume the management of the company and cannot under the guise of rate making interfere in matters of business detail with the judgment of its officers reached in good faith and within the limits of a reasonable discretion"). Instead, the Department reviews company management under well-established administrative principles applicable to cost and rate recovery.

10 The GCA sets outs the requirements of the Department's review process. After the PAs file a proposed Three-Year Plan, the Department must conduct a public hearing and, within 90 days, "issue a decision on the plan which ensures that the [PAs] have identified and shall capture all energy efficiency and demand reduction resources that are cost effective or less expensive than supply." G.L. c. 25, § 21(d). The Department "shall approve, modify and approve, or reject and require the resubmission of the plan accordingly." G.L. c. 25, § 21(d).

11 The GCA states that, in authorizing energy efficiency programs, the Department "shall ensure that they are delivered in a cost effective manner capturing all available efficiency opportunities, minimizing administrative costs to the fullest extent practicable and utilizing competitive procurement processes to the fullest extent practicable." G.L. c. 25, § 19(a, b). In order to mitigate capacity and energy costs for all customers, the GCA also requires the Department to ensure that electric and natural gas resources are first met "through all available energy efficiency and demand reduction resources that are cost effective or less expensive than supply." G.L. c. 25, § 21(a).

with the Massachusetts Administrative Procedure Act, G.L. c. 30A, which requires the Department to maintain standards of fair procedure such as notice, an opportunity to be heard, and the ability to appeal decisions.[12]

4. Energy Efficiency Advisory Council

The Department appoints and convenes the Council, which consists of 15 voting members of diverse backgrounds and expertise. G.L. c. 25, § 22(a). The Council's membership is comprised of governmental and non-governmental members, including representatives of DOER, the Department of Environmental Protection ("DEP"), the Attorney General, the environmental community, and residential, low-income and commercial and industrial customers. G.L. c. 25, § 22(a). The Council also includes one "non voting, ex-officio member" from each of the twelve Program Administrators (comprised of Massachusetts electric and natural gas distribution companies and municipal aggregators). G.L. c. 25, § 22(a). There is also one non-voting member from the heating oil industry, energy efficiency businesses, and Independent System Operator - New England ("ISO-NE"). G.L. c. 25, § 22(a).

Each Three-Year Plan must be prepared in coordination with the PAs and the Council. G.L. c. 25, § 21(b)(1). As part of the Department plan approval process, the Council is required in its advisory role to "seek to maximize net economic benefits through energy efficiency and load management resources and to achieve energy, capacity, climate and environmental goals through a sustained and integrated statewide energy efficiency effort." G.L. c. 25, § 22(b). In this role, the Council "shall review and approve demand resource program plans and budgets, work with program administrators in preparing energy resource assessments, determine the economic, system reliability, climate and air quality benefits of efficiency and load management resources, conduct and recommend relevant research, and recommend long term efficiency and load management goals to maximize economic savings and achieve environmental goals." G.L. c. 25, § 22(b). As part of its review of Three-Year Plans, the Council must approve "efficiency and demand resource plans and budgets" with a two-thirds majority vote. G.L. c. 25, § 22(b). In addition, the Council must "examine opportunities to offer joint programs providing similar efficiency measures that save more than one fuel resource or to coordinate programs targeted at saving more than one fuel resource," with costs for joint programs being allocated equitably. G.L. c. 25, § 22(b). After receipt of the April 30th draft plan, the Council has three months to review it and submit "approval or comments" to the PAs. G.L. c. 25, § 21(c).

The Council may retain energy efficiency experts provided they have no contractual relationship with the PAs or an affiliate. G.L. c. 25, § 22(c). The Department approves (and may modify) the level of funding required for the retention of experts and reasonable administrative costs. G.L. c. 25, § 22(c). The Council may ask the PAs for information as part of the development of the Three-Year Plan, and must provide an annual report to the Department

[12] See G.L. c. 30A, §§ 5, 10-12, 14 (outlining adjudicatory proceedings and availability of judicial review). Additionally, to comply with c. 30A, the Department must maintain a record of its adjudicatory proceedings, afford parties the opportunity to present evidence and argument and issue decisions in writing or on the record with a statement of reasons. G.L. c. 30A, §§ 10-11. Finally, Department decisions are subject to appeal to the Supreme Judicial Court on the record formed during the c. 30A adjudicatory proceeding. G.L. c. 30A, § 5.

and the Legislature regarding the implementation of the PAs' statewide Three-Year Plan. G.L. c. 25, § 21(c). The Council must also periodically review program cost-effectiveness. G.L. c. 25, § 21(b)(3). To conduct its business, the Council holds meetings, which are subject to the open meeting law, typically on a monthly basis with the full Council and with its Executive Committee.

In sum, the Council is designed to engage the expertise of its diverse membership and consultants to provide strategic, objective advice to the PAs and the Department. The Council is uniquely positioned to coordinate energy efficiency information on a statewide basis. It provides a forum for coordinating a statewide view from different PAs and for similarly coordinating stakeholder feedback on a statewide basis.

C. **Reporting of Energy Efficiency Data**

The Program Administrators provide extensive energy efficiency data sets in numerous public reports to the Department and the Council. This data is reported in a consistent and timely manner on a monthly, quarterly and annual basis. The D.P.U. 08-50 tables are one of the most comprehensive sources of reported PA data, providing quantitative data elements on numerous topics.[13] These tables were collaboratively developed by a diverse group of stakeholders.[14] In developing the table templates, the stakeholder working group sought "to serve the compatible but, not identical, requirements of both the Council and the Department." Energy Efficiency Guidelines, D.P.U. 08-50-B at 10 (2009). Each PA files detailed data tables as part of a

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[13] The D.P.U. 08-50 tables address the following topic areas (with some gas/electric variations):

> (1) funding sources (summary, funding comparison between each Program Administrator's planned funding and the statewide total, SBC funds, FCM proceeds, RGGI proceeds, other funding if available, prior year carryover, energy efficiency surcharge funds); (2) budgets (summary, budget comparison between each Program Administrator's planned budget and the statewide total, budget comparison between the three-year plan's budget and previous year's budgets); (3) cost-effectiveness (summary, costs summary, costs comparison between each Program Administrator's planned costs and the statewide total, cost comparison between the three-year plan's costs and previous year's costs, benefits summary, benefits comparison between each Program Administrator's planned benefits and the statewide total, benefits comparison between the three-year plan's benefits and previous year's benefits, savings summary, savings comparison between the three-year plan's savings and previous year's savings, avoided cost factors summary, distribution and transmission avoided costs factors comparison between each Program Administrator's planned factors, distribution and transmission avoided costs factors comparison between the three-year plan's factors and previous year's factors); (4) monitoring and evaluation; (5) performance incentive; (6) cost recovery (LBR and energy efficiency surcharge); (7) low-income customer budget allocation; (8) outsourced services (summary, outsourced services comparison between each Program Administrator's planned outsourced services and the statewide total, outsourced services comparison between the Three-Year Plan's outsourced services and previous year's outsourced services); and (9) master summary. Energy Efficiency Guidelines, D.P.U. 08-50-B at 11-12 (2009).

[14] These tables were collaboratively developed in five months over 11 stakeholder meetings and were approved by the Department. D.P.U. 08-50-B at 10. Representatives from several entities actively participated in these meetings, including: Attorney General, DOER, the Council, Associated Industries of Massachusetts, Environment Northeast (n/k/a Acadia Center), Conservation Law Foundation, The Energy Consortium, LEAN, PAs, and Department staff. Id. at 9 & n.5.

Three-Year Plan, and annual and term performance reports.[15] The PAs have updated and enhanced the D.P.U. 08-50 tables for the 2016-2018 Plan and refer to them as the Energy Efficiency Data Tables (see Appendix C).

Program Administrators must provide quarterly reports to the Council on the implementation of their plans. G.L. c. 25, § 22(d). To be responsive to Council requests for additional data, the PAs voluntarily provide monthly data dashboards in months where no quarterly report is due to provide even greater transparency on their implementation efforts. The PAs developed the Council reporting formats in collaboration with the Council consultants. The PAs have been providing quarterly and annual reports since 2010 and monthly data dashboards since 2011. As part of this data reporting, the PAs provide preliminary numeric data on savings, costs, and participants to the Council on a monthly and quarterly basis. Since 2010, the PAs and the Council's consultants have together worked to expand and improve these reports in response to Council interests. PAs also provide large amounts of data with contextual analysis through the EM&V process, with all studies and executive summaries available on the Council's website after finalization, as well as filed with the Department as part of annual plan-year ("Plan-Year") and three-year term ("Term") Reports.

Final data is reported to the Department and Council in Plan-Year Reports and Term Reports. In order to provide final data, the PAs undertake an extensive process to ensure that the data is verified and reliable. Rigorous quality assurance/quality control ("QA/QC") of cost and savings information occurs throughout the year, and additional QA/QC of both cost and savings data is performed specifically for the final reports. PAs review invoices and take steps to quality check and correct any errors in PA tracking systems and review any outliers. They assess items such as participation, vendor savings, and measure categorization; review labor and vendor costs; and review competitively procured services. PAs prepare a report-version of the Technical Reference Manual for Estimating Savings from Energy Efficiency Measures ("TRM") and apply updated evaluation impacts to the data. Following this process, the PAs populate benefit-cost screening models to assess measure, program, sector, and portfolio cost-effectiveness as well as data tables for filing with the Department. This rigorous review process ensures that the data provided by the PAs and relied upon by the Department, Council, and other stakeholders, including ISO-NE, is accurate and of high quality.

Historically, reports to the Department and Council were made in writing, with the quarterly reports being provided in narrative and Excel formats. In order to increase accessibility, in 2014, the PAs developed a database to make energy efficiency data reported to the Department and the Council available in a user-friendly and accessible web-based platform. The public can access this information at www.MassSaveData.com and export data to PDF or Excel formats. The data is available by individual PA and can also be aggregated statewide or for specified PAs. The information available on www.MassSaveData.com replicates the data

15 Prior to 2013, the PAs would file D.P.U. 08-50 tables with mid-term modification filings. On January 30, 2013, the Department issued revised Energy Efficiency Guidelines as part of its streamlining docket in D.P.U. 11-120, which was focused on reducing regulatory burdens where possible. In finding that energy efficiency plans should be treated as true three-year plans and not three annual plans, the Department minimized the need for mid-term changes to the 08-50 tables. Energy Efficiency Guidelines, D.P.U. 11-120-A, Phase II (2013).

available in the Energy Efficiency Data Tables, except for those limited data points that do not lend themselves to quantitative roll-ups. The website currently replicates the data provided to the Council on a quarterly basis. The PAs recently released a monthly data tab that replicates the monthly data dashboard provided to the Council. The website also includes additional information, such as Home Energy Services ("HES") closure rates, cost to deliver and greenhouse gas emission reductions stemming from energy efficiency. Because the data available on www.MassSaveData.com is aggregated, it appropriately protects customer privacy and reduces the need for expensive data security measures, which are core database concerns of the PAs, Department, and stakeholders.[16]

In 2014, the PAs also began developing an electronic version of their specific inputs to the TRM, which documents impact factors and input assumptions used to calculate savings, with sources and references. This electronic version, known as the Technical Resource Library ("TRL"), reflects the effort of the PAs to align common measure naming across all PAs and will allow the public to access information from a central website. The TRL is currently in development, and is anticipated to be complete in 2016. The PAs provide a paper TRM in Appendix V of this 2016-2018 Plan and expect to supplement that document with the TRL when it is available.

D. Overview of Green Communities Act Compliance

1. The Sustained Acquisition of All Cost-Effective Resources

a. Reasonable Pace for Sustained Acquisition

The GCA requires the PAs to acquire all cost-effective energy efficiency resources in their Three-Year Plans. The Department has determined that the acquisition of these resources, however, must be achieved through a sustained effort. 2013-2015 Energy Efficiency Plans, D.P.U. 12-100 through D.P.U. 12-111, at 37 (2013) ("2013-2015 Order"); 2010-2012 Gas Order, D.P.U. 09-121 through D.P.U. 09-128 ("2010-2012 Gas Order"), at 71 citing G.L. c. 25, § 22(b); 2010-2012 Electric Order, D.P.U. 09-116 through D.P.U. 09-120 ("2010-2012 Electric Order"), at 85. To determine the rate at which PAs must acquire these resources, the GCA requires the PAs, Council, and Department to consider a number of factors.

> Determining a reasonable pace for a sustained acquisition requires the Program Administrators and the Council (in developing the Three-Year Plans) and the

[16] In Massachusetts, the PAs strictly control access to sensitive customer-specific account information like customer names, account numbers, rate class, location, usage, and demand data. The PAs have each adopted strict corporate privacy policies and safeguards to protect customer information. These corporate privacy policies explicitly state that customers' personal information will be safeguarded and only disclosed for a regulated PA business purpose. Each of the PAs maintains physical, electronic, and procedural safeguards to protect such sensitive data. Customer consent is necessary to permit third-party access to sensitive customer-specific account information outside the conduct of regulated PA business. Disclosure of customer information to a third-party without customer authorization would violate corporate privacy policies and expose a PA to liability under the Massachusetts Right to Privacy Act, M.G.L. c. 214, § 1B or Chapter 93A, Department precedent and directives to maintain customer confidentiality, and potentially other statutes.

> Department (in reviewing the Three-Year Plans) to strike an appropriate balance between several factors, including: (1) identifying the potential level of cost-effective resource currently available; (2) exploring ways in which this level can be increased; (3) assessing the capability of the energy efficiency vendor and contractor industry to support increased program activity; and (4) assessing the capacity of the Program Administrators to administer increases in program activity efficiently and effectively. The Department must take into consideration an additional factor: the rate and bill impacts that result from increased program activity.

2010-2012 Gas Order, at 71-72 and 2010-2012 Electric Order at 85-86. Consistent with the Department's directives, the 2016-2018 Plan provides a strategy for acquiring all cost-effective energy efficiency resources at a reasonable pace during this three-year term.

b. Statewide Strategic Plan

Like its predecessors, the 2016-2018 Plan includes multiple parts that taken together as an integrated whole describe the PAs' strategy for acquiring all cost-effective energy efficiency resources through a sustained effort. The provisions of the entire Plan must be considered as a whole in order to fully appreciate and understand both the PAs' energy efficiency programs and their strategy for satisfying the mandates of the GCA over the next three years.

While detailed, a Three-Year Plan is a strategic plan, not an implementation guide. This strategic plan approach provides the PAs with the flexibility necessary to make implementation changes to meet changing circumstances in order to deliver on their Plan goals and satisfy the GCA. Each PA retains the flexibility during the implementation of a Three-Year Plan to make modifications without Department or Council approval. A PA may adjust spending, add or subtract program measures, and make ongoing revisions and enhancements after the adoption of the Three-Year Plan in order to reflect in-the-field conditions, technological advances, financing opportunities, and state-of-the-art new technologies. PAs will seek Department and Council review and approval for modifications requiring such approval as set forth in the Department's Guidelines, as revised in Energy Efficiency Guidelines, D.P.U. 11-120-A, Phase II (2013) ("Guidelines").

2. Energy Efficiency Advisory Council

a. Introduction

For each three-year term the Program Administrators are required to submit to the Council a statewide energy efficiency plan on or before April 30th of the year prior to implementation. The GCA specifies the contents of the plan and requires that the plan be prepared by the Program Administrators in coordination with the Council. G.L. c. 25, § 21(b)(1)-(2). As part of the plan approval process, the GCA requires the Council to maximize benefits and achieve its goals through "a sustained and integrated statewide energy efficiency effort." G.L. c. 25, § 22(b).

To meet these statutory requirements for the 2016-2018 Plan term, the Program Administrators worked collaboratively to prepare an integrated statewide Plan that represents the collective efforts and objectives of the Program Administrators. The PAs also coordinated with the Council, participating in the processes developed by the Council for providing input on the 2016-2018 Plan. On April 30, 2015, the Program Administrators submitted the initial draft 2016-2018 Plan for the Council's comment and approval. After receipt of the April 30thdraft Plan, the Council had three months to review it and submit "approval or comments" to the PAs. G.L. c. 25, § 21(c). The Council approved a resolution on the April 30th draft Plan on July 21, 2015.

The PAs have been active and engaged participants in the Council process since its inception in 2009. Between 2009 and 2012, the PAs participated in at least 79 meetings of the full Council and/or its Executive Committee. From 2013 to the time of this Plan, the PAs have participated in at least 116 meetings of the full Council, its Executive Committee, its database subcommittee/working group, and/or planning workshops. In 2012, the Council membership was expanded, adding both voting and non-voting members. In 2015, membership in the Council's Executive Committee was also expanded by adding a Commercial and Industrial ("C&I") seat, replacing a low-income seat with a consolidated residential and low-income seat, and by formalizing a seat for the PAs. While these expansions have broadened the input on plan development and implementation, they have also increased the complexity of the Council dynamics and the time and effort the PAs must invest in responding to Council and individual councilor inquiries.

b. Council Priorities

In its January 13, 2015 Draft Priorities for 2015, the Council articulated a priority related to the 2016-2018 Plan, stating that the Council should "relay clear Council priorities and recommendations to the Program Administrators for inclusion in the 2016-2018 Three-Year Plans." The PAs worked with the Council on the 2016-2018 Plan and achieving all available cost-effective energy efficiency by maximizing net economic benefits through a sustained and integrated statewide energy efficiency effort, setting aggressive and achievable goals and addressing barriers to energy efficiency, while staying focused on bill impacts, cost efficiency and integrated program delivery.

c. Council Workshops

In February and March 2015, the Council conducted a number of sector-related workshops, facilitated by Raab Associates, Ltd., to assist in the development of the 2016-2018 Plan. The PAs were active and engaged partners in the development of meeting materials and in the workshops. There were three C&I workshops, three residential workshops, and one multi-family/low-income workshop. These workshops assisted the Council in developing recommendations for its Resolution dated March 31, 2015.

After the filing of the April 30th draft Plan, the Council held two follow-up workshops in June 2015 to allow for further stakeholder engagement and discussion of program designs. There was one residential/low-income workshop and one C&I workshop. The PAs provided insights and answered questions at these workshops. These workshops assisted the Council in developing recommendations for its Resolution dated July 21, 2015.

d. Council Resolution of March 31, 2015

On March 31, 2015, the Council adopted a "Resolution Concerning Its Priorities for the Development, Implementation, and Evaluation of the 2016-2018 Three-Year Energy Efficiency Plans." See Appendix E. This Resolution articulates the Council's priorities for the 2016-2018 Plan and makes 150 specific recommendations based upon the Council workshops. The PAs closely reviewed these recommendations and incorporated many of the themes and comments into the program design for the April 30th draft Plan.[17] Many of the topics in the recommendations were discussed at the June Council workshops. While the PAs did not adopt each and every recommendation in the April 30th draft Plan, the recommendations were valuable to the PAs in developing program designs that they believe will keep Massachusetts at the forefront of energy efficiency design in the nation. Working with DOER and Raab Associates, the PAs developed a matrix that gives feedback on each of the Council's 150 specific recommendations. See Appendix F (matrix dated May 25, 2015).

e. Council Resolution of July 21, 2015

In accordance with the GCA, "the [C]ouncil shall review the plan and any additional information and shall submit its approval or comments to the electric and natural gas distribution companies and municipal aggregators not later than 3 months after submission of the plan." G.L. c. 25, § 21(c). On July 21, 2015, the Council adopted a resolution entitled "Comments regarding the April 30th draft 2016-2018 Energy Efficiency Plan." See Appendix G. This Resolution articulates the Council's priorities for the 2016-2018 Plan and makes over 100 specific recommendations and other comments based upon the comments from councilors, stakeholders, legislators, and Council consultants provided during various Council meetings, including two public comments sessions of the Council and nine Council workshops. Like the previous Council recommendations, the PAs have carefully reviewed the Council's July 21st recommendations and incorporated many but not all of the themes and comments into the September draft plan.[18] The PAs appreciate the Council's thoughtful feedback on the April plan and believe that, together with the Council's input, they have developed comprehensive and innovative program designs that will continue to set the standard for the rest of the nation. For ease of reference, the PAs developed a matrix that provides feedback on each of the over 100 specific recommendations in the Council's resolution. See Appendix H (matrix dated September 23, 2015). The PAs look forward to continuing to discuss the Council's

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[17] As expressly stated in this Resolution, the Council developed "recommendations," consistent with the Council's advisory role under the GCA, but they were not a consensus view of the Council. See Minutes of March 31, 2015 Council Meeting.

[18] As expressly stated in this Resolution, the Council made "recommendations," consistent with the Council's advisory role under the GCA. In addition the Resolution makes clear that the recommendations are not a consensus view of the Council, stating that they "may not represent the opinion or position of every Councilor on certain issues, but on the whole, the Council has determined that the recommendations should be considered and addressed in the Revised Plan." July 21, 2015 Resolution at 5; see also Minutes of July 21, 2015 Council Meeting.

recommendations in a collaborative and productive manner consistent with both the mandate of the GCA and the rich history of stakeholder discussions that are the hallmark of energy efficiency in Massachusetts.

f. Term Sheet

Following the July 21st Resolution of the Council, the PAs collaborated with the Council's consultants, along with the Executive Office of Energy and Environmental Affairs, DOER, and the Office of the Attorney General, to further discuss goals, budgets, and key priorities. As a result of these discussions, the PAs, DOER, and the Attorney General were able to agree upon the Term Sheet. See Appendix D (Term Sheet). The Term Sheet sets forth fundamental core goals for 2016-2018 that have served as a guide for the PAs in developing this Plan.

g. Council Resolution of October 26, 2015

In September and October 2015, the Programs Administrators continued to work collaboratively with the Council consultants and individual councilors to incorporate key priorities, and the goals and budgets reflected in the Term Sheet into the Plan. On October 26, 2015, the Council adopted, by a 14 to 1 super-majority vote, a Resolution commending the PAs, strongly supporting the 2016-2018 Plan, and respectfully requesting that the Department of Public Utilities approve the Plan. See Appendix I. The Program Administrators express their appreciation for the efforts of each councilor and the Council consultants. The ability to achieve such an overwhelming consensus on a Plan as complex and with as many moving parts as this one, reflects a signature achievement for the Commonwealth.

3. Department of Public Utilities

a. Introduction

In accordance with the GCA, the Program Administrators submit their 2016-2018 Plan "together with the [C]ouncil's approval or comments and a statement of any unresolved issues, to the [D]epartment," for approval no later than January 31, 2016. Since the Department reviews each PA's Three-Year Plan individually, these filings also include company-specific information. Additionally, for the 2016-2018 Plan the Department has requested that the PAs respond to certain questions set forth in the Department's Revised Additional Filing Requirements dated October 2, 2015. Responses to these questions are set forth in each PA's pre-filed testimony and in Appendix X.

b. All Cost-Effective or Less Expensive than Supply

In approving a Three-Year Plan, the Department is seeking to mitigate capacity and energy costs for all customers "through all available energy efficiency and demand reduction resources that are cost effective or less expensive than supply." G.L. c. 25, § 21(a). The Department is charged with ensuring that the PAs "have identified and shall capture all energy efficiency and demand reduction resources that are cost effective or less expensive than supply." G. L. c. 25, § 21(d)(2). To comply with the GCA, a Three-Year Plan must provide for the acquisition of these resources "with the lowest reasonable customer contribution." G.L. c. 25, § 21(b)(1).

In developing their 2016-2018 Plan, the PAs considered what an optimal pace is for acquiring all cost-effective energy efficiency resources for the period from 2016 to 2018, in order to ensure long-term sustainability for their energy efficiency program offerings. In developing savings goals for 2016-2018, the PAs took into consideration the four factors set forth in Section II.D.1.a, above, as well as rate and bill impacts on their customers. The PAs provide detailed information on the development of their goals in Section III, as well as their individual benefit/cost ratio ("BCR") models, demonstrating that they are seeking to acquire all cost-effective energy efficiency resources for the 2016-2018 term.

c. Program Cost-Effectiveness

The GCA specifically requires cost-effectiveness screening for energy efficiency programs. G.L. c. 25, §§ 19(c), 21(b)(3).[19] The Department has determined that a Total Resource Cost ("TRC") test that weighs the impact of societal benefits and costs associated with each program satisfies this requirement D.P.U. 08-50-A at 14; Guidelines § 3.4.3. The TRC test operates by weighing all program costs and benefits. Benefits calculations include the cost of energy supply that is avoided when energy efficiency efforts are utilized and therefore the TRC test satisfies the GCA's requirement that energy efficiency programs be less expensive than supply. D.P.U. 08-50-A at 14-15.

For the 2016-2018 Plan, the PAs applied the results of the regional Avoided Energy Supply Costs in New England: 2015 Report ("2015 AESC"), which was completed on March 27, 2015 and revised on April 3, 2015, and is attached hereto at Appendix J.

d. Program Authorization and Delivery

In authorizing energy efficiency programs, the Department must ensure that the PAs are: "[1] deliver[ing] programs in a cost-effective manner capturing all available efficiency opportunities [2] minimizing administrative costs to the fullest extent practicable and [3] utilizing competitive procurement processes to the fullest extent practicable." G.L. c. 25, § 19(a, b). The PAs have addressed each one of these issues throughout the Plan, and specifically in Sections V.A, V.D, and V.E, below.

e. Program Funding

i. <u>Funding Sources</u>

The PAs seek to leverage available funding sources and financing initiatives in order to increase the benefits of Three-Year Plans and minimize customer bill impacts. For electric PAs,

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[19] The GCA requires energy efficiency programs included in PAs' Three-Year Plans to "be screened through cost effectiveness testing which compares the [economic] value of program benefits to the program costs to ensure that the program is designed to obtain energy savings and system benefits with value greater than the costs of the program." G.L. c. 25, 21(b)(3).

the GCA identifies four specific funding sources for energy efficiency programs: (1) revenues collected from ratepayers through the System Benefit Charge ("SBC"); (2) proceeds from the PAs' participation in the Forward Capacity Market ("FCM"); (3) proceeds from cap and trade pollution control programs, including but not limited to the Regional Greenhouse Gas Initiative ("RGGI"); and (4) other funding as approved by the Department, including revenues to be recovered from ratepayers through a fully reconciling funding mechanism (*i.e.*, an energy efficiency surcharge ("EES")). G.L. c. 25, §§ 19(a); 21(b)(2)(vii). For gas PAs, the GCA does not identify multiple funding sources for energy efficiency programs and instead requires the gas PAs to include a fully reconciling funding mechanism to collect energy efficiency program costs from customers (*i.e.*, EES). G.L. c. 25, § 21(b)(2)(vii); see also G.L. c. 25, § 21(d)(2). For a detailed discussion of the funding sources and financing initiatives that are currently available to the PAs, please refer to Section VI, below.

ii. Funding Allocation

Consistent with the Department's Guidelines, the Program Administrators allocate SBC, FCM, and RGGI revenues to each customer sector in proportion to the kWh consumption of each class. The low-income sector is allocated at least ten percent of the funds for electric energy efficiency programs and 20 percent of the funds for gas energy efficiency programs pursuant to G.L. c. 25, § 19(c).

iii. Funding Mechanism

The EES is a fully reconciling funding mechanism that the Department approves for funding the Three-Year Plans. G.L. c. 25, § 21(d)(2). Electric Program Administrators collect the EES through Energy Efficiency Reconciliation Factor ("EERF") or Energy Efficiency Program Cost Adjustment ("EEPCA") tariffs. Guidelines §§ 2(9), 3.2.1.6. For gas Program Administrators, the EES is collected through the local distribution adjustment clause ("LDAC") tariff in accordance with established Department practice. Guidelines §§ 2(9), 3.2.2. The EERF/EEPCA and LDAC filings of the PAs are separate proceedings from the Three-Year Plan proceeding and are implemented on schedules that vary among the PAs.

III. STATEWIDE PROGRAMS

A. Strategic Overview of Residential, Low-Income, and C&I Programs

The Commonwealth of Massachusetts has achieved national recognition for its leadership in energy efficiency policy and programming, ranked as the top state in the nation by American Council for an Energy-Efficient Economy ("ACEEE") for the past five years running. The Program Administrators' comprehensively designed and implemented energy efficiency programs operate day to day to deliver energy efficiency savings and benefits for Massachusetts businesses and consumers.

The PAs provide programs to three core sectors: Residential, Low-Income, and C&I. Within the residential sector, the PAs offer two programs: Whole House and Products, comprised of a total of seven core initiatives. PAs support the Low-Income sector with Whole House programming, delivered through two core initiatives targeting single family (1-4 unit) and multi-family buildings. The C&I sector is served by two programs, Retrofit and New Construction, with six tailored core initiatives within the programs. The Residential and C&I programs coordinate closely and are served by the Statewide Marketing and the Evaluation Management Committees. The Low-Income sector coordinates closely with LEAN.

The first Three-Year Plan (2010-2012) built upon a strong foundation of the efficiency programs that had been offered for years in the Commonwealth, but which revolutionized the scale and pace of efficiency programming. Lessons from that first Three-Year Plan led to significant expansion, including program re-design with multiple enhancements and additions. Those programming updates succeeded in broadening participation across sectors, increasing savings, and delivering unprecedented benefits for participants. In the second Three-Year Plan (2013-2015), the PAs continued to build on successful programs and strategies and make improvements to reach additional customers and seek deeper and broader energy efficiency opportunities. Over both terms, the PAs have consistently achieved record-setting levels of savings and participation, and in 2014 achieved greater than 100 percent of plan savings and benefits goals across gas and electric programs.

In reviewing the 2016-2018 Plan, it is critical that the energy efficiency community considers and celebrates the historic achievements of the PAs' energy efficiency programs, and the contributions of multiple stakeholders, including the Council, the DOER, the Department, the Attorney General, and LEAN, to these achievements. At the same time, it is necessary to acknowledge that many market factors, including more stringent codes and standards, the saturation of certain markets, and lower avoided costs, will naturally lead to a leveling off of savings and higher costs to secure additional kilowatt hour and therm savings. Recognizing these pressures on costs, PAs remain ever-conscious of the trust invested in PAs to deliver solid efficiency investments without creating undue bill impacts. PAs also remain committed to maintaining the stability of the robust efficiency infrastructure that has been built; most critically the network of energy efficiency vendors, contractors, installers, distributors, and manufacturers which form the backbone of the PA program delivery.

To address these pressures and commitments, the PAs have focused this Three-Year Plan on optimizing program potential by balancing investments to maximize benefits against a consistent, reasonably and moderately increased, funding scenario. This approach will require continued adaptation through market segmentation, effective targeting, streamlining, and improving access and program processes, along with ongoing review and inclusion of new efficiency technologies. PAs remain committed to continuously broadening and growing a competitive delivery workforce of participating vendors and contractors, and investigating and exploring program modifications through field tests and evaluations of novel approaches.

The 2016-2018 Plan also seeks to maintain the PAs' commitment to ensuring the highest quality customer experience. Ultimately, this customer experience is the cornerstone on which the programs must be built to ensure continued enthusiasm and support for securing energy efficiency as the Commonwealth's first and lowest cost fuel.

B. Sustainable Infrastructure

The Massachusetts model of Program Administrator delivery of energy efficiency programming has proven highly successful in building a robust energy efficiency industry. According to the 2014 Massachusetts Clean Energy Industry report[20] there are 65,000 workers and more than 4,000 firms working in the Massachusetts energy efficiency industry, representing a 35.6 percent growth in the number of firms conducting energy efficiency work since 2013. Energy efficiency employment makes up half (50.9 percent) of jobs at startups working on pre-commercialized technologies. The PA programs have broadened the ability of market actors to participate in energy efficiency programming. Partners have been able to grow businesses and continue to invest in growth based on the confidence that they, and their customers, have in the energy efficiency regime. The continued strength and growth of this energy efficiency industry is reliant on consistency in programming and a stable budget; this Plan provides the necessary predictability and stability, consistent with multiple comments and suggestions from contractors, including those offered at the Council's January and May stakeholder input meetings. The PAs remain committed to supporting the Massachusetts energy efficiency infrastructure with continued rigorous program design, evaluation, and delivery, while avoiding large shifts in direction or budget. The PAs will continue to optimize systems and expand offerings while recognizing the key role that PA partners play.

C. Mechanisms for Program Collaboration, Continuous Improvement, and Sharing and Incorporation of Best Practices Information

1. The Residential and C&I Management Committees

A central theme running through each generation of Three-Year Plans has been the ongoing PA commitment to work collaboratively on a daily basis to ensure that: (a) all eligible customers in Massachusetts experience seamless programs, with common application procedures, incentives, and supportive educational and technical services; and (b) those programs are subject to continuous improvement in order to retain their status as among the best in North America.

[20] Available at: http://www.masscec.com/content/2014-clean-energy-industry-report.

Before the first Three-Year Plan was submitted, the PAs developed informal working groups that brought together the respective residential and commercial program managers from every gas and electric company and energy efficiency service provider in the Commonwealth. Tasked with transitioning to an integrated statewide program portfolio, these working groups focused on producing the initial uniform administrative procedures, developing supporting materials for seamless program delivery across fuels and across service territories, and maintaining consistent messaging to customers, trade allies, manufacturers, market actors, and market channels.

However, managing and delivering a statewide portfolio of programs is an ongoing and dynamic exercise. Programs must evolve and respond in real-time to a myriad of forces, such as changing consumer dynamics and expectations, the appearance of new efficiency technologies in the market, price and baseline changes to existing technologies, as well as the impact of the general economy, which strongly influences the nature and degree of program participation. In order to facilitate efficient and timely program decision-making the successful informal structures of the working groups were formalized into a Residential Management Committee ("RMC") and a C&I Management Committee ("C&IMC"). Each committee developed a formal written charter to ensure that the roles and responsibilities of the committee and its members were understood by all PAs. To ensure efficient resolution of issues that come before them, each PA has delegated decision-making authority to their committee representative. Each committee has a chair or lead, who speaks for the PAs collectively on program matters, and a coordinator to assist in organizing committee activities and performing administrative tasks, such as memorializing the record of committee decisions and ensuring that decisions that impact program delivery are disseminated to every PA.

The management committees may delegate some tasks to various expert technology teams, individual experts, the Massachusetts Technical Assessment Committee ("MTAC"), or any other ad-hoc or permanent subgroups they may establish. The committees may also use contractors to facilitate specific elements of their work where internal capacity or expertise is insufficient or where an independent view is valued.

Each management committee works to ensure that: (a) all PAs remain abreast of the key activities of other PAs; (b) implementation activities and efforts by all PAs are integrated and coordinated to the optimal extent; (c) statewide marketing and media campaigns are developed with easy-to-understand communications that serve eligible customers; (d) evaluation and market assessment studies are reviewed and program modifications are executed accordingly; (e) program policy and implementation issues are resolved collectively, and decisions are communicated to each PA's staff to ensure uniform application; and (f) program best practices, technology innovations, and integration/coordination efforts in other jurisdictions are reviewed and incorporated as appropriate.

In addition to enhancements to existing programs and initiatives, new programs and initiatives are designed by the management committees, with input from the appropriate working groups, internal subject matter experts, and a variety of "best practices" resources.[21]

With respect to low-income efforts, LEAN has convened the highly effective Low-Income Best Practices Group to coordinate practices across all PAs and agencies. The Low-Income Best Practices group continues to offer opportunities for various stakeholders to discuss program implementation, new measures, innovative strategies, and other matters related to the PAs' low-income programs.

2. The Massachusetts Technology Assessment Committee

MTAC reviews new technologies that have the potential to cost-effectively save energy. MTAC is both a proactive and a reactive body, and consists of key technical staff from among the PAs. The committee addresses both residential and commercial/industrial technologies, drawing on the subject matter experts from the committee, PA staff, or outside expertise as necessary. It establishes and publishes threshold technical requirements that must be met to qualify products or processes as eligible for program incentives. It documents its findings in a standardized manner and disseminates them to the PA program managers, technical staff, account managers, and outside parties such as vendors, customers, and other interested parties, as appropriate.

The MTAC is the authority for consistent program interpretation of technical matters and provides information, documented technical interpretations, and technology assessments to the PAs. The committee has developed a set of protocols for the content of their review and procedures for documenting and disseminating their conclusions and technical interpretations. These protocols are publicly available on MassSave.com.[22] The MTAC meets as needed, either as a whole committee or in ad hoc technology or issue-specific subgroups, and more regularly during the annual program review and planning period.

In accordance with the October 26th Resolution, the Program Administrators commit to providing semi-annual updates to the Council on the PAs' progress reviewing and implementing new technologies into programs.

3. Ongoing Commitment to Innovation and Technology

The Program Administrators have been national leaders in their commitment to innovation, and the development and deployment of cutting-edge new technologies. As part of the Term Sheet, the PAs, EEA, DOER, and the Attorney General have prioritized the importance of this commitment as follows:

> The Council and the PAs agree on the importance of implementation of new technologies and program approaches. The PAs are committed to increasingly

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21 Examples include the recent Retro-commissioning best practices study conducted in conjunction with the Council consultants, and a review of emerging program and technology trends conducted by E Source for both the C&IMC and the RMC.

22 MTAC materials can be found here: http://www.masssave.com/professionals/business-opportunities/assessment-of-new-efficiency-technologies.

develop and deploy new technologies, delivery models and business strategies with performance-based results that are appropriate for the customers and that are proven to be cost-effective. The Plan will reflect a continuous commitment by the PAs to exploring and adopting cost-effective innovations and new technologies in the residential, low-income and C&I sectors. In addition to specific efforts identified in the Plan, the PAs commit to continuous collaboration on innovation, including appropriate program updates and evaluation efforts with the Council.

D. Engaging Third Party Stakeholders

The PAs are constantly engaged with a myriad of stakeholders. Every day the PAs hear from and respond to residential and commercial customers, program participants, contractors, service providers, equipment manufacturers and distributors, trade and professional associations, legislators and regulators, environmental and community advocates, civic leaders, business owners and organizations, and other interested parties. Every citizen and every business has an interest and a stake in the effectiveness of the portfolio of Massachusetts energy efficiency programs because energy costs touch and affect every person and business in the Commonwealth.

The energy efficiency programs are designed and administered by the public utilities and energy efficiency service providers, which are open to input from members of the public. Massachusetts citizens and other interested parties are able to voice their views through existing and established public oversight processes. The Council, which represents a broad spectrum of stakeholder interests, has facilitated additional organized venues for individual and organizational input specific to the content of the Three-Year Plan through a series of topic area-specific public workshops and a number of general public hearings. The DOER has also invited and received comment and plan suggestions from all the cities and towns in the Commonwealth. All of the comment and input collected from these various forums has been reviewed closely by the PAs, and much of it has been reflected in this plan document. An additional opportunity for stakeholder input exists after the plan has been reviewed by the Council and forwarded to the Department. The Department’s regulatory processes are open to any interested parties.

On a continuing basis, there are a variety of other structured or semi-structured events, venues, or processes through which stakeholder input is encouraged. For example:

- **Annual open houses for trade allies/vendors.** Every year the PAs host several large statewide events for the express purpose of presenting and explaining program changes and updates to the business partners the PAs depend on to deliver their various programs to customers. Attendees have ample opportunity to network with each other and PA staff, and to engage in a dialog about program design and operations.
- **Best Practices Working Group.** This group is constituted of a subset of the HES contractors elected annually by their peers, as well as the PAs, and the Lead Vendors. The members meet monthly to provide continuous feedback for the improvement of the program across the state. Topics discussed have ranged from refining the QA/QC process, and adopting new measures such as spray foam to pricing and training.

- **The Proposal process.** The PAs provide a structured process by which any third-party organization can propose a program concept or proposal to supplement or enhance the PAs approved programs to the management committees. The criteria and two-step process for considering a proposal is clearly articulated. This process, while open, is rigorous and applicants must demonstrate that their concept can demonstrate and produce cost-effective and incremental savings beyond the approved program designs.[23]

- **The Massachusetts Technology Assessment Committee Process.** The clearly-articulated and open process by which MTAC reviews submitted technologies provides a level playing field. Any manufacturer or vendor of an emerging or newly-commercialized efficiency technology can make a science-based case for acceptance of their product into the PA incentive offerings.

- **Informal PA speakers' bureau.** PA representatives are regularly called upon to represent and explain the programs to trade and civic associations. Industry associations, like the Massachusetts Restaurant Association and the Massachusetts Lodging Association, seek knowledgeable speakers to explain how the programs can work for their members and provide relevant case study examples from their industry.

- **Proactively solicit input from customer and industry experts.** The PAs routinely seek input from key constituencies when they are considering program design changes or considering new product innovations. For example, Eversource recently completed a field trial of a new commercial laundry product in partnership with the product manufacturer and a customer – in this case, a hotel. The PA needed to establish that the product met the customer's priority need (*e.g.*, clean, white guest sheets and towels) before promoting the energy and water saving attributes.

- **Input and advice from peer programs.** The delivery of energy efficiency programs throughout the country is largely a collaborative and congenial business. PA program managers have come to know their peers in other leading jurisdictions around the country, and consider each other stakeholders in a shared mission of improving the efficiency of homes and businesses in the United States and reducing our collective carbon footprint. This means that emerging program ideas and best practices are freely shared. Massachusetts program managers test program concepts and share evaluation results and technical information with their counterparts, and receive feedback which is built into new program designs or improvements to existing ones.

- **Provide collateral materials for customer events.** Individual PAs routinely offer stakeholders significant volumes of program collateral for distribution at local community and trade association meetings.

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[23] The documents related to the proposal process are available at http://www.masssave.com/professionals/business-opportunities/process-for-managing-unsolicited-proposals.

E. **Residential Programs**

1. Overview of Residential Programs – Whole House & Products

Massachusetts Program Administrators deliver the most comprehensive programs in the nation, with program and product offerings for every type of residential customer and every type of residential energy efficiency opportunity. The PAs' residential programs are designed to provide cost-effective energy efficiency savings opportunities to Massachusetts residential electric and gas customers. The programs address a range of building types, including both the traditional free-standing single-family home and the wide variety of multi-unit residential structures, from the iconic "triple decker" to mixed-use high rises to townhouse developments. The residential programs serve new construction and retrofit markets, and are responsible for ensuring that services are available to all residential sectors, including low-income.[24] The PAs have been offering residential programs for over 20 years.

Whole House Program Core Initiatives	Products Program Core Initiatives
New Construction	Heating & Cooling Equipment
Home Energy Services	Consumer Products
Multi-Family Retrofit	Lighting
Behavior/Feedback	

Low Income Whole House Program
Single Family
Multi-Family

There are two programs, Residential Whole House and Residential Products. The Whole House program targets residential single-family and multi-family dwellings, comprehensively addressing energy efficiency opportunities in the entire home or facility. Multiple core initiatives (New Construction, Home Energy Services, Multi-Family Retrofit, and Behavioral/Feedback) fall under the Whole House program. These initiatives allow for variations in program delivery and marketing that address specific moments in building life cycle, customer type, or market demand. Together these initiatives ensure that the Whole House Program is available to all customers and building types with targeted yet comprehensive energy efficiency services.

The Products program complements the Whole House program by focusing on optimizing the efficiency of lighting, heating and cooling equipment, and energy-consuming products that are introduced to the residential consumer market, whether they are sold by contractors or sold directly to consumers through big box stores, hardware stores, wholesale clubs, discount chains, and other retailers. The high visibility of the Products program across all sales channels provides tremendous marketing value and ensures that customers who do not take advantage of in-home services are able to easily participate in Mass Save® energy savings opportunities. PAs work with retailers, manufacturers, distributors, and trade allies within each

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[24] The Green Communities Act requires that low-income residential demand side management and education programs be implemented through LEAN.

of the Products program's core initiatives (Lighting, Consumer Products, and Heating and Cooling Equipment) to ensure the highest-quality energy-efficient products are introduced and promoted to the residential consumer market. The Whole House and Products programs are tightly coordinated to ensure that innovations in technology and market dynamics are shared and leveraged. The PAs also work to provide consistent messaging and easy access for customers through coordinated marketing and the Mass Save® website.

2. Residential Highlights

The residential programs have historically met or exceeded their targets for participation, savings, and benefits statewide. The Whole House program has deployed highly effective participation paths, particularly in the HES core initiative. The HES core initiative generates greater participation rates than any other whole-house program nationwide, while maintaining high savings-realization rates. The Products program provides a broad opportunity to serve all customers, touching any customer who has purchased an efficient bulb or appliance. The Products program successfully leverages a complex array of delivery channels and partners to encourage Massachusetts consumers to install high efficiency technologies, including lighting, consumer products, heating, cooling, and water heating.

Much of the success of the last three years is due to the strong partnerships the PAs have developed with their network of vendors, contractors, manufacturers, distributors, and stakeholders. This network works alongside PA program staff to help PAs better understand their markets, identify new ideas, and support innovation in technologies and delivery systems.

The Council structure has offered a rich forum for exploring ideas. Several key successes noted as highlights below stemmed from a shared commitment by PAs and the Council to expanding and deepening participation by all customer segments, growing the qualified energy efficiency workforce, and securing cost effective energy efficiency for Massachusetts energy consumers. These successes will be key building blocks on which the shared priorities of the PAs and Council can be realized while maintaining Massachusetts' leadership in bringing cutting edge technologies into program design, ensuring customer acceptance and maintaining cost effectiveness.

The deployment of the online assessment tool and the incredible success of the Mass Save® Facebook page (which currently has more likes than ENERGY STAR®) speaks to the on-going commitment of PAs to reach out broadly and provide effective and creative entry points for customers. The on-line assessment effectively provides customers with a no–cost home energy score card, tied directly to customer-specific actionable Mass Save® energy efficiency opportunities specific to the resident's circumstances, all from the comfort of their keyboard and at their leisure. The existing online assessment tool and resulting scorecard provides a cost-effective, customer-centric approach, and addresses the Council's interest in ensuring that customers have access to actionable home energy scorecards.

Residential Highlights — 2013-2015

Customer Focus	Technology	Program Design
✓ Increased customer awareness of programs ✓ Social media outreach: over 110,000 Facebook fans (More than ENERGY STAR) and nearly 15,000 Twitter followers ✓ Mass Save® Online Assessment with digital path to HES ✓ Increased use of Multi-Family Market Integrator ✓ Expansion of HEAT loan program	✓ LED testing ✓ LED promotion through award winning marketing ✓ LED bulbs installed per household realized through bulk procurement ✓ Wireless-enabled thermostats ✓ Behavioral programs	✓ HES redesign ✓ Early boiler, furnace, and air-conditioning rebates ✓ Low cost pre-weatherization ✓ Deeper-energy savings incentives ✓ Contractor Best Practices working group ✓ Evaluation of Efficient Neighborhoods+ ® and review of Renew Boston ✓ Builder education on efficient building practices ✓ Multi-Family High Rise path in new construction

a. *Customer Focus*

- Increased customer awareness of programs, with 77 percent of customers agreeing that Mass Save® communicates how to lower energy bills, and 83 percent finding the Mass Save® campaign messaging clear and relevant. A majority of residential customers report awareness of the Mass Save® website, and 30 percent report using the website more than once in the past year.
- Built a strong social media presence over the 2013-2015 term, with over 110,000 Facebook fans (https://www.facebook.com/MassSavers) and nearly 15,000 Twitter followers (https://twitter.com/masssave).
- Jointly procured an industry-leading online assessment solution and configured it to meet the unique needs of Massachusetts consumers. This included a first-in-the-nation approach to displaying appropriate PA-specific information while maintaining the Mass Save® branding and enabling effective data sharing across PAs.
- Implemented the online assessment to introduce a digital path to participation in the HES program, while identifying opportunities for customers who may not be best served via HES. This easy-to-use tool gives customers a better sense of whether their home can benefit from the initiative, provides a high-level estimate of the potential savings that can be achieved, and identifies other opportunities they can pursue, all from the comfort of their home (or connected device) in under ten minutes.

- Increased access and use of the central point of contact, Multi-Family Market Integrator ("MMI") for customers of the Multi-Family Retrofit offerings. In 2012, there were 1,570 incoming calls to the MMI. In 2014, this number grew to 8,360. This increase in volume tracks the increased marketing with trade associations and coordination with account executives and other initiatives.
- Partnered with the local lending community to grow the Mass Save® HEAT loan initiative, the most successful initiative of its kind in the nation, growing from 532 loans in 2006 to over 11,000 loans in 2014 (annual). Since its inception, the Mass Save® HEAT loan has made over $200,000,000 available to thousands of homeowners implementing home energy efficiency improvements.

b. Technology

- Maintained leadership in testing and promoting LED technology in residential applications. Since 2008, several PAs have worked with the Department of Energy to test high quality LEDs in homes in the Commonwealth. Learning from its experience in the early promotion of compact-fluorescent lamps ("CFLs"), the PAs focused on LED lumen output, color, and dimming, among other desirable qualities for residential applications.
- Maintained leadership in a lighting program that has exponentially increased the number of LED sales and the breadth of LED types offered.
- Increased penetration of LED lighting technology through award-winning marketing campaigns promoting aggressive markdowns and buy-downs in retail outlets.
- Released a request for proposals ("RFP") to procure high-quality lighting through bulk purchase for Whole House initiatives. The effort dramatically reduced costs for the PAs while allowing them to install LEDs at a much more rapid pace than was originally planned.
- Offered rebates for wireless-enabled thermostats. The PAs completed a successful evaluation of the emerging wireless-enabled thermostats, becoming the first-in-the-nation energy-efficiency program to add a savings value to the TRM based on rigorous evaluated field results. Some PAs have begun to offer direct installation of wireless-enabled thermostats in the Whole House program; other PAs are exploring similar offers.
- Implemented one of the earliest and most comprehensive residential-behavioral programs in the country. Building off multiple early experimental designs, several PAs have been able to go to scale on behavioral program deployment, allowing for significant annual savings.

c. Program Design

- Implemented the redesigned HES program, expanding contractor participation in the program and supporting employment growth, contractor quality, and consumer value.

- Deployed early boiler, furnace, and air-conditioning rebates, demonstrating the ability to seamlessly integrate gas and electric initiatives.
- Offered special incentives to help customers overcome low-cost pre-weatherization barriers.
- Created the deeper-energy-measures offer to support customers seeking to super-insulate exterior walls, floors over a garage, or cathedral ceilings in retrofit applications.
- Convened the Contractor Best Practices working group forum to support regular communication between PAs, HES lead vendors, Independent Installation Contractors ("IICs"), and Home Performance Contractors ("HPCs"), resulting in several innovations and improvements, including a formal pricing-review process, support for training and marketing, and development of performance standards.
- Began evaluation of Efficient Neighborhoods +® and review of Renew Boston field trial to better understand how to increase access and secure savings for moderate-income residential customers and renters.
- Supported education of the builder market and promotion of efficient building practices, resulting in the average tier three (highest incentivized level) new construction homes achieving 50 percent savings, with some builders going all the way to net zero.
- Led the efficiency industry with deployment of the Multi-Family High Rise path in new construction, integrating Commercial and Industrial program expertise and Residential program expertise on the Joint Management Committee.

3. New and Innovative in 2016-2018

The focus for the residential programs in this next Three-Year Plan is to capitalize on growth and enhancements made in 2013-2015 through targeted optimization efforts for program delivery, marketing, and new technology deployments. The PAs are using the following six high-level principles to prioritize and deploy program innovations in the 2016-2018 Plan:

- Streamline the customer experience where possible.
- Maximize integration and cross-promotion between programs and among initiatives.
- Increase the use of technology and information tools to put customers in charge of their energy use.
- Adjust rebates and incentives to support energy savings, cost efficiency, and cost effectiveness goals.
- Increase customer awareness to continue increasing customer participation.
- Leverage and protect the robust energy-efficiency workforce built over the past two plan periods, while taking steps to grow the existing workforce via training/outreach.

Each program core initiative is described in detail below. For each core initiative "New Enhancements" are outlined in detail.

Carefully considering the wealth of interesting ideas brought forward—whether from internal PA processes, from EM&V studies, from the Council Workshops and the resulting recommendations, or from other stakeholders and partners—has resulted in a rich set of program enhancements.

New in 2016-2018

- **Renter visit**
- **Moderate income offer**
- **New construction path to zero**
- **Performance path for high rise multi-family new construction**
- **Home automation field trials**
- **Multi-family project point of contact**

Enhancements in 2016-2018

- Deep review of the customer experience, investigation of online/digital options
- Broaden adoption of wireless enabled thermostats
- Increase adoption of LEDs for phase out of CFLs
- Exploration of behavioral initiatives leveraging near-real-time electric consumption feedback
- Continued focus on market segmentation
- Continued offer of training subsidies for HPCs and IICs
- Continued review of upstream delivery models

This dialog during the planning year, combined with rigorous application of the six principles above, has spurred planning for the introduction of a possible breakthrough—**a renter-specific visit**. The PAs will offer a program enhancement that provides effective screening and direction of renters to a specially designed home visit that is tailored to renter opportunities and constraints. The PAs see the potential for a well-designed renter visit to increase participation of both renters and landlords in HES offerings. The renter visit will focus on installation of instant savings measures such as LED bulbs, advanced power strips, and water saving devices, and inform the customer of other appropriate opportunities for renters. In addition, the renter visit will allow for the collection of key information to help PAs follow up with landlords. The renter visit is detailed under the HES initiative description. The PAs will launch the effort in Q1 2016 and closely monitor, review and refine over the Plan term to ensure it succeeds in securing additional savings. The PAs believe the renter visit shows real promise and can present another opportunity for Massachusetts to be at the forefront of national efficiency program design.

The renter visit is by no means the only enhancement to respond to the Council's and PAs' shared commitment to ensuring all customers are supported in realizing energy-savings opportunities. The Council workshops and resolutions helped to crystalize the need for continuity with the Low-Income programs and the need for a streamlined channel of entry and delivery for customers, regardless of income. PAs want to minimize customer confusion and avoid adding complicated layers and channels for program participation. The PAs are committed to optimizing the customer experience and connection points through the existing market rate HES initiative and the Low-Income program.

The PAs will offer a program enhancement to ensure that moderate income customers, from 61-80 percent of state median income, whose homes have weatherization opportunities, can be better supported. PAs are exploring an opt-in solution for an enhanced incentive for income qualified moderate income customers. This approach would ensure that customers remain in control of the process while targeting additional financial support to enable them to realize energy-efficiency opportunities. PAs will work closely with LEAN and our Low-Income vendors to ensure that customers falling into this income band are served effectively. Customers who seek Low-Income services but are determined by the Low-Income program to be fall above the qualification limit will be able to use the documentation to qualify for the moderate income incentive.

The continued evolution and optimization of the Multi-Family Initiative is another example of a significant program enhancement envisioned for the 2016-2018 Plan where PA and Council priorities closely align. PAs share the Council's objective to improve the customer experience and specifically to provide customers with a single point of contact. For 2016-2018, the PAs are planning to assign a single project-level lead contact. Under the enhanced program design, customers will have a project point of contact ("PPC"). The PPC will be the designated agent or lead vendor identified by the PA responsible for efficiency measures for the primary heating fuel. The PPC will support customers through the full program delivery path, coordinating efficient delivery of applicable measures.

The PAs are also moving forward with the Council recommendation to track and report Multi-Family commercial and residential meter savings separately. The PAs look forward to seeing how this information may illuminate new understanding and opportunities for further program enhancements.

The PAs will continue to coordinate on the best tactical approaches for implementing these new enhancements. Much of the planning for these enhancements has been completed. The renter visit and the moderate income offer are set to be available to customers in Q1 2016. The addition of a clear project point of contact in the Multi-Family Retrofit core initiative will be integrated within the first half of 2016. Fully realizing the promise of these strategic enhancements will entail work that continues well into the future, in a cycle of continuous review and refinement.

Additional enhancement highlights include:

- Conduct a deep review of the customer experience to identify opportunities for increased streamlining, improved timing and simplified content of customer information to more effectively influence customers to take action. This will include investigating digital and online options for customers and exploring enhanced follow-up strategies to track and reach out to customers at key moments, helping them pursue deeper and/or additional measures.
- Explore the inclusion of home-automation technologies across residential programs. Deploy new construction field trials in the 2016-2018 Plan. Depending on results, integrate home-automation technologies into the residential new-construction program design.
- Evaluate PA opportunities to leverage home-automation technologies, including eligible wireless enabled thermostats and their associated communication tools, as well as other custom engagement tools for behavioral messaging. Continued review of opportunities to incorporate behavioral-science-based messaging into existing program marketing and customer-engagement efforts.

- Expand efforts to increase adoption of LED bulbs and fixtures into the marketplace and phase out CFL bulbs. PAs will also explore lighting controls as a possible initiative-expansion measure.
- Explore offering behavior initiatives that have the potential to provide near-real-time electric consumption feedback via a mobile-based application (in addition to traditional web-based or paper reporting). Some PAs may research what potential exists to tie in home automation and smart appliances and other controls where applicable.
- Promote value of net-zero and renewable-ready measures to builders through marketing, education, and training.
- Explore creation of a "Path to Zero" option for the top tiers of the Residential New Construction performance path.
- Shift to a performance path for the Residential New Construction high rise multifamily initiative.
- Continue to improve the multi-family customer's single-point-of-contact experience, leveraging and expanding from the success of the MMI model to further support customers with project-level single-point coordination through a designated project point of contact ("PPC").
- Continue to seek to understand and delineate moderate-income and renter markets and explore solutions for clearly defined segments.
- Offer a renter specific visit to HES customers beginning in Q1 2016. A Whole Building Incentive will be offered in parallel to encourage landlords to participate in building enrollment.
- Offer moderate income HES customers the opportunity to qualify for an increased incentive(s) when income is a barrier to proceeding with identified weatherization opportunities.
- Support the continued development of highly qualified HPCs and IICs by continuing to offer training subsidies for workforce-development needs such as technical skills, business skills, and sales trainings. PAs will also continue active dialogue with HPCs and IICs through the Contractor Best Practices working group to support program quality and growth.
- Continue to review and monitor opportunities for upstream program models. The PAs will continue to coordinate with C&I team and work with manufacturers and distributors to identify potential approaches.

4. <u>Contractor Engagement</u>

The PAs are committed to working effectively with contractors, and to ensuring that contractors perform in accordance with rigorous quality and safety standards for the benefit of customers and deliver savings effectively. In accordance with the Term Sheet, the PAs will be active participants in a new contractor engagement effort. This effort is described in the Term Sheet as follows:

The Council and the PAs recognize that the successful implementation of the Three-Year Plan requires an engaged contractor community. The PAs and the Council will collaborate to identify opportunities to continue to maximize the impact of the contractor community in order to maintain high quality, cost-effective/efficient, high impact programs and increase penetration and success in new sectors. As part of this effort, the PAs will participate in a new Residential Contractor engagement effort to be convened by the DOER. PAs will participate in residential program related topics as appropriate, which may include how residential program contractors can be most effectively engaged in the programs, quality assurance/quality control related topics, appropriate data collection and analysis, and suggestions from the contractor community and the PAs for enhancements and improvements. This DOER effort is not in replacement of the ongoing contractor Best Practices group and does not constitute the formation of a new regulatory or adjudicatory body. The PAs will continue to have the right and responsibility to require contractor engagement and contract terms that protect customers consistent with their corporate/institutional quality and safety standards.

5. Residential Program and Core Initiative Descriptions

a. Residential Whole House: Residential New Construction

RESIDENTIAL WHOLE HOUSE	**CORE INITIATIVE** **RESIDENTIAL NEW CONSTRUCTION**
Overview & Key Objectives	The Residential New Construction core initiative strives to increase the construction of energy efficient homes that exceed the Massachusetts User Defined Reference Home ("UDRH"), a baseline determined by assessing the efficiency of homes across the state. Through support for builder and market acceptance of high efficiency design, the initiative has increased market penetration of high performance homes and residential technologies in the market. **Target Market:** All residential new construction projects in the Commonwealth are encouraged to participate in the initiative. The initiative has a Low Rise path targeting single and multi-family projects under three stories and a High Rise path designed for residential buildings of four stories and above.
	New Enhancements: • Explore the addition of home automation technologies in new construction. Deploy field trials in the 2016-2018 Plan.

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	Depending on results, integrate home automation technologies into the residential new construction program design. • Transition the High Rise path to a performance path in 2016. • Explore a "Path to Zero" option for the top tiers of the performance path. • Increase promotion of the value of net zero and renewable ready measures to builders through marketing, education and training. • Continue to examine "pay for savings" models as a strategy to promote builders pursuit of deeper incremental energy savings levels, beyond the current tiered performance path cut-offs.
Core Initiative Design	**Measures Promoted:** Builders are encouraged to improve a building's energy efficiency through enhanced envelope measures, energy efficient space and water heating, appropriately sized cooling equipment, wireless enabled programmable thermostats, ENERGY STAR® qualified appliances, WaterSense® plumbing fixtures, efficient lighting and controls, and proper mechanical ventilation. Builders are also encouraged to properly orient homes to take advantage of passive heating and cooling. The Low Rise option offers a prescriptive path with two bundles and a performance path with incentives tied to tiered savings levels. The prescriptive path for Low Rise supports savings achievements over the UDRH. The High Rise option has offered a prescriptive in-unit package, a whole building prescriptive package and a whole building custom option (performance path). PAs will transition the High Rise option to a performance path in 2016. All homes participating in the initiative are required to install efficient lighting products in appropriate hard wired sockets and pass a final verification inspection. **Implementation Strategy:** The Residential New Construction core initiative's primary objectives are to provide builders and other allied professions with training, targeted incentives, and associated technical assistance to increase adoption of high efficiency technologies and construction practices in the residential market. PAs further support the adoption of efficient technologies and construction practices by broadly marketing the value

RESIDENTIAL WHOLE HOUSE	**<u>CORE INITIATIVE</u> RESIDENTIAL NEW CONSTRUCTION**
	of high efficiency homes to consumers and other key decision makers and influencers in the residential new construction market. A recent program impact evaluation has confirmed the strength of the program's approach, and identified the initiative as a market-leading program, which is defining best practices for the nation. The current core design elements have been demonstrated to be highly effective in gaining program participation and savings as well as more broadly driving efficient building practices. The evaluation also documented substantial spillover effects based on the initiative's success in driving market adoption of efficient building practices in new residential construction beyond direct participants seeking program incentives. Massachusetts PAs are amongst the earliest to offer a comprehensive Residential New Construction initiative and recognized early the challenges in serving the larger multi-family and mixed-use new construction sector. The successful deployment and continued refinement of this pioneering path for high rise and mixed-use residential new construction was a highlight of the 2013-2015 Plan accomplishments. The initiative is recognized for leading the program design nationally for this sub-sector. The US Environmental Protection Agency, the Department of Energy Better Buildings Program, and multiple other state efficiency programs are currently engaged in efforts to promote or emulate this model. The PAs will transition to a performance only path for the High Rise buildings. This will include common statewide modeling software, outreach and training on the new path, and evaluation to provide a smooth transition in 2016. The PAs will explore a "Path to Zero" option for the top tiers of the performance paths. The enhancement is envisioned to recognize new construction homebuilders for achieving both a high energy efficiency standard as well as the potential incorporation of renewable energy building features. The PAs plan to continue to deliver in-depth trainings to builders, architects, and others engaged in new construction to support high efficiency new construction. Historically, trainings have included technical topics such as the fundamentals of building science, energy codes, and the latest emerging technologies. PAs also support workforce development efforts to help ensure a robust and well-trained community of partners. The combination of builder training, targeted incentives, associated

RESIDENTIAL WHOLE HOUSE	**<u>CORE INITIATIVE</u> RESIDENTIAL NEW CONSTRUCTION**
	technical assistance, and targeted outreach all support enrollment in program offerings. Home Energy Rating System ("HERS") raters play a critical role in recruiting builders to enroll projects in the Low Rise path. HERS raters have the ability to directly enroll projects into the program via an online intake tool. Account managers, from the lead vendor work directly with larger developers and builders to enroll them in the High Rise path. The PAs will strive to retain existing participating builders and recruit additional developers, homebuilders, and contractors. The PAs will continue to provide targeted trainings on critical technical topics and techniques for achieving high energy savings in quality durable housing. For the Low Rise path, the PAs will continue working with the HERS infrastructure. In the High Rise path, the Joint Management Committee ("JMC"), including residential and commercial new construction technical experts from PA staff and the lead vendor, will continue to assist in defining performance targets, including setting performance path tiers, establishing incentive structures, recruiting developers, completing energy analysis, and providing technical guidance on energy efficiency construction practices.
Delivery Mechanism	PAs administer the initiative through a joint, competitively bid, statewide implementation vendor. The PAs have a residential working group of residential sector experts from each PA to oversee the implementation strategy with the lead vendor. The JMC, comprised of PA staff from both the residential teams and the commercial and industrial teams, oversees the implementation of the High Rise path. The lead vendor provides the direct field implementation. The vendor is principally responsible for development and deployment of training, education, and outreach efforts as well as tracking and reporting program activity to each PA. The lead vendor also has principal responsibility for recruiting and enrolling projects. In addition, many PAs maintain additional account representative and field personnel that support project recruitment and maintain relationships with the target market and allies. HERS raters, as noted above, play a key role in the Low Rise path for recruiting and enrolling projects. Incentives are directly tied to a home's modeled energy performance or installed prescriptive measures,

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	and all participating homes must pass a final verification inspection. The PAs will continue to work with the market-based network of trained contractors who offer energy efficiency and rating services to homebuilders.
Marketing Overview	The initiative markets to a wide variety of partners engaged in the residential new construction process. The primary target of outreach is to the homebuilders, developers, and contractors who directly participate in program offerings. PAs also provide outreach to the associated market actors that interact with program participants, such as architects, designers, and trade allies. A third critical focus on initiative marketing is directed at key decision makers and influencers in the residential real estate market including homebuyers, realtors, code officials, appraisers, and mortgage bankers. This multi-pronged strategy guarantees that at each touch point in the new home construction and delivery process, PAs build awareness and demand for high efficiency homes and provide potential participants clear and easy access the residential new construction offerings. The new construction market is continuously evolving. The PAs are therefore continuously monitoring the market for key opportunities to engage market actors and promote efficient building practices. PAs have utilized multiple routes to engage key market actors including trade shows, builder trainings, lumber yard outreach, and strategic partnerships with targeted regional and national associations including the Home Builder Associations, Massachusetts Chapter of the US Green Building Council, The Boston Society of Architects, Youth Build and Northeast Sustainable Energy Association. The HERS rater community also continues to be a strong partner in helping to engage and educate builders about the programs. Recent work with the City of Boston and through the PAs' codes and standards efforts has offered additional opportunities to explore partnering with local building departments and other municipal programs to market offerings at critical moments when new construction is in a planning or permitting stage. Although not a requirement for participation, the initiative promotes participation in the national ENERGY STAR® Homes program and as a partner benefits from the regional, as well as national, advertising efforts that ENERGY STAR® Homes implements.

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Three-Year Deployment Strategy/Roadmap	For the 2016-2018 term, the program will concentrate on continuous improvement to processes and exploration of targeted additions. The Residential New Construction initiative will continue to pursue efforts that aim to achieve both deeper savings and gain broader market penetration. A critical focus will be on ensuring the breadth and depth of the initiative's reach into the developer and builder communities with high quality trainings and an optimized experience for builders and home owners participating in program offerings. In 2013-2015, the program continued to see increased participation in the Low Rise tiered performance path and a corresponding decrease in participants utilizing the prescriptive path. In addition, it was noted, participants in the performance path kept closely to the tiered savings markers. Although the tiered approach is successful, the PAs continue to explore whether a "pay for savings" initiative might capture additional savings. PAs have begun evaluation of modeling software to allow full transition of the High Rise path to a tiered performance path and anticipate a smooth transition in 2016. Another success of the performance path has been that multiple builders in the highest performance tier are including renewable ready elements along with super-efficient designs and construction resulting in homes that achieve net zero or net zero ready status. The PAs have already begun to share these success stories and promote the approaches used in training and education offerings and through marketing. PAs will review these successes as they explore offering a "Path to Zero". The Residential New Construction core initiative plans, as early as possible, to include advances in high efficiency home measures determined to be cost effective. Field trials for home automation technologies will be a focus of exploration, with an eye toward potential inclusion of proven measures. The Residential New Construction core initiative will continue to review the participant experience and identify mechanisms for increasing the ease and fluidity of the system. The program is continuing to explore how to leverage information technology to increase ease of access to technical information and support for partners and customers.

b. Residential Whole House: Residential Multi-Family Retrofit

RESIDENTIAL WHOLE HOUSE	**CORE INITIATIVE** **RESIDENTIAL MULTI-FAMILY RETROFIT**
Overview and Key Objectives	The Multi-Family Retrofit core initiative provides comprehensive energy efficiency services to market rate* properties with five or more dwelling units. The initiative offers energy assessments that identify energy savings opportunities throughout the facility. An Energy Action Plan ("EAP") is developed for each facility, identifying all energy efficiency opportunities regardless of fuel source. Historically, this initiative has provided incentives for cost effective gas and electric measures. The PAs anticipate the addition of oil measures and other deliverable fuels, pending issuance of updated RCS regulations. Incentives include (but are not limited to) lighting, shell improvements, heating, cooling, and water heating equipment and controls. The Multi-Family Retrofit core initiative is part of an emerging set of relatively new efficiency program designs across the nation working to serve this unique building sector. The Massachusetts program is a leading national model that meets a majority of the best practices outlined by ACEEE. The PAs plan to continue to refine the initiative through significant new enhancements in the 2016-2018 term. A program impact evaluation is currently in progress, which will influence PAs ultimate program enhancement and design adjustments. **Target Market:** The target market for this initiative is market rate residential multi-family facilities with five or more dwelling units on a property. The Multi-Family Retrofit core initiative can address unique circumstances associated with mixed-use buildings. The low-income multi-family market is served through the Low-Income Multi-Family Retrofit core initiative. *(*i.e.*, 50 percent or more of units are market rate)
	New Enhancements: Massachusetts has pioneered a dedicated approach to the multi-family sector and has engaged in continuous improvements over the past two three-year planning cycles. During the 2010-2012 term, the PAs established the Multi-Family working group, integrated gas and electric measures, and introduced the MMI, a vendor supported call center which supports customer enrollment in connection to PA multi-family offerings. During the 2013-2015 term, the PAs added C&I representation to the Multi-Family working group, expanded HEAT

RESIDENTIAL WHOLE HOUSE	**<u>CORE INITIATIVE</u> RESIDENTIAL MULTI-FAMILY RETROFIT**
	Loan availability to residentially metered condominium owners, and successfully added in-unit direct install measures. The PAs rolled out the Multi-Family EAP in January 2014, further integrating all efficiency opportunities into a comprehensive customer-facing document. For the 2016-2018 cycle, the PAs will continue to focus on enhancing measure offerings and streamlining customer experience. Strategies to achieve deeper savings include: • Provide a single point of contact for measure delivery. The designated PPC will aid in streamlining the customers experience on the delivery side of the process, building off the success of the MMI model. In most cases, the PPC will be the designated agent or lead vendor identified by the PA responsible for the efficiency measures for the primary heating fuel.* • Incorporate additional emerging technologies. Ongoing throughout program years 2016-2018. • Continue to improve multi-family target marketing and education through groups such as landlords, building management, building operator trade associations, landlord associations, condominium associations, and other organizations and professionals involved in regular interaction with this unique hybrid market. Ongoing throughout program years 2016-2018. • Continue to focus on coordinating the residential multi-family and commercial initiatives through the joint participation on the Multi-Family working group of Residential and C&I program management staff and vendors, working together to streamline delivery of packaged, comprehensive energy efficiency services to the multi-family sector. *(For very large multifamily buildings PAs may continue to utilize Account Executives as the PPC.)
Core Initiative Design	**Measures Promoted:** The measures available to each property vary based on unique building characteristics/constraints but may include: • Insulation for attic, wall, basement, pipe, rim joist (in-unit, common areas)

RESIDENTIAL WHOLE HOUSE	CORE INITIATIVE RESIDENTIAL MULTI-FAMILY RETROFIT

	• Air sealing
	• Domestic hot water equipment (in-unit)
	• Heating equipment (in-unit)
	• Light fixtures (common area/exterior)
	• Instant savings measures (in-unit) typically include:
	  o Energy efficient light bulbs and nightlights
	  o Light fixtures
	  o Programmable and wireless enabled thermostats
	  o Faucet aerators
	  o Low-flow showerheads
	  o Smart strips
	Because multi-family buildings may contain residential and/or commercial metering, and include building level systems more traditionally found in commercial facilities, there are a number of measures more commonly found in the C&I Retrofit program. These C&I measures may include:
	• HVAC high efficiency equipment upgrades and controls
	• Variable speed drives, motors
	• Chillers
	• Air compressors
	• Water heating equipment
	• Energy management systems
	• Custom measures
	The Multi-Family Retrofit core initiative offers the residential 0% HEAT Loan to residentially metered condominium owners residing in facilities with five or more dwelling units on the property.
	Implementation Strategy:
	The PAs strive to deliver a comprehensive energy efficiency offering to participants, regardless of fuel type, service territory, or rate class. An integral part of the initiative's design involves the services of the MMI, who provides a single point of contact at intake. The newly created role

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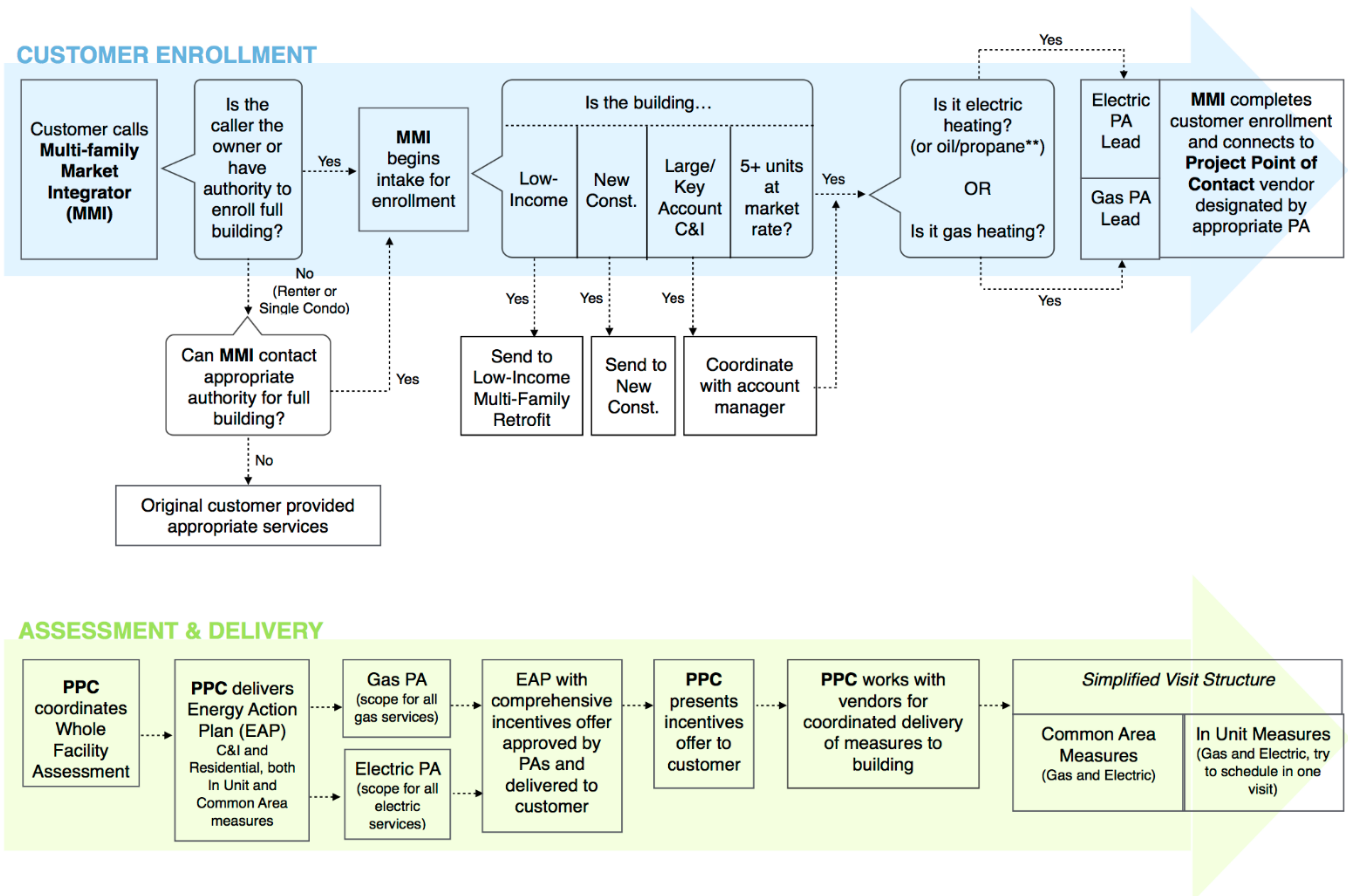
	of PPC will be responsible for managing the program delivery path, coordinating efficient delivery of applicable measures, and clearly tracking all measures and incentives regardless of meter type. The goal is to provide a seamless customer experience, mitigate potential customer confusion, and minimize or eliminate lost opportunities.



**conditional on approval of RCS regulations.

RESIDENTIAL WHOLE HOUSE	**CORE INITIATIVE** **RESIDENTIAL MULTI-FAMILY RETROFIT**
Core Initiative Design, cont.	Enrollment: The diversity of facility types, ownership, and management structures within the multi-family market, and the variety of actors involved, requires multiple points of entry for intake into the initiative. Participants may enroll via telephone or their request for services may be initiated by other market actors, such as a PA's Account Executive, or a referral from another PA initiative, contractor, consultant, or engineer. Regardless of point of entry, all participants will only need to contact one party to avail themselves of comprehensive services. Once the MMI is made aware of a project (either via telephone or lead from another market actor), he or she reviews the information provided, makes the initial contact with the customer, and collects further information, as needed, to complete screening and enrollment. Participant Screening: The MMI uses a screening process to obtain key information to identify projects and optimally dispatch resources to support customer participation in the initiative. During the initial discussion with the potential participant, the MMI will gain a better understanding of the end uses available for treatment and the motivations that drove the potential participant to solicit energy efficiency services. The MMI will explain the initiative's offer of an assessment to identify all energy saving opportunities and the value of the resulting EAP. Once the MMI has ascertained that the potential participant fits the parameters to enroll in the initiative, the MMI will record the heating source type (electric, gas, or pending RCS regulation approval, oil or propane) and connect the participant with the PPC assigned by the appropriate lead vendor. Whole Facility Assessment The assigned PPC will proceed to coordinate the Whole Facility Assessment. Based on the outcome of the enrollment and screening process, the appropriate technical resources will be assigned by the PPC to conduct a whole facility, fuel blind assessment. The MMI will attempt, through the screening process, to identify all resources required for the assessment. In the majority of cases the PPC will be able to deliver all assessment activities. However, there may be instances where additional expertise is required and additional custom technical

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	assessments, benchmarking, and engineering studies will be coordinated. Proposal for Energy Efficiency Services Using the findings from the site-specific assessment, the PPC will draft an EAP, including all applicable energy efficiency opportunities, both residential and commercial (in-unit and common area measures). The EAP can provide participants with a road map to implement energy efficiency upgrades. The PPC will present the comprehensive offer to the customer, outlining all measures and services eligible and approved by both the gas and electric PAs for incentives, and assist the customer in fully understanding the opportunities. The customer then selects which measures they wish to implement. Delivery of Measures and Services The PPC will coordinate the delivery of the measures and services requested and agreed to by the customer. To the extent possible, all dwelling unit measures will be installed in a single visit to minimize disruption for the tenants; however, multiple visits may be required for the installation. The Multi-Family Retrofit core initiative will continue to integrate with the C&I initiatives for applicable measures and services for seamless delivery to the customer. Quality Assurance PAs contract with a third-party Quality Assurance/Quality Control (“QA/QC”) vendor to perform inspections on a select percentage of projects. The QA/QC vendor provides valuable information and feedback on successes and identifies areas of possible program improvement. These inspections are complementary to the final inspections performed by the implementation vendors of their subcontractors. Additional Core Initiative Design Elements A link to the current EPA Benchmarking tool (Portfolio Manager) is included on the website page(s) associated with the Multi-Family Retrofit core initiative. This supports building owners/managers in assessing the energy efficiency of their buildings against comparable facilities. EPA Portfolio Manager is a publicly available and free tool accessible to all property owners. PAs have supported data upload

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	through the green button initiative and have extensively coordinated with disclosure efforts such as the Boston Energy Reporting and Disclosure Ordinance to support customers' ease of access to benchmarking and compliance with reporting requirements. The PAs recognize that proper training for building operators and maintenance staff is a key factor in ensuring that expected savings are realized initially and persist over time. The PAs' C&I offerings include building-operator training to support customers in maintaining their efficiency gains through proper operations and maintenance. The PAs plan to explore expanding training events and opportunities as appropriate
Delivery Mechanism	The initiative will be administered cooperatively by the gas and electric PAs. Each PA is represented in the Multi-Family working group, which will continue to be responsible for oversight of the initiative and promote continuous improvement/best practices with regard to the multi-family market. The MMI, jointly contracted by all PAs, remains the key to the delivery of this fully integrated statewide Multi-Family Retrofit core initiative. The MMI, as described above under program implementation, is responsible for ensuring all customers are properly enrolled and directed to the appropriate program resources, including connection to the designated PPC. PPCs will be designated by each gas and electric PA. Individual PAs have contracts with lead vendors for services to multi-family facilities, contracts with additional specialty vendors and access to a variety of supplemental engineering and other services. The MMI helps ensure smooth coordination to optimize the services for each participating facility. PAs have revised their BCR models and internal tracking to provide distinct gas and electric Residential and C&I Multi-family measure lines.
Marketing Overview	**Strategy:** • Target market and industry actors. Messages may focus on, but are not limited to: lower energy and maintenance costs, more durable and comfortable building, enhanced property value, generous financial incentives, tenant retention, and

RESIDENTIAL WHOLE HOUSE	**CORE INITIATIVE** **RESIDENTIAL MULTI-FAMILY RETROFIT**
	environmental benefits for the community. • Continue to promote case studies for print and online media to help educate and market to facility owners. • Target landlord, building management, building operator trade associations, design professionals, and other organizations and professionals involved in regular interaction with multi-family facilities. • Continue to enhance the online user experience. • Continue to build on the MMI relationship with larger property managers to enroll complete portfolios of eligible sites. • Explore opportunities in industry newsletters to educate market actors such as engineers, realtors, landlord associations, architects, and/or property managers. Participate, as appropriate, in trade ally shows, such as realtor and multi-family property manager conferences.
Three-Year Deployment Strategy/Roadmap	The Multi-Family working group will continue to coordinate efforts through the MMI and incorporate the PPC, to ensure consistent implementation across the Commonwealth for the next three years. The Multi-Family working group will continually review and evaluate new applicable measures and technologies. PAs have already identified and broken out for tracking measures both by meter type (Commercial/Residential) and fuel type (Gas/Electric) in preparation for the coordination efforts to be led by the PPCs. The integration of PPC services into the Multi-Family Retrofit core initiative is set to roll out in the first half of 2016. The Multi-Family working group will continue to coordinate with the Residential and C&I Management Committees and the Low-Income Best Practices working group, while working across the residential and commercial sectors, to ensure consistency and support for an integrated initiative. Results of the current Multi-Family evaluation will also influence the program evolution in the coming plan years. PAs welcome continued dialogue with Massachusetts affordable housing stakeholders to evaluate opportunities to maximize the opportunity for capturing energy efficiency savings at the time of financing and refinancing of affordable housing properties. PAs have committed to engaging with these stakeholders to jointly explore and scope these opportunities via planning meetings. The PAs are excited

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	to learn from the experts within the Massachusetts Housing community about the timing, scope and processes of affordable housing finance and refinance, to share the PAs' technical resources and understanding on efficiency programming, and to work together to identify critical moments of potential opportunity in the finance and refinance process to secure additional savings. The PAs look forward to receiving additional and more specific information from the Massachusetts affordable housing stakeholders so that the PAs can explore opportunities to incorporate program design and implementation refinements that result from these dialogues within the 2016-2018 Plan term. In accordance with the Resolution, the PAs will continue to work with the Commonwealth's housing financing agencies and LEAN (with mutual expectations and deliverables) to develop and implement enhanced approaches to leverage multi-family refinancing events to maximize retrofit potential. The parties will specifically consider performance-based retrofit products. The PAs will present the results of these efforts and specific proposals derived from them by the close of Q1 2016.
Special Notes	

c. *Residential Whole House: Home Energy Services- Measures; Home Energy Services- RCS*

RESIDENTIAL WHOLE HOUSE	**<u>CORE INITIATIVE</u>** **RESIDENTIAL HOME ENERGY SERVICES – MEASURES** **RESIDENTIAL HOME ENERGY SERVICES – RCS**
Overview and Key Objectives	The Home Energy Services ("HES") core initiative provides residential customers, living in single family (1-4 unit) homes, energy efficiency recommendations and incentives that enable customers to identify and implement cost effective energy efficiency improvements. The initiative uses incentives, financing, outreach and education to make it easy, clear and compelling for customers to participate in residential energy efficiency programs. HES is a flagship initiative for the residential programs, and exemplifies a systems approach where all components work together to support customers in achieving deeper

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	energy savings. HES is fuel blind. Massachusetts's HES is a mature program with over 20 years of program delivery experience, including many refinements and expansions. The core initiative consistently delivers strong fuel blind energy savings while maintaining broad participation. The Massachusetts HES core initiative has the greatest reach of any whole home program in the nation, serving over 80,000 participants statewide in 2014 and continuing to grow. **Target Market:** HES targets all residents (home owners and renters) in single family and two to four unit buildings on a single property. HES is a market rate program serving non-low income residential customers. Low income customers (those under 60 percent SMI) are referred to appropriate low income programs.
	New Enhancements: The 2013-2015 Plan rolled out multiple new elements gradually over the three-year plan term, many of which are currently under evaluation. In the 2016-2018 Plan, PAs are focused on refining and expanding the successful elements begun in the 2013-2015 Plan, while avoiding elements or program redesigns that add complexity for customers and contractors. PAs plan to: • Conduct a deep review of the customer experience to identify opportunities for increased streamlining, simplifying and better targeting time and content of customer information to maximize the opportunity to influence customers taking action. This will include investigating digital and online options that improve the customer experience, and exploration of enhanced customer follow-up strategies that continue to track and reach out to customers at key moments, helping them pursue deeper measures and stay on track with open recommendations from their Home Energy Assessment ("HEA"). This is an ongoing effort. • Continue to seek to understand and delineate moderate income and renter markets and explore solutions for clearly defined segments. Beginning in Q1 2016, the PAs will trial a renter

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	visit and a moderate income offer enhancement, detailed below. • Support renter participation with a renter-specific visit beginning in Q1 2016. Customers will continue to be screened at intake, and an update is planned for the on-line audit tool to provide a clear path for renters. Customers for whom a full HEA may not be appropriate can schedule a renter visit. The renter visit will focus on installation of instant savings measures, high level screening for deeper measures, and follow up with landlords and other interested tenants. A Whole Building Incentive will be offered in parallel to encourage landlords to participate in building enrollment. • Offer moderate income HES customers the opportunity to be "qualified" for an increased incentive(s) when income is a barrier. The initial enhanced incentive is anticipated to apply to insulation, covering 90 percent of costs up to $3000. PAs will explore additional enhanced incentives, potentially including targeted appliance rebates and pre-weatherization barrier remediation, appropriate for qualifying customers. Each PA will monitor spending, customer interest, and savings from this trial offer in 2016, and adjust implementation accordingly for 2017-2018. • Investigate incorporation of additional cost effective new technologies and measures, including sealing and insulation for ducts, early clothes-washer turn-in rebates, and broader implementation of Wi-Fi thermostat installations. PAs will work with the evaluation team to review mechanisms to reduce the time between technology review and deployment. • Support the continued development of highly qualified HPCs and IICs by continuing to offer training subsidies for workforce development needs such as technical skills, business skills, and sales trainings. PAs will also continue active dialogue with HPCs and IICs through the Contractor Best Practices working group to support program quality and growth. • Explore improvements in tracking across programs for measure implementation originating from an HEA.

RESIDENTIAL WHOLE HOUSE	**<u>CORE INITIATIVE</u> RESIDENTIAL HOME ENERGY SERVICES – MEASURES RESIDENTIAL HOME ENERGY SERVICES – RCS**
Core Initiative Design	**Measures Promoted:** Customers receive a ***Home Energy Assessment ("HEA")***, an in-home visit. During the HEA, the Energy Specialist will: • Install instant energy saving measures at no cost to the customer, which may include ***LED bulbs, compact fluorescent light bulbs, faucet aerators and showerheads, programmable thermostats, and advanced power strips.*** • Provide recommendations on ***weatherization, including air sealing and insulation***, qualifying customers for instant incentives for these measures delivered by HPCs or IICs. • Provide recommendations and connections to ***heating, cooling, water heating equipment, and other qualified efficient product rebates***). • Provide connections to the HEAT Loan offers zero percent interest financing of loans from $500-$25,000 with terms from 2 to 7 years to approved customers for qualified measures PAs will work with the MTAC to include new measures or technologies as appropriate. For the renter-specific visit, the PAs plan to provide: • Installation of instant energy savings measures at no cost to the customer, identical to instant savings measures offered through an HEA. • Refrigerator screening, high-level visual inspection of possible weatherization opportunities, and review the heating system for potential rebates. • Information on deeper measures that could be installed with landlord approval. PAs plan to develop marketing materials specifically tailored to renters. **Implementation strategy:** <u>The HEA Visit:</u> The primary entry into HES is the HEA, an in-home visit that includes a variety of diagnostic testing and offers installation of instant energy savings measures. The HEA also provides education and direction on additional energy saving opportunities, rebates, and connection to

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	appropriate service providers. Customers schedule an HEA through a dedicated statewide toll free number. The Mass Save® marketing collateral and website, including the recent addition of the online energy assessment portal, supports customers accessing an HEA. The online assessment tool also helps any customers who may not benefit from an in-home visit to follow up with additional appropriate offerings. The HEA is a single comprehensive in home assessment. The HEA allows customization at the household level, ensuring the program delivers cost effective personalized energy saving recommendations on incentives while serving a broad market of customers in a variety of housing types. The HEA provides customers with specific energy efficiency education and identifies their unique opportunities for energy saving installations. With the customer's permission, efficient lighting is installed at no cost in all appropriate locations, as are the other instant savings measures (as needed and qualified). The instant energy savings from directly installed measures during the HEA are intended, on average, to exceed the expected average cost to deliver this visit. The HEA may include a variety of diagnostic techniques such as infrared scanning (temperature permitting) and combustion safety testing. A critical focus is to identify opportunities for thermal savings from air sealing and insulation. The HEA will include scoping of air-sealing and insulation work and support customers' to pursue implementation of measures. This support includes connection to appropriate contractors and information on the HEAT loan. At this stage of the HEA, customers with identified weatherization opportunities will be presented with information on the potential to qualify for an enhanced incentive if income is a barrier to completing weatherization savings measures. The Energy Specialist will provide direction to customers on how to verify that they meet moderate income criteria (61-80 percent SMI). Customers referred to the HES program from the Low-Income program, due to incomes above the low-income threshold, will be able to use the Low-Income program screening to document qualification for the moderate income enhanced incentive (to the extent that their screening documents income in the moderate income range) and not require further income verification. Two groups of participating contractors, HPCs and IICs provide installation of weatherization measures. A more detailed description of

RESIDENTIAL WHOLE HOUSE	**<u>CORE INITIATIVE</u>** **RESIDENTIAL HOME ENERGY SERVICES – MEASURES** **RESIDENTIAL HOME ENERGY SERVICES – RCS**
	the differing roles of each type of contractor is provided under Delivery Mechanism, below. Customers are always free to choose their preferred qualified participating contractor. Regardless of weatherization contractor type, full installation of targeted cost-effective air sealing is provided at no cost to the customer. Insulation work is similarly provided with an instant incentive; however, there is a customer co-pay and incentive cap. The enhanced moderate income incentive increases the amount of the incentive, reduces the co-pay, and increases the incentive cap for qualifying customers When the customer elects the fully subsidized air sealing offer or insulation installation, a blower door test and combustion safety test will be performed pre and post installation to measure air leakage reduction and ensure combustion safety standards. If specific energy efficient improvements require professional contractors, the Energy Specialist explains the contractor services required to install recommended measures. If the improvements require a customer contribution, the Energy Specialist provides information on available incentives and rebates. <u>Special Visits:</u> A special home visit may be scheduled for those customers interested in screening to determine incentive eligibility, a targeted visit such as a boiler screening, or in response to a specific request/concern. An Energy Specialist will perform an assessment of the home addressing the specific concern and/or screening a specific measure (*e.g.*, boiler) and install instant savings measures (where appropriate). A customer may be scheduled for a special home visit as determined during the initial intake process. <u>The Renter Visit:</u> The PAs will trial a renter visit, which is a modified HEA, offering a level of service better tailored to renters. Many renters are not in a position to participate in or influence adoption of weatherization measures for their units. The renter visit will focus on installation of instant savings measures and provide information on rebate opportunities appropriate for renters. The renter visit will be shortened by exclusion of the many diagnostic tests and inspection elements of the

RESIDENTIAL WHOLE HOUSE	**<u>CORE INITIATIVE</u>** **RESIDENTIAL HOME ENERGY SERVICES – MEASURES** **RESIDENTIAL HOME ENERGY SERVICES – RCS**
	full HEA. The renter visits allows a more streamlined delivery system to provide instant savings measures to renters. PAs see the potential for a well-designed renter visit to increase both renter and landlord participation in HES offerings. The renter visit will allow collection of key information for follow up with landlords, including a refrigerator screening, a high level visual inspection of possible weatherization opportunities and review of the heating systems for potential rebates. Energy specialists delivering the renter visit will also seek to collect landlord and other interested tenant information (if not already provided through intake or the online audit tool). PAs hope that renters with positive experiences can help secure the participation of their landlord and fellow tenants. The site specific information on potential opportunities provided by the high level visual screening for weatherization and heating system opportunities will help tailor messages for landlord enrollment in HES offerings. PAs are also planning to add a Whole Building Incentive for additional support for 2-4 unit building owners to move forward with full weatherization of the entire property. Deployment of a renter visit may also help to increase cost effective program delivery by providing the right level of service at a reduced delivery time and cost. Triaging customers in this way may also help vendors providing HEAs to effectively concentrate on customers who can convert to deeper measures.

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The Program Administrators plan to offer the following (as appropriate).

	Renter Visit	HEA Visit
Instant Savings Measures	• LEDs • Low flow showerheads • Faucet aerators • Smart strips • Programmable thermostats	• LEDs • Low flow showerheads • Faucet aerators • Smart strips • Programmable thermostats
Assessment	• Refrigerator screening • High-level visual inspection for weatherization opportunities • Quick review of heating system	• Infrared scanning • Combustion safety testing • Identify weatherization opportunities (air sealing and insulation) • Recommendations for heating, cooling, water heating equipment
Collateral	• Renter specific rebates • Tailored collateral	• Rebates • HEAT Loan information • Standard collateral

<u>Quality Assurance Visits:</u>

A quality assurance visit allows weatherization work to be inspected to ensure the work is completed to the core initiative's standards. This may be done through a combination of methods, including a phone survey, postcard, email, or actual site visit by the lead vendor and/or a third party PA-approved vendor. Quality inspections are performed to ensure that contractor installed measures are accurate, professional, and safely and properly installed based on statewide material and installation initiative standards, as well as to ensure savings. On site

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	quality inspections are crucial to sustaining the impressive saving realization rates Massachusetts has experienced. The quality inspection visits provide valuable peace of mind for participants, as well as create the objective feedback loops that allow participating contractors to provide their employees with the training that assures continued high quality service delivery for Massachusetts rate consumers.
Delivery Mechanism	The program is delivered by PA-specific lead vendors selected through a competitive procurement process. Lead vendors are available, and required by contract, to provide services to any eligible customer. This ensures that all eligible Massachusetts customers, regardless of PA territory will have access to HES services. Lead vendors are also responsible for a multitude of program delivery elements including managing and training participating contractors such as the participating IICs and HPCs. Additional lead vendor responsibilities include intake via the statewide toll free number, customer eligibility screening, customer education, recruitment and follow-up, customer satisfaction and achievement of aggressive savings, administration of the HEAT loan, development and deployment of consistent statewide training, data invoicing, tracking and reporting, licensing approved energy modeling software at no cost to participating HPCs, developing and enforcing quality control standards for all participating contractors, scheduling requirements, maintenance of and reporting on health and safety information, technical assistance to customers, participating contractors and other market actors, management of multiple contractual relationships with IICs and HPCs, assistance in evaluation studies, management of performance rating systems for IICs and HPCs, and participation and collaboration in the Best Practices working group. In the original HES model, the lead vendor provided the HEA and coordinated comprehensive delivery of weatherization measures through direct sub-contractors. The new model requires lead vendors to enter into participation agreements with any qualified IIC and distribute weatherization projects via a merit based allocation system. HPCs were phased into the program in the 2013-2015 three-year plan. The promise of including the HPC track which can independently recruit customers, provide HEAs, and implement weatherization measures, was to open the market to additional providers who could drive more and different customers into the program. In order to receive incentives or rebates, customers are required to have

RESIDENTIAL WHOLE HOUSE	**<u>CORE INITIATIVE</u>** **RESIDENTIAL HOME ENERGY SERVICES – MEASURES** **RESIDENTIAL HOME ENERGY SERVICES – RCS**
	an HEA through either the PAs' lead vendor or via a participating HPC to identify and prioritize all cost effective energy efficiency upgrades. The initiative continues to implement "set" pricing, developed in conjunction with the Council and the Council consultants. The set pricing model provides certainty regarding *cost effective* energy efficiency upgrades for customers, contractors, and PAs alike. This prevents claims of price gouging by customers, provides ease of participation (*e.g.*, no requirement of the customer to solicit multiple bids) and helps generate and support further business within the market. Set pricing also allows contractors and PAs to plan more efficiently and ensure the total resource costs remains cost effective. Without set pricing the HEA could not result in the production of an executable weatherization contract for the customer, which is a very unique and valuable program design within the Massachusetts HES core initiative. All participating contractors must meet program eligibility requirements. HPCs independently recruit customers of their choice, provide the HEA, and implement weatherization measures. HPCs also have the opportunity to engage the customers they serve in additional turnkey energy efficiency services offered by their respective company (*e.g.*, heating upgrades, etc.) as ancillary services. IICs provide installation of weatherization measures for those customers who received an HEA from the lead vendor. IICs also have the opportunity to independently recruit customers who have identified weatherization opportunities and refer them to the lead vendor for the HEA. If an Energy Specialist from the HES lead vendor performs the HEA, the customer will be directed to a participating qualified IIC to complete the work. If a program IIC refers the customer to the HEA, the program will assign that IIC to complete the weatherization measures. Customers are always free to choose their preferred qualified participating HPC or IIC. Insulation work, whether performed by an HPC or IIC, may be selected to have a quality control inspection performed by the lead vendor or third party vendor when the work is complete. IICs are provided with merit-based allocation of work determined through several factors including documented work quality. This ensures that high quality is maintained and installations meet the Mass Save® Materials and Installation Standards. Through a competitive bidding process, the PAs contract with a third-party Quality Control ("QC") vendor to perform QC inspections of program implementation vendors, including PA lead

RESIDENTIAL WHOLE HOUSE	**<u>CORE INITIATIVE</u>** **RESIDENTIAL HOME ENERGY SERVICES – MEASURES** **RESIDENTIAL HOME ENERGY SERVICES – RCS**
	vendors and participating contractors. The QC vendor provides valuable information and feedback to the PAs on successes and identifies areas of possible improvement. The PAs are working together toward a best practices approach to provide more coordinated statewide training to reinforce quality installation techniques in HES. Recent evaluation results have found differences in realization rates when comparing lead vendor completed work versus HPC work. PAs will continue to review this third party research and explore if program changes are warranted to ensure whole house treatment is consistently implemented and customers are receiving the highest level of savings. It is expected that training requirements will increase over time in order for contractors to retain their status as an HES participating contractor. Additionally, contractors must maintain a high level of customer satisfaction to continue participating in the initiative. Most PAs have adopted a rating system to help contractors understand their performance in a holistic manner. These systems award work and/or financial bonuses based on performance. The PAs strive to maximize energy savings realized by promoting and supporting contractor training and education in an effort to establish a broader workforce knowledgeable and skilled in proper installation techniques. The goal is to have a sustainable and experienced workforce focused on achieving maximum energy savings and ready and able to meet customer demand. The contractors' ability to deliver high quality work that results in high realization rates is critical to delivering energy savings.
Marketing Overview	The HES initiative is marketed to all non-low income residential customers living in single-family houses or one-to-four unit buildings that are not part of a larger site where an association exists (such as a condominium association with multiple four unit buildings). Marketing efforts are designed to meet the objectives of reaching more customers (going broader into the customer base) and maximizing energy savings opportunities (going deeper into each home to find ways to save energy). The successful inclusion of a common online assessment tool that funnels interested customers to the HEA provides a model for

RESIDENTIAL WHOLE HOUSE	**<u>CORE INITIATIVE</u>** **RESIDENTIAL HOME ENERGY SERVICES – MEASURES** **RESIDENTIAL HOME ENERGY SERVICES – RCS**
	identifying low cost/high touch digital enhancements that streamline and improve customer experience. The PAs will continue market segmentation work to identify and strategically target customers with the most opportunity to increase the rate of audits that result in energy efficiency measure recommendations. The PAs will work closely with IICs and HPCs as a means to increase participation, satisfaction and energy savings. Further, the PAs will continue to seek new ways to identify, educate and reach segments such as landlords, renters and moderate income home owners. Efforts may include targeted marketing based on identified key demographics to overcome identified awareness and access barriers for specific customers. Different PAs are planning to explore partnerships and opportunities that respond to their service territories and will share learning as successful models emerge. The initiative will build off of the Mass Save® multi-media outreach campaign that focuses on partnerships with local media outlets or affiliates such as radio, print advertising, web-based marketing through various social media sites, and through www.Masssave.com. Current forms of multi-media outreach include the Mass Save® website, bill inserts, radio, print, and visual media advertising, digital media advertising (advanced online options), and targeted outreach through strategic partnerships with community organizations, municipalities, and other allies. PAs use timed marketing techniques to help support customers entry and deeper participation in program offerings. PAs will continue and explore enhancing the use of limited time "spiffs" during slower participation seasons as well as engage in follow up campaigns to participants known to have remaining opportunities. Individual PAs conduct additional marketing, such as behavior feedback mechanisms, and may ramp their marketing up or down as needed to meet participation and budget goals. This marketing targets specific measures/customer segments and is conducted strategically to meet initiative savings goals.
Three-Year Deployment Strategy/Roadmap	The goal of new enhancements in the 2016-2018 term is to refine and optimize the initiative, minimizing radical shifts in program design or delivery. PA efforts will focus on streamlining and enhancing the

RESIDENTIAL WHOLE HOUSE	**<u>CORE INITIATIVE</u>** **RESIDENTIAL HOME ENERGY SERVICES – MEASURES** **RESIDENTIAL HOME ENERGY SERVICES – RCS**
	customer experience while supporting a sustainable and robust delivery infrastructure. This focus will ensure the network of energy efficiency vendors and contractors meet the highest standards, and support delivery of highly cost effective deep savings. The PAs have worked over the Plan development year (2015) to be able to roll out, in accordance with the Resolution: • A renter-specific initiative to be rolled out in Q1 2016, including semi-annual PA reports to the Council that will include timely rental visit metrics including participation levels and conversion rates by renters and their landlords by PA, and qualitative information on any barriers encountered and plans to address them; • A moderate income initiative beginning in Q1 2016, including semi-annual PA reports to the Council on participation rates by PA. The PAs anticipate learning from the trials and adjusting and refining these new enhancements over the three-year plan term. The PAs are planning for increased installation of LEDs and expanded access to wireless enabled thermostats. PAs are also planning to explore sealing and insulation for ducts and offering a rebate for early clothes-washer turn-in. The PAs anticipate exploring similar technology advancements, particularly in home automation and control technologies, within the next three year cycle and aim to incorporate new technologies in HES as they are demonstrated to be cost effective and meet consumer performance expectations and acceptance. The key to new enhancements and field trials will be to research and test theories, program design changes, and new measures before broad application. PAs are also keenly attuned to balancing introduction of new enhancements with maintaining and responsibly growing opportunities for their delivery partners. Avoiding cycles of boom or bust are critical to maintaining a skilled and capable workforce and ensuring high customer satisfaction.

d. Residential Whole House: Behavioral/Feedback Initiatives

RESIDENTIAL WHOLE HOUSE	**CORE INITIATIVE** **RESIDENTIAL BEHAVIORAL/FEEDBACK INITIATIVES**
Overview and Key Objectives	The primary goal of the Behavioral core initiative is to encourage customer level behavioral change to conserve energy. Behavioral initiatives seek to identify the motivational factors that cause residential customers to actively employ personal energy saving actions and/or participate in energy efficiency programs. The PAs are continuously exploring opportunities to leverage behavioral science in the service of securing energy efficiency. Several PAs introduced and evaluated behavior based initiatives within their respective territories in previous plan periods. These initiatives varied in size and scope and include different implementation mechanisms along with a mix of vendors. One program, the Home Energy Report ("HER"), has moved from trial to full implementation by the largest PAs and is described more fully under implementation. **Target Market:** All residential customers
	New Enhancements: • Continued review of opportunities in the marketplace, new vendor offers, and opportunities to incorporate behavioral science based messaging into existing program marketing and customer engagement efforts. • Some PAs may explore offering behavior initiatives that have the ability to provide near real time electric consumption feedback, and have that ability to offer a mobile based application in addition to traditional web based or paper reporting. Some PAs may also look to see what potential exists to tie in home automation and smart appliances and other controls where applicable. Some electric PAs may leverage funding from their Grid Modernization Plan in areas where energy efficiency and grid modernization cross over. • Continue to evaluate and explore PA opportunities to leverage home automation technologies including eligible wireless enabled thermostats and their associated communication tools as well as other custom engagement tools for behavioral messaging.

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<tr><th>RESIDENTIAL WHOLE HOUSE</th><th><u>CORE INITIATIVE</u>
RESIDENTIAL BEHAVIORAL/FEEDBACK INITIATIVES</th></tr>
<tr><td>Core Initiative Design</td><td>Measures Promoted:

Behavioral initiatives focus on motivating energy-conserving actions that residents can control, such as programming thermostats, monitoring and adjusting home temperatures via wireless-enabled thermostats or turning off or down power using equipment and electronics. Behavioral initiatives also cross-promote participation in other initiatives with specific measures including HES, lighting, and products offerings.

Implementation Strategy:

The most prevalent behavioral initiative currently deployed by multiple PAs is the HER program. PAs assign participants to the program and participants are offered an opt-out option.

The HER program assigns qualifying customers to treatment and control groups. The treatment groups receive mailer-based reports on an ongoing basis and have access to an online portal. Control groups are retained for the purposes of evaluation. Customers are treated as a group indefinitely, or until the PAs decide to stop treating customers.

The HER program prompts energy savings through two primary paths:
Educational reports;
Educational reports and customer interaction with their online platform.
The HER details and benchmarks customers’ energy usage against their past usage and against similar homes in the area. Customers also have the option of opting-in to an online platform to gain greater feedback on their energy usage.</td></tr>
<tr><td>Delivery Mechanism</td><td>The HER model is individually contracted by each participating PA with a single vendor. The vendor works with each participating PA individually to define the treatment group within the PAs customer group, the treatment periodicity, engagement mechanisms (generally mail, email and web portal) and content from a limited number of vendor designed options.</td></tr>
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RESIDENTIAL WHOLE HOUSE	**CORE INITIATIVE** **RESIDENTIAL BEHAVIORAL/FEEDBACK INITIATIVES**
Marketing Overview	The current initiative uses an opt-out model, therefore does not employ additional marketing beyond direct offerings to selected customers.
Three-Year Deployment Strategy/Roadmap	PAs actively deploying HER initiatives intend to continue. PAs intend to continue to monitor opportunities for amendments to the current HER model and new behavioral initiative opportunities. The field of behavioral energy efficiency is evolving, with new product offers from vendors as well as new opportunities created by technology and engagement tools. The behavioral arena is ripe for experimentation. A benefit of the Massachusetts efficiency program regime is having multiple creative Program Administrators with varied territories where a variety of approaches can be explored and tested in the field. The Cape Light Compact already deploys an alternate behavioral approach and pioneered early learning in the field. In the 2016-2018 term many PAs will be exploring how the emergence of home automation and smart appliances and other controls may be tied into behavioral efforts. Some PAs may explore offering behavioral initiatives that have the ability to provide near real time electric consumption feedback, and/ or have the ability to offer a mobile based application in addition to traditional web based or paper reporting.
Special Notes	

e. Residential Products: Heating and Cooling (electric)

RESIDENTIAL PRODUCTS	**CORE INITIATIVE** **RESIDENTIAL HEATING AND COOLING - Electric**
Overview and Key Objectives	The primary objective of the Residential Heating and Cooling core initiative is to encourage consumers to purchase the most efficient heating, ventilation and air condition ("HVAC") and heat pump water heating technologies available when replacing older, less efficient equipment, and when considering equipment in new construction. The initiative also seeks to encourage contractors who service and install residential central air conditioning ("CAC") equipment and air source heat pumps to follow installation best practices. The PAs began offering rebates for residential CACs and heat pumps in

RESIDENTIAL PRODUCTS	**<u>CORE INITIATIVE</u>** **RESIDENTIAL HEATING AND COOLING - Electric**
	2004. Originally called the ENERGY STAR® HVAC Program, COOL SMART® was re-branded and designed to increase consumer awareness and the market share of ENERGY STAR certified CAC units, air-source heat pumps, and ductless mini-splits, and to promote quality cooling installations by HVAC technicians and contractors. With over ten years of implementation experience the program is considered mature. **Target Market:** Residential electric customers.
	New Enhancements: The PAs will explore the following proposed enhancements: • Explore emerging technologies, ongoing effort. • Continue to review and monitor opportunities for upstream program models. The PAs will continue to coordinate with C&I team and work with manufacturers and distributors to identify potential approaches. • Explore offering an online training for contractors in order to expand their participation in the program while reducing costs. • Explore protocols for installation and best practices for ductless mini-split heat pumps.
Core Initiative Design	**Measures Promoted:** High efficiency CAC, ducted air source heat pumps, ductless mini-split heat pumps (for heating and cooling), heat pump water heaters, ECM furnace fans, ECM circulator pumps. There are incentives provided to appropriate contractors for following installation best practices. COOL SMART® trained contractors earn an incentive for performing the proper testing to check and adjust system air flow and refrigerant charge using third-party verification. Other incentivized measures include duct testing and sealing and downsizing of replacement equipment. Additionally, customers may utilize the 0% HEAT loan to finance

RESIDENTIAL PRODUCTS	**<u>CORE INITIATIVE</u>** **RESIDENTIAL HEATING AND COOLING - Electric**
	eligible HVAC equipment purchases. **Implementation Strategy:** This core initiative provides rebates for the installation of qualified HVAC equipment, provides installation best practices training to residential heating and cooling contractors who install rebate eligible equipment, and provides upstream incentives on ECM circulator pumps. PAs use a third-party verification process for their quality installation verification offerings for all residential HVAC installations and tune-ups, including existing systems, retrofit, and new installations. The Residential Heating and Cooling - Electric core initiative will continue to work with the Residential Heating and Cooling – Natural Gas core initiative (GasNetworks®) on joint offerings; marketing, contractor training, and trade ally outreach including circuit rider. By collaborating, the PAs offer a near seamless integration of the gas and electric energy efficiency programs. The PAs will continue their work with HVAC distributors, and where possible, develop upstream opportunities. In addition, the PAs will continue to work with industry partners to promote best installation practices, awareness, education, and training for HVAC contractors, such as: • ENERGY STAR® HVAC Quality Installation program (EPA) • Consortium for Energy Efficiency • Air Conditioning Contractors of America The Residential Heating and Cooling - Electric core initiative will continue to promote the North American Technician Excellence (“NATE”) in HVAC contractor and customer educational materials. This strategy is designed to promote the value of NATE certification in the HVAC community and support installation best practices, education, and training for HVAC technicians and contractors
Delivery Mechanism	The Residential Heating and Cooling - Electric core initiative will be administered by the electric PAs in each service territory. Delivery is

RESIDENTIAL PRODUCTS	**<u>CORE INITIATIVE</u>** **RESIDENTIAL HEATING AND COOLING - Electric**
	through a common vendor selected through a competitive RFP. Whenever possible, there is coordination with the Residential Heating and Cooling – Natural Gas core initiative. These initiatives will continue to use a single, joint circuit rider in the field. The Residential Heating and Cooling - Electric initiative coordinates with Residential Whole House Program initiatives (Residential New Construction, HES, and Multi-Family Retrofit) to support comprehensive customer and contractor access to program offerings. The initiatives ensure participating residential new construction builders and their HVAC contractors are made aware of the Residential Heating and Cooling training. Whenever appropriate, these trainings are provided jointly with the Residential Heating and Cooling – Natural Gas core initiative. HES and qualifying Multi-Family Retrofit participants are also provided appropriate information and referral to ensure they can access appropriate rebates. Quality control/follow-up inspections are performed by independent inspectors on up to 10 percent of installations to verify equipment installation. The initiative continues to use equipment distributors to sell high-efficiency equipment and quality installation related technology, and to provide indoor training labs for HVAC contractors.
Marketing Overview	The Residential Heating and Cooling - Electric core initiative is designed to promote the purchase and proper installation of energy efficient residential central air conditioning and air source heat pump systems at multiple levels and therefore must design marketing and outreach to reach each of these levels. The marketing activities aim to reach several target markets: • New systems in existing and new homes (new systems) • Replacement systems in existing homes (new equipment/old systems), including the early retirement of existing equipment • Improvements in operational systems in existing homes (new equipment/old systems) Marketing strategies are developed for educating and promoting efficient choices to residential customers directly as well as working with other key decision makers such as new construction builder, renovation contractors, distributors, and retailers to ensure key

RESIDENTIAL PRODUCTS	<u>CORE INITIATIVE</u> RESIDENTIAL HEATING AND COOLING - Electric
	decisions makers and influencers are all aligned to promote efficient equipment adoption. In addition, the initiative marketing increasingly emphasizes the importance of proper installation and sizing practices as well as the promotion of duct sealing and enhanced air distribution system efficiency. The Residential Heating and Cooling – Electric core initiative will continue to collaborate with the Residential Heating and Cooling – Natural Gas core initiative to develop and implement joint marketing activities whenever feasible. The initiative also leverages relationships with HVAC professionals allowing them to market the advantages of supported products directly to their customers, thereby increasing the opportunity to sell energy efficient units while helping the PAs to achieve their energy saving goals. Marketing activities will continue to emphasize outreach to HVAC professionals (contractors and distributors, including gas contractors). The PAs will continue to build an integrated marketing and branding approach incorporating key elements such as contractor and distributor outreach and training, the Mass Save® website, collateral updates, email blasts, bill inserts, as well as other activities. In 2016-2018 the marketing strategy will utilize effective contractor and customer education messaging to meet the initiative goals and provide essential opportunities for HVAC professionals in coordination with all Residential Whole House core initiatives. A joint circuit rider will continue to provide outreach services, education, and support in the field through visits and calls to HVAC distributors, supply houses, and contractors. The circuit rider also participates in training, trade shows, and related industry events. The initiative tracks and provides targeted outreach to large HVAC contractors previously inactive in the program. The PAs plan to continue use of contractor competitions and awards programs, including an annual recognition celebration for contractors to maintain and improve program participation from existing HVAC partners and to recruit more contractors. The PAs will also work with the ENERGY STAR® HVAC Quality Installation program team, the CEE HVAC Committee, and other industry partners to promote best installation practices, awareness, education, and training for HVAC contractors.

RESIDENTIAL PRODUCTS	**<u>CORE INITIATIVE</u>** **RESIDENTIAL HEATING AND COOLING - Electric**
	The PAs plan to review cooperative (upstream) promotions with the HVAC industry, in coordination with C&I where feasible. The PAs will use print and media advertising targeting consumers, contractors, and distributors (including information on the website, participation at trade shows, articles in trade publications, and mailings to distributors, contractor, and non-participants). The PAs will collect and use consumer testimonials affirming the benefits of program measures. These efforts will be in conjunction with the Residential Heating and Cooling – Natural Gas core initiative, where possible. The PAs will continue to leverage manufacturer/distributor level marketing and training infrastructure as a platform to educate contractors and wholesalers at a regional level. These will be in conjunction with the Residential Heating and Cooling - Natural Gas core initiative, where possible. PAs will market and leverage all available federal tax credits where applicable as well as all supplemental consumer incentives (*e.g.*, equipment manufacturers) as a means to increase consumer purchases of high efficiency central air conditioning and heat pump systems.
Three-Year Deployment Strategy/Roadmap	A mini-split evaluation currently underway and due in the summer of 2016 will influence incentive deployment in the 2016-2018 plan term. Consumer interest in cold climate heat pump technology and its application in Massachusetts is also likely to lead to additional PA exploration and testing of different heat pump technologies and applications.
Special Notes	

f. Residential Products: Heating and Cooling (gas)

RESIDENTIAL PRODUCTS	**<u>CORE INITIATIVE</u>** **RESIDENTIAL HEATING & COOLING - Natural Gas**
Overview and Key Objectives	The primary objective of the Residential Heating and Cooling - Natural Gas core initiative is to overcome market barriers and increase market awareness and penetration of high efficiency gas heating (hot water boilers and warm air furnaces), water heating equipment, and associated

RESIDENTIAL PRODUCTS	**CORE INITIATIVE** **RESIDENTIAL HEATING & COOLING - Natural Gas**
	controls including wireless programmable thermostats and outdoor reset controls. This initiative is administered by the Gas PAs. Heating and water heating systems fueled with oil, propane, or solar (in the case of CLC) have been supported through the HES core initiative by electric PAs. A major focus of program activity is to provide support to plumbing and heating contractors and the full supply chain (manufacturers, distributors and suppliers) to ensure availability, promotion, and quality installation of the highest efficiency equipment. Program rebates are provided to customers to help offset the higher cost of their investments in high-efficiency heating and water heating equipment. Massachusetts PAs were amongst the earliest sponsors of gas efficiency programs, offering gas high efficiency heating and water heating rebates for over 15 years. While the core program design is considered mature, the PAs continue to innovate and lead the nation in program refinement. The PAs' concentration of incentives on the highest efficiency models and concurrent reduction or elimination of incentives on lower efficiency models has had a demonstrable effect in increasing the availability, promotion, and acceptance of the highest efficiency equipment by Massachusetts residential gas customers. **Target Market:** All residential gas customers.
	New Enhancements: The PAs anticipate the following initiative enhancements for the three year planning term of 2016-2018: • Continue to expand trade ally awareness and strengthen existing partnerships, including deploying use of the redesigned website for contractors, implementing seasonal or year-round contractor incentive promotions, and new technology training initiatives. These efforts will be ongoing throughout the Three-Year Plan. • Continue to focus on streamlining customer and contractor transactions with tools such as online rebate fulfillment and increased leveraging of data from the GasNetworks® website to design additional targeted marketing as well as increase use of digital marketing.

RESIDENTIAL PRODUCTS	**<u>CORE INITIATIVE</u>** **RESIDENTIAL HEATING & COOLING - Natural Gas**
Core Initiative Design	**Measures Promoted:** The Residential Heating and Cooling – Natural Gas core initiative promotes high efficiency products and installation best practices for hot water boilers, warm air furnaces (with electronically Commutated Motor or equivalent advanced furnace fan systems), select heating system controls including after-market boiler rest controls, programmable and wireless enabled thermostats, gas water heating equipment, and heat recovery ventilator equipment (“HRV”). **Implementation Strategy:** The Residential Heating and Cooling – Natural Gas core initiative is designed to overcome market barriers and increase awareness among consumers, plumbing/heating contractors, and home builders/developers. The initiative utilizes a combination of marketing and customer rebates to help build demand and acceptance of high efficiency natural gas equipment. The purchase and installation of heating and water heating equipment is heavily influenced by the installing contractors and the supply chain behind them. For this reason, a major focus of this initiative is the market actors who strongly influence the purchase and placement of efficient options. These include : • Plumbing and HVAC contractors and technicians • Manufacturers, distributors, and suppliers of high efficiency heating and water heating equipment and related parts/accessories • New home builders and remodeling contractors • Home designers, architects, and engineers. • Building Inspectors and industry affiliate organizations including the Massachusetts Building Inspectors, *i.e.*, Southeastern Massachusetts Building Officials Association (“SEMBOA”), Plumbing, Heating and Cooling Contractors of MA (“PHCC of MA”), International Association of Plumbing and Mechanical Officials (“IAPMO”) • Residential home owners and multi-family property owners (residentially metered) with natural gas heating and water heating equipment or in the market to purchase equipment.

RESIDENTIAL PRODUCTS	**CORE INITIATIVE** **RESIDENTIAL HEATING & COOLING - Natural Gas**
	The initiative maintains a contractor facing GasNetworks® website that was recently completely refreshed. The site is tied to the Mass Save® website but allows for more in depth and targeted information for the target market actors. The initiative keeps current on emerging trends and technologies, works closely with manufacturers and distributors, as well as coordinates with supply houses to ensure awareness of the highest efficiency equipment availability and benefits. Equipment stocking must be done well in advance of the season and has significant impact on what contractors will offer and promote. The initiative includes regular visits with supply houses and big box stores to educate partners and to support optimal stocking practices. These regular visits can also leverage the relationships for training and promotions targeted at the installation contractors. The initiative depends significantly on high quality training opportunities as a mechanism to connect with installation contractors and influence installation practices. GasNetworks® has run numerous training events as well as a highly effective annual conference for over 15 years. The initiative also works with vocational school faculty to reach emerging professionals. The initiative offers customer rebates to offset the higher cost of purchasing qualifying gas heating, water heating equipment, and controls in the new construction and replacement market. In collaboration with the Residential Heating and Cooling - Electric core initiative, the Residential Heating and Cooling – Natural Gas core initiative also offers a dual electric/natural gas rebate incentive for high-efficiency furnaces equipped with Electronically Commutated Motor ("ECM") or equivalent advanced furnace fan systems. The initiative offers customer incentives for energy efficient water heating equipment. In addition to heating and water heating equipment, customer incentives are also offered for select heating system controls, such as programmable and Wi-Fi thermostats, boiler reset controls, and heat recovery ventilator units. The initiative will continue to support the early replacement boiler/furnace promotion, integrated with the HES core initiative, which provides an incentive to replace old, inefficient, but still operating, heating equipment with new high efficiency equipment. Gas PAs consistently monitor this initiative and evaluate free-ridership

RESIDENTIAL PRODUCTS	**CORE INITIATIVE** **RESIDENTIAL HEATING & COOLING - Natural Gas**
	in order to drive customers to go deeper and achieve the highest level of efficiency available.
Delivery Mechanism	The initiative is administered by gas PAs. Given the complex nature and critical importance of the supply chain and installation contractors in reaching end customers the residential Heating and Cooling – Natural Gas core initiative uses three complimentary delivery support vendors. PAs jointly contract with a competitively bid primary delivery vendor. This vendor is responsible for direct communication and education of all key trade allies, in particular manufacturers, distributors, supply houses, heating and water heating contractors, and vocational school faculty members. This vendor monitors the website interface, helps connect PA partners to the website and offers suggestions for content. The vendor maintains primary circuit riding responsibilities to supply houses. PAs have also leveraged the circuit rider secured by the Residential Lighting and Products core initiatives to provide field visits and sales training through the distribution of point-of-purchase rebate materials to big box stores and other applicable retail outlets. PAs jointly contract with a rebate processing vendor. This vendor is secured to review, process, and deliver valid rebate claims to customers. This vendor is also responsible for tracking and reporting program activity to gas and electric PAs as well as providing verification of a percentage of installed qualified equipment across PAs. PAs own the GasNetworks® website. PAs jointly contracted with the vendor who had supported the Massave.com site for a complete site refresh. This vendor is continuing to provide support to PAs for website interface and functionality related updates to the website and to support digital marketing opportunities.
Marketing Overview	The initiative will be promoted through a variety of marketing and educational campaigns including, but not limited to: upstream outreach, direct mail, bill inserts, sponsorships and trade ally circuit-rider visits, and other training events. The GasNetworks® annual conference is a signature event with over 400 attendees annually and a key opportunity to connect with installation contractors, manufactures and distributors of high efficiency technologies. The initiative has been particularly successful utilizing a direct vendor outreach marketing approach to gas equipment suppliers and installation contractors. The

RESIDENTIAL PRODUCTS	**<u>CORE INITIATIVE</u>** **RESIDENTIAL HEATING & COOLING - Natural Gas**
	PAs will continue to implement this approach in 2016-2018. PAs have also built strong relationships with building inspectors and industry affiliate organizations including the Massachusetts Building Inspectors, *i.e.*, SEMBOA, PHCC of MA, IAPMO and will continue to promote initiative offerings through these strategic relationships. The PAs will continue to enhance their outreach to customers in collaboration with the other PA working groups. PAs will also enhance awareness through successful targeted techniques involving website and email. In addition to direct rebate offers to customers, PAs offer strategic seasonal or year-round contractor incentives to further encourage the installation of high efficiency heating equipment. PAs also market and leverage all available federal tax credits where applicable and other consumer incentives as a means to increase consumer sales of high efficiency heating and water heating equipment.
Three-Year Deployment Strategy/Roadmap	PAs will continue to explore cost-effective offerings, such as seasonal incentives to contractors or special promotion resources to trade allies and other market actors, which assist with the stocking, sales, and installation of high efficiency heating and water heating equipment. The March 2015 High Efficiency Heating Equipment Impact Evaluation has raised some concerns over the installation of condensing boilers. The high efficiency of condensing boilers relies on a low boiler return water temperature, which means that differences in installation practices that impact return water temperature have a large impact on savings. PAs remain enthusiastic about the savings potential of this technology and will focus on additional study and experimentation to overcome these issues in installation practice. PAs will continue to leverage the GasNetworks® website. The refreshed website offers new analytics on who and what partners are searching for and allows new opportunities for increased targeting and digital marketing. The PAs will continue to enhance integration and cross-promotion efforts with the Residential Heating & Cooling – Electric and HES core initiatives. In addition, PAs will review emerging technologies for cost-effectiveness and will continue to explore an upstream program model.

RESIDENTIAL PRODUCTS	**CORE INITIATIVE** **RESIDENTIAL HEATING & COOLING - Natural Gas**
Special Notes	Increasing product standards and significant volatility of the avoided cost of natural gas are putting increased pressure on this program to deliver cost effective savings.

g. Residential Products: Residential Consumer Products

RESIDENTIAL PRODUCTS	**CORE INITIATIVE** **RESIDENTIAL CONSUMER PRODUCTS**
Overview and Key Objectives	The objective of the Residential Consumer Products core initiative is to increase consumer awareness of the importance and benefits of purchasing or ENERGY STAR® certified appliances and electronic products. It also seeks to expand the availability, consumer acceptance, and use of high-quality energy-efficient technologies. This initiative also promotes the recycling of certain older, less efficient appliances. The initiative utilizes upstream incentives, mail-in rebates, and an on-line catalog to deliver lower product costs to customers and drive increased customer acceptance and sales. Increasing product standards combined with the success and maturity of Program Administrator programs have limited the savings opportunities in several appliance product categories. PAs continue to explore emerging technologies and innovative program design to drive market penetration of the most efficient products. This is accomplished through increasing the balance of upstream and midstream incentive placement and alternative or bundled incentive/rebate structures and placement. The Products initiative has successfully leveraged creative marketing, including significant social media, affinity marketing, retail partnerships and point of purchase promotions. **Target Market:** All residential electric customers
	New Enhancements: PAs are exploring various methods to streamline incentive delivery

RESIDENTIAL PRODUCTS	**<u>CORE INITIATIVE</u>** **RESIDENTIAL CONSUMER PRODUCTS**
	methods to the consumer (*e.g.*, midstream/upstream) and to address the rapidly changing appliance and electronics marketplace. This is an ongoing effort.
Core Initiative Design	**Measures Promoted:** Incentives are provided for qualifying consumer products. The list is continuously updated and frequently changes. It has included certain refrigerators, freezers, air cleaners, clothes dryers, advanced power strips, televisions, desktop computers, pool pumps, dehumidifiers, water saving products and refrigerator/freezer recycling.
	Implementation Strategy: The Residential Consumer Products core initiative educates consumers about the benefits of ENERGY STAR® certified products to increase consumer acceptance of products and to encourage them to look for and purchase ENERGY STAR® certified models when they shop. The initiative promotes select ENERGY STAR® certified consumer products at the point of sale by providing promotional literature and displays to retailers, working with sales staffs to ensure they understand and can accurately market the benefits of these products, and providing labels to identify models that meet ENERGY STAR® standards. The initiative actively participates in national ENERGY STAR® awareness campaigns and in efforts to keep ENERGY STAR® specifications up to date and relevant. The Residential Consumer Products core initiative primarily focuses on customer rebates, which can be completed on line or mailed in. The initiative is tightly interwoven with the Lighting initiative and leverages many of the same access points as the Lighting program including: • Upstream incentives/negotiated promotions which can provide instant price discount to the consumer for qualified products. Along with the price reductions provided by rebates, incentives and promotions makes products more attractive to the customers, which in turn increases the number of retail outlets willing to carry these products. • Partnerships with local and national retailers with joint

RESIDENTIAL PRODUCTS	**<u>CORE INITIATIVE</u>** **RESIDENTIAL CONSUMER PRODUCTS**
	promotions and coordinated point of purchase promotional materials and support. Retailers are also provided training and additional support to ensure they can be one-on-one consumer educators and effective champions for the energy efficient appliances and electronics. • Social media outlets, like Facebook and Twitter, offer the ability to launch creative campaigns promoting energy efficient products and package with lighting offers. • "Pop-up" retail allows the PAs to offer smaller products such as advanced power strips ("APS"), a product that's benefits typically need to be explained to consumers, along with lighting in temporary retail locations, such as mall kiosks, corporate, and public events. This brings the technology and education about the technology directly to the consumer.
Delivery Mechanism	PAs jointly contract with a ***manufacturer/retailer outreach contractor***, often called a "circuit rider". This contractor recruits and train retailers (including discount retail outlets) to participate in the incentive program, places point of purchase materials in participating retail stores, and acts as a liaison for PAs, manufacturers, and retailers. This vendor is also responsible for supporting and tracking midstream incentive efforts. The Residential Consumer Products core initiative utilizes the same competitively bid ***rebate fulfillment contractor*** used in the Residential Lighting initiative to process both mail in and online rebates. This vendor also collects data and payment requests from consumers, manufacturers, and retailers. In addition, they will process reimbursement requests from customers and NCP partners. The contractor provides documentation to the PAs for program tracking and evaluation purposes. The Consumer Products initiative is also able to share the ***internet/mail-order sales channel contractor*** used in the Residential Lighting Initiative. This vendor maintains stock of products offered through the catalog and the Mass Save® website, staffs a toll-free line for customers, and processes catalog and website purchases. The temporary "pop-up" retail kiosks described under implementation, done in conjunction with the Residential Lighting initiative, create an opportunity to promote a small number of consumer products, currently the APS and Shower Start products. To the extent that smaller

RESIDENTIAL PRODUCTS	**CORE INITIATIVE** **RESIDENTIAL CONSUMER PRODUCTS**
	electronics or other efficiency technologies appropriate to a retail kiosk are added to the program they may be deployed in this way. This involves an additional specialized vendor jointly contracted by the PAs for this offering.
Marketing Overview	The Consumer Products initiative provides significant opportunity to market the Mass Save® brand, by placing the brand and efficient products firmly in the consumer market place. The value of end cap displays in major retail outlets with direct access to Massachusetts customers brings efficiency into the daily lives of many who may otherwise never encounter the efficiency messages. Relationships with product manufacturers also offer unique opportunities for “prizes” and special promotions like the Super Bowl efficient TV sweepstakes that can broaden PA reach and tap new market segments with efficiency messages. Even as the Consumer Products category becomes more challenging as a sector for savings, its value to overall efficiency marketing and Mass Save® brand should not be underestimated. In the appliance and electronics category, marketing initiatives will be designed to leverage new product specifications being rolled out in several product categories and the emergence of new high efficiency technologies. Key marketing strategies will aim to build awareness and demand for new, high efficiency products, as well as consumer education to help customers take advantage of these technologies. Consumer education tactics will continue to employ retail point of purchase materials, sales promotions, consumer engagement events, social media, email, and other best practice marketing tactics to drive sales of qualified energy efficient appliances and electronics. Efforts will continue to monitor the market for energy efficient "smart" technologies in appliances and consumer electronics to inform future program planning and marketing opportunities. Go-to-market strategies will be explored to introduce new connected smart appliances and plug load controlling electronics into the marketplace as the PAs better understand their value in securing energy efficiency benefits for their customers. Tactics to support these efforts will include consumer education via social media channels, consumer events, and retail promotions and point of sale materials to educate and motivate consumers to use these new technologies.

RESIDENTIAL PRODUCTS	**CORE INITIATIVE** **RESIDENTIAL CONSUMER PRODUCTS**
	As in lighting, product marketing will continue to leverage the strong social media presence built over the 2013-2015 term.
Three-Year Deployment Strategy/Roadmap	For consumer products, efforts to broaden categories as well as allow consumers the opportunity to increase the savings in their homes with new technologies provide unique challenges for the PAs. Increasing standards and market saturation will continue to decrease electric savings for some energy efficient products, forcing the PAs to adapt and explore avenues of program deployment that are new and possibly untested. PAs will continue to explore expanding the products included in upstream efforts in an attempt to duplicate the successes with lighting. As standards became more stringent during the 2013-2015 term, the PAs successfully developed tools and techniques for promoting more efficient products to consumers, such as the higher CEE Tiers, and the newer higher tier of ENERGY STAR® "Most Efficient" categories. The PAs plan to continue to use these tools and techniques to continue to support the consumer awareness and adoption of highest efficiency appliances. The PAs will also explore tactics to support deeper savings through education, promotion, and possibly higher incentive offerings, if appropriate.
Special Notes	

h. Residential Products: Residential Lighting (electric)

RESIDENTIAL PRODUCTS	**CORE INITIATIVE** **RESIDENTIAL LIGHTING**
Overview and Key Objectives	The objective of the Residential Lighting core initiative is to increase consumer awareness of the importance and benefits of purchasing ENERGY STAR® qualified lighting products and expand the availability, consumer acceptance, and use of high quality energy efficient lighting technologies and controls. Residential lighting provides 54 percent of the annual electric savings for the residential and low income sectors. There are increasing pressures on these savings

RESIDENTIAL PRODUCTS	**<u>CORE INITIATIVE</u> RESIDENTIAL LIGHTING**
	from increased standards/baselines and higher prices for the newer energy efficient technologies. However, lighting remains a critical driver of residential savings. The initiative utilizes a combination of upstream incentives at the manufacturer and retail level, and an online catalog channel to deliver lower product costs to customers and drive increased customer acceptance and sales. The Lighting initiative has successfully leveraged creative marketing, including significant social media, affinity marketing, retail partnerships and point of purchase promotions. Lighting technology has evolved rapidly from the basic compact fluorescent spirals to multiple specialty bulbs, fixtures, and light emitting diodes ("LEDs") applications. PAs saw rapid expansion of the LED market in 2013-present through aggressive upstream incentives enabling more affordable pricing by manufacturers and retailers. **Target Market:** All residential electric customers.
	New Enhancements: PAs will continue to explore approaches that support additional savings. This is an ongoing effort. • PAs plan further expansion and focus on introducing LED bulbs and fixtures into the marketplace and phasing out CFL bulbs. • PAs will explore lighting controls as a possible initiative expansion measure. PAs will coordinate with other research and development efforts.
Core Initiative Design	**Measures Promoted:** The Residential Lighting core initiative promotes ENERGY STAR certified light bulbs and fixtures. Current offerings include CFL and LED bulbs, with a continuing emphasis on expanding LEDs while phasing out CFL bulbs. **Implementation Strategy:**

RESIDENTIAL PRODUCTS	**<u>CORE INITIATIVE</u>** **RESIDENTIAL LIGHTING**
	The Residential Lighting program strategy depends on a fluid mixture of: • Advanced market knowledge and data of efficient lighting technology and products • Sophisticated incentive structure that includes incentive placement at the manufacturer (upstream) and at retail purchase points (midstream) • Cutting edge marketing and educational strategies to support customer adoption of the most efficient technologies To achieve this complex mixture, PAs invest strongly in staying up to date on overall residential lighting market conditions, product availability, market share, and pricing. This allows PAs to adapt initiative offerings, as needed, to introduce new cost effective savings technologies, target incentives, and marketing to build customer acceptance and adoption. This ultimately increases the market share of energy efficient lighting products. The Residential Lighting core initiative includes several components and entry points designed to educate consumers about the benefits of ENERGY STAR® qualified lighting products and to make these products more affordable and easily available: • Upstream incentives/negotiated promotions provide instant price discounts to the consumer for qualified products. The price reductions provided by incentives and promotions makes lighting products more attractive and affordable to the customers, which in turn increases the number of retail outlets willing to carry these products. • Partnerships with local and national retailers with joint promotions and coordinated point of purchase promotional materials and support. Retailers are provided training and additional support to ensure they can be one-on-one consumer educators and effective champions for the energy efficient lighting technologies. The initiative partners with retailers for end cap space for display and with point of purchase marketing putting high efficiency lighting prominently in consumer’s path. The initiative’s field service vendor will also set up educational tables to promote the program at various times throughout the year. • Special attention and increased incentives to retail outlets

RESIDENTIAL PRODUCTS	**CORE INITIATIVE** **RESIDENTIAL LIGHTING**
	designated to serve hard to reach customers, to ensure equal access to affordable efficient lighting for all customers. • An internet/mail-order sales channel offers education, rebates, and introductions to new products that may not be available at most retailers, as well as access to a variety of hard to find replacement bulbs. PAs are working on improvements to the internet/mail-order website, increasing its functionality as an educational tool for consumers. PAs have enhanced the products pages of the Mass Save® website helping guide customers to the online store and to local retailers with promotional activity. • Social media outlets, like Facebook and Twitter, offer the ability to launch creative campaigns promoting energy efficient lighting as well as other products. Social media campaigns and contests provide an exciting way to leverage PA customers as brand ambassadors and greatly expand the initiative's reach. • Affinity marketing has been added to the mix of promotional strategies. Similar to social marketing, affinity marketing allows a reach into a broader consumer demographic while continuing to build brand awareness. It offers additional community benefits through the significant charity donation raised. PAs are continuing to explore additional affinity marketing opportunities. • "Pop-up" retail allows the PAs to offer efficient lighting products to consumers in temporary retail locations, such as mall kiosks, corporate, and public events. This brings the technology and education directly to the consumer. • Some PAs provide a school fundraising offer which allows PAs the opportunity to educate students on the benefits of energy efficiency, while helping schools to raise funds through the sale of lighting products.
Delivery Mechanism	With the multiple points of entry for customers and the multilayered incentive and marketing strategy, the Lighting and Products programs have a complex set of delivery vendor partners. PAs engage vendors to support manufacturer and retail recruitment, on-going partnership training and promotion activity, as a marketing vendor partner, and a rebate and on-line store vendor. To ensure a consistent and smooth customer experience as well as greater ease for manufacturers and retailers to engage with the program, PAs have worked effectively to coordinate and jointly contract services with common vendors.

RESIDENTIAL PRODUCTS	CORE INITIATIVE RESIDENTIAL LIGHTING
	PAs jointly contract with a ***manufacturer/retailer outreach contractor***, often called a circuit rider. This contractor recruits and train retailers (including discount retail outlets) to participate in the incentive program, places point of purchase materials in participating retail stores, oversee the Negotiated Cooperative Promotions ("NCP") process, attends in-store events on behalf of the PAs to further promote the programs, and acts as a liaison for PAs, manufacturers, and retailers. A ***rebate fulfillment contractor*** collects data and payment requests from manufacturers, retailers, and consumers. In addition, they will process reimbursement requests from NCP partners and provide documentation to the PAs for program tracking and evaluation purposes. The ***internet/mail-order sales channel contractor*** will purchase and stock products offered through the catalog and the Mass Save® website, staff a toll-free line for customers, and process catalog and website purchases. PAs employ temporary "pop-up" retail kiosks at key events and locations as described under implementation. This involves an additional specialized vendor jointly contracted by the PAs for this offering.
Marketing Overview	**Strategy:** As lighting technology rapidly expands with new LED replacement bulbs and fixtures, and we explore lighting control options increasingly introduced into the market, marketing initiatives may include support for consumer trial through the use of discounted products and special manufacturer/retailer promotions. A key to growing market share for LEDs will be to shift consumer perception of lighting from a commodity product to a more considered purchase. It remains critical for marketing to support customers understanding of each lighting product's application and benefits. This will be accomplished through strategic use of educational advertising, in-store displays, social media outreach, and other point of sale communications. It is critical to roll out products that have proven performance and clearly communicate to customers the appropriate application to ensure their optimal experience with the new technologies. PAs remain ever cautious of the potential for customer rejection of new technology

RESIDENTIAL PRODUCTS	**CORE INITIATIVE** **RESIDENTIAL LIGHTING**
	classes due to the experience of continued customer perception of CFL applications from early sub optimal customer product experience. PAs remain vigilant in managing introduction of technologies at optimal product evolution stage and doing so with strong communication about best applications. The marketing team has designed highly effective campaigns that help focus consumers on appropriate end uses or applications for specific lighting technology, *e.g.*, LED BR 30. For example, few customers have any idea what a LED BR 30 is and its shape is somewhat unfamiliar as it is meant for use in recessed can fixtures rather than traditional lamp application. To take the mystery out of a specialty bulb like BR30s marketing works to offer promotions and marketing that help consumers connect the lighting to a specific room or use, like a "kitchen 3 pack" in the case of BR30s. The Residential Lighting initiative has seen tremendous success and intends to expand its affinity marketing activity. In the 2013-2015 term, the Residential Lighting initiative launched a promotion with our manufacturers and retailers supporting the Ellie Fund, described more fully under the implementation section above. The PAs will explore other affinity marketing opportunities to expand the reach to new market segments while offering the added benefit of supporting our community beyond energy efficiency.
Three-Year Deployment Strategy/Roadmap	The Residential Lighting core initiative continues to face challenges in the upcoming three-year term. The per unit annual savings for CFLs and LEDs will continue to decline to account for the anticipated multi-year phase out of incandescent bulbs due to EISA standards. In addition, both the per unit lifetime savings and the per unit measure lives have been reduced in this plan to estimate the post 2020 EISA code change may have on savings for both CFLs and LEDs. PAs plan to continue to increase penetration of LEDs and roll out new LED bulb types and fixtures based on estimates of future product availability and price. While LED technology is evolving very rapidly and becoming more cost competitive, the bulb price is still markedly higher than for equivalent energy saving CFLs. Even when longer life is included in savings, the shift to an increasing mix of LEDs will impact the cost of savings. PAs will be balancing the phase in of LEDs to maximize provision of high performance lighting that offers customers a positive experience and builds continued acceptance with a focus on responsible investment of efficiency dollars to continue to achieve savings targets

RESIDENTIAL PRODUCTS	**<u>CORE INITIATIVE</u> RESIDENTIAL LIGHTING**
	within responsible budgets. For the three-year deployment, the PAs will focus on: • Expanding the mix of energy efficient lighting products available in retail • Increased focus on LED products to reach “deeper” savings for each customer with more options for each socket • Continuous offerings over longer horizon periods at retail to ensure year-round product availability to consumers • Innovative approaches to community and corporate events including areas with high percentages of renters or moderate income households. • Phasing in of qualified products for new technologies that require new entrants and implementation strategies.
Special Notes	Specialty CFL bulb incentives will phase out in 2016.

F. **<u>Low-Income Programs</u>**

1. <u>Low-Income Program Descriptions</u>

a. Low-Income: Single Family

LOW-INCOME	**<u>CORE INITIATIVE</u> SINGLE FAMILY**
Overview and Key Objectives	The Low-Income Single Family core initiative implements cost-effective, energy efficiency products and services directly for residential customers living in one to four unit dwellings in which at least 50 percent of the occupants are at or below 60 percent of the state median income level. The initiative is implemented by local Community Action Program (“CAP”) Agencies and integrated with the Department of Housing and Community Development (“DHCD”) Weatherization Assistance Program (“WAP”). All applicable revenue streams from each program are leveraged and offered jointly to income eligible residents. This approach provides a seamless, integrated experience for the participants with deeper efficiency penetration consistent with a whole house approach generally with no co-payment

LOW-INCOME	**CORE INITIATIVE** **SINGLE FAMILY**
	required from participating customers. **Target Market:** Residential customers living in one to four unit dwellings who are at or below 60 percent of the state median income level or who are qualified to receive fuel assistance and/or utility discount rates. For two to four unit dwellings, 50 percent of the occupants must qualify as low-income in order to be served by the Low-Income Single Family core initiative. Any changes to eligibility criteria will be addressed collectively between the PAs, LEAN, DHCD, lead vendor (where applicable) and CAP agencies.
	New Enhancements: • The PAs will continue to work with the Low-Income Best Practices working group to identify new cost-effective energy efficiency services, measures and technologies that are appropriate to offer to low-income customers. In 2014, the PAs collectively went out to bid for the fulfillment distributor of High Efficiency Lighting Products for all residential and low-income, direct install programs. Through this process, the PAs have realized significant cost savings and are in the process of transitioning the bulb offer to allow for more installations of LED bulbs within low-income customer homes. As new LED technology continues to emerge and pricing continues to decline, the PAs will look to transition to LED technology over the next three years exclusively as applicable and dependent upon PA budgets. • PAs will work with LEAN, state organizations such as the DHCD, lead vendor, and CAP agencies to increase qualified contractor participation in the initiative through training and workforce development. The PAs also plan to continue to support contractor and auditor training as needed, throughout the 2016-2018 program years.
Core Initiative Design	**Measures Promoted:** Measures are provided at no cost to the customer with established caps, where applicable. The measures available to each low-income single family property include:

LOW-INCOME	<u>**CORE INITIATIVE**</u> **SINGLE FAMILY**
	• Insulation (attic, wall, pipe, and duct) • Air sealing • Heating system repair and replacement • Programmable thermostats • Domestic water heating, including low-flow showerheads, faucet aerators, pipe wrap, heat pump water heater (electric) • Lighting, including LEDs, CFLs, lighting fixtures, and torchieres • Appliances, including refrigerator and freezer replacement, second refrigerator removal, advanced power strips, window air conditioner replacement • Weatherization repairs (electrical, roofs, etc.) • Health and safety In coordination with LEAN, the PAs will work with the MTAC to include new measures or technologies as appropriate **Implementation Strategy:** Once customers are deemed eligible, they will receive an in-home energy assessment from their local CAP agency. The assessment evaluates the building shell, efficiency, and (for electric PAs only), the appliance conditions. All assessments include an evaluation of home health and safety. The lead vendor/CAP agency will then arrange for all applicable measures and services to be installed by a qualified contractor. The initiative piggybacks on the current DHCD WAP. All applicable revenue streams available are leveraged to enhance services consistent with a whole-house approach. PA funding will primarily be used to address more items on the cost-effective priority list, including approved weatherization-related repairs. Federal money will primarily be used to address health and safety issues, as well as repairs, to allow for cost-effective energy efficient measures to be installed. As mandated by DHCD for all projects that receive Department of Energy ("DOE") funding, the CAP agencies perform 100 percent post-installation quality assurance inspection of projects to ensure that all work is performed to the program guidelines. The CAP agencies also perform a minimum of 50 percent in-process inspection of projects.

LOW-INCOME	**CORE INITIATIVE** **SINGLE FAMILY**
	Because the PA initiative piggybacks on the DHCD program, many jobs are multi-funded; therefore, quality control is completed for both DOE and PA-funded projects at the same time. DHCD performs another level of visual inspection for 20 percent of all DOE-funded projects. During these inspections, DHCD reviews both DOE and PA-funded work. Additionally, the PAs have an independent third-party vendor perform quality assurance inspections for an additional level of quality control. PAs require 5 percent of all jobs that are exclusively funded by the PAs to be inspected by a third party quality control vendor. Energy efficiency education and information is provided to all participating customers. The primary form of energy education is verbal communication between the auditor and the client along with leave-behind materials. In 2013, the PAs collaborated with the Low-Income Best Practices working group and developed common, statewide educational materials. Educational materials will continue to be updated and provided to customers as applicable. The PAs will work in collaboration with the Low-Income Best Practices working group, including LEAN, DHCD, lead vendors (where applicable), and CAP agencies to coordinate statewide on all aspects of the Low-Income Single Family core initiative, including but not limited to planning, delivery, implementation, education, marketing, training, cost-effectiveness, evaluation, and quality assurance.
Delivery Mechanism	PAs, when appropriate, use lead vendors to administer the initiative. The PAs work closely with their lead vendors and/or respective CAP agencies on all aspects of the initiative design and implementation. The lead vendors/CAP agencies are responsible for providing coordination of energy efficiency services to the customer. The lead vendors/CAP agencies work with installation contractors to ensure that the proper initiative guidelines are enforced. These agencies are also responsible for ensuring that the customer meets the eligibility requirements for initiative participation and providing the lead vendors and/or PA with the required documentation of all work performed. Quality assurance is completed by the lead vendor/CAP agencies, DHCD, as well as by a PA-funded independent third party vendor.
Marketing Overview	**Strategy:** Marketing outreach designed to reach more income-eligible customers

LOW-INCOME	**CORE INITIATIVE** **SINGLE FAMILY**
	and maximize energy savings opportunities will continue to expand through the 2016-2018 Low-Income Single Family core initiative (where applicable). PAs, in collaboration with lead vendors (where applicable) and CAP agencies, will continue to engage in targeted, localized outreach efforts to notify customers of the availability and value of energy efficiency services. Marketing consists of contacting qualified income-eligible customers subscribing to the discount rate who have not received prior energy efficiency services. Telemarketing, direct mail, bill inserts, and literature distributed through social services agencies, government offices, and other networks when appropriate are also used to market the initiative. In addition, PAs are participating in statewide marketing efforts to encourage all customers to participate in energy efficiency initiatives. Those efforts will assist in driving income-eligible customers to take advantage of not only energy efficiency programs but also discount rates, fuel assistance, and other social programs. Awareness of the initiative is also gained through participation in local community events such as job fairs, senior centers, and employee presentations, which may include case studies. Outreach and marketing efforts, as well as PA collaboration, will be expanded as needed. Approaches may include building relationships with unemployment centers, medical service providers, and other venues that could reach potential income-eligible customers. PAs will continue to examine other potential service providers and venues that could reach income-eligible customers.
Three-Year Deployment Strategy/Roadmap	The PAs will coordinate efforts through the existing low-income weatherization and fuel assistance program via LEAN to ensure consistent implementation throughout the state and retain the advantages of the existing infrastructure of central coordination while avoiding the creation of a new or central entity. Training and workforce development will be accomplished by the PAs working with LEAN, DHCD, lead vendors, and CAP agencies to increase the number of qualified contractors, energy auditors, and administrative staff. The PAs in conjunction with LEAN, the lead vendors and the CAP agencies will continually review and evaluate new measures and technologies. All applicable revenue streams available will be leveraged to enhance services. Through marketing and outreach efforts, the PAs will attempt to broaden initiative participation. PAs will attempt to deepen efficiency penetration consistent with a comprehensive, whole house approach.

b. Low-Income: Multi-Family

LOW-INCOME	**<u>CORE INITIATIVE</u>** **MULTI-FAMILY**
Overview and Key Objectives	The Low-Income Multi-Family Retrofit core initiative provides cost-effective, residential energy efficiency improvements that benefit income-eligible occupants and owners of multi-family buildings. Energy efficiency products and services are implemented within the common areas as well as directly in the dwellings of residential, income eligible customers living in multi-family facilities (with 5 or more attached units), in which at least 50 percent of the occupants are at or below 60 percent of the state median income level. The Program Administrators will provide up to 100 percent of the funding for cost-effective projects with established caps based on projected savings. **Target Market:** Low-Income Multi-Family properties owned by public housing authorities, non-profit organizations as well as for-profit organizations are eligible to participate. The initiative targets residential customers on the discount rate and/or customers living in multi-family facilities with five or more dwelling units in which at least 50 percent of the occupants are at or below 60 percent of the state median income level in addition to the landlords and property managers of these buildings. Any changes to eligibility criteria will be addressed collectively between the PAs, LEAN, lead agencies and CAP agencies.
	New Enhancements: • In 2012, the funding of the Low-Income Multi-Family core initiative and Low-Income Single Family core initiative was proposed to be combined. The PAs continue to combine funding for the Low-Income Multi-Family and Single Family core initiatives in 2016-2018 to offer more flexibility in servicing the greatest potential number of income-eligible customers if demand for one initiative surpasses the other. Additionally, the PAs and LEAN will explore ways to address the disproportionate electric and gas Multi-Family budgets. Ongoing throughout program years 2016-2018. • The PAs will continue to work with the Best Practices working group to identify new cost-effective energy efficiency services, measures, and technologies that are appropriate to offer to income-eligible customers. Common area lighting controls

LOW-INCOME	<u>**CORE INITIATIVE**</u> **MULTI-FAMILY**
	provide an excellent opportunity to reduce wasted lighting energy in common-area applications such as stairwells and hallways when the area is unoccupied. In 2014, the PAs collectively went out to bid for the fulfillment distributor of High Efficiency Lighting Products for all residential and low-income, direct install programs. Through this process, the PAs have realized significant cost savings and are in the process of transitioning the bulb offer to allow for more installations of LED bulbs within income eligible customer homes. As new LED technology continues to emerge and pricing continues to decline, the PAs will look to transition to LED technology over the next three years exclusively as applicable and dependent upon PA budgets. • As a new initiative in 2010, the Low-Income Multi-Family core initiative focused on multi-family properties that were non-institutional dwellings owned or operated by non-profit entities or public housing authorities. In 2012, based upon available funding, some PAs also served for-profit properties under the same guidelines in which at least 50 percent of the occupants were at or below 60 percent of the state median income level. The Low-Income Multi-Family core initiative will continue to serve all three types of properties. Currently each type of property represents approximately one third of properties served, and PAs will continue to balance by type of property and by geography. Ongoing throughout the program years 2016-2018 • PAs will work with LEAN, the Low-Income Multi-Family Advisory Committee, state organizations such as the DHCD, and CAP agencies to increase qualified contractor participation in the initiative through training and workforce development. The PAs also plan to continue to support contractor and auditor training as needed. Ongoing throughout program years 2016-2018. • Currently, the Low-Income Multi-Family core initiative serves properties that are heated by gas and electricity. Historically, this initiative has provided incentives for cost effective gas and electric measures. PAs anticipate the addition of oil measures and potentially other deliverable fuels, if allowed by RCS regulations.

LOW-INCOME	**<u>CORE INITIATIVE</u>** **MULTI-FAMILY**
Core Initiative Design	**Measures Promoted:** PAs will pay up to 100 percent of the project cost with established dollar caps where applicable. Larger capital investment projects will be screened for cost-effectiveness (with the Low-Income Multi-Family Advisory Group). The measures available to each low-income multi-family property include: • Insulation (attic, wall, pipe, and duct) • Air sealing • Heating system repair and replacement • Programmable thermostats • Domestic water heating, including low-flow showerheads, faucet aerators, pipe wrap, water heating equipment, heat pump water heater (electric) • Lighting, including LEDs, CFLs, lighting fixtures, common area (interior and exterior) lighting upgrades and controls, torchieres • Appliances, including refrigerator and freezer replacement, ENERGY STAR® clothes washer replacement, power smart strips, window air conditioner replacement • HVAC/mechanical systems, including Energy Management System (“EMS”), motors and drives, chillers, air compressors, ventilation system repair adjustment or replacement, heat recovery ventilation/energy recovery ventilation, redistribution systems, temperature building controls • Weatherization repairs (electrical, repairs, roofs, etc.) • Health and safety The PAs will work with the MTAC to include new measures or technologies, as appropriate, and in coordination with LEAN’s other efforts.
	Implementation Strategy: The Low-Income Multi-Family core initiative services properties that have five or more units in which at least 50 percent of the occupants are at or below 60 percent of the state median income level, owned by public housing authorities, non-profit organizations as well as for-profit

LOW-INCOME	**<u>CORE INITIATIVE</u>** **MULTI-FAMILY**
	organizations. Eligibility for the initiative measures and services will be based on the established cost-effectiveness test, which includes agreed upon non-energy benefits, and will not be restricted, to the greatest extent possible, by rate class associated with the meter(s) for the facility. Eligible projects involve efficiency upgrades for buildings with currently high energy consumption and require that applicants participate in benchmarking their building's energy usage post-improvements. The Low-Income Multi-Family building inventory has been an innovative component of this initiative to both help identify potential participants and help determine usage patterns in this sector. The PAs will work in collaboration with the Low-Income Best Practices working group including LEAN, the Low-Income Multi-Family Advisory Committee, DHCD, lead vendors, and CAP agencies to collaborate and coordinate statewide on all aspects of the Low-Income Multi-Family core initiative, including but not limited to planning, delivery, implementation, education, marketing, training, cost-effectiveness, evaluation, and quality assurance. When topics to be discussed apply to both market-rate customers and low-income customers, PAs will further coordinate between initiatives as needed. The initiative will be structured to ensure that participants are provided with a whole building, fully integrated offering that targets both gas and electric end users. Once a property is deemed eligible, it will receive an energy assessment through a lead vendor or local CAP agency. The assessment evaluates the building shell, efficiency, and (for electric PAs only), the appliance conditions. All assessments include an evaluation of home health and safety. The CAP agency will then arrange for all applicable measures and services to be installed by a qualified contractor. Savings will be deepened by installing additional efficiency measures; to the extent the overall project remains cost-effective. The initiative piggybacks on the current DHCD low-income energy efficiency programs and all other eligible funding sources (*i.e.*, federal and state) to enhance services consistent with a whole-building approach. PAs will use a lead vendor or local CAP agency to administer the initiative. Sub-contracting will be appropriate due to the complexity of the work required. Low-income customer inquiries will be referred to the lead vendor/CAP agency, the Low-Income Multi-Family Advisory Committee, or PA by the MMI, as defined in the Multi-Family Retrofit Core Initiative. Low-income customers may also apply directly to the initiative via the Low Income Multi Family Energy Retrofits website, their PA and/or local CAP agency. An essential

LOW-INCOME	**<u>CORE INITIATIVE</u>** **MULTI-FAMILY**
	element of this initiative is that interested customers also have the option, at their discretion; of electing to participate in the Multi-Family Retrofit core initiative. This approach helps ensure that there are multiple paths to participation in energy efficiency initiatives in this unique market sector that has also been served over many years by skilled contractors and engineering firms. These firms will continue to be eligible to provide services in this sector, both through the Multi-Family Retrofit core initiative (and its terms and conditions) and, where qualified, as providers for the Low-Income Multi-Family core initiative under the terms and conditions of this initiative. <u>Customer Education</u> Energy efficiency education and information are included in all PAs energy efficiency initiatives. The primary forms of energy education are benchmarking building inventories, verbal communication between the auditor and the participants, as well as leave-behind materials. In 2013, the PAs collaborated with the Low-Income Best Practices working group and developed common, statewide educational materials. Educational materials will continue to be updated and provided to customers as applicable. The Low-Income Multi-Family core initiative plans to develop/improve education materials that will include education for landlords, property managers, building occupants, and property management personnel as well as development of case studies as applicable.
Delivery Mechanism	The initiative will be administered cooperatively by the gas and the electric PAs in conjunction with interested stakeholders. <u>Enrollment</u> Participants for this initiative may enroll through a local CAP agency, statewide website, the multi-family statewide toll free number, PA(s), the Low-Income Multi-Family website or other venue (use of the low-income multi-family website is required in most cases). <u>Participant Screening</u> Currently, the Low-Income Multi-Family Advisory Committee composed of LEAN, Community Development Corporations (“CDCs”), other non-profit owners of low-income non-institutional multi-family housing, and Public Housing Authorities (“PHAs”) are tasked with prioritizing low-income multi-family projects for each PA.

LOW-INCOME	**CORE INITIATIVE** **MULTI-FAMILY**
	The advisory committee integrates flexibility into their planning to handle unique needs of PAs and their customers or potential participants. The Low-Income Multi-Family Advisory Committee may include representatives of other sectors. Due to the nature of this market segment, most leads will be generated through the Low-Income Multi-Family Advisory Committee. However, leads coming in via other venues will be screened by the MMI and forwarded to the Low-Income Multi-Family Advisory Committee for eligibility confirmation. Upon confirmation of a project, the lead vendor or CAP agency is responsible for coordinating the appropriate parties to address the project needs based on protocols agreed to by the specific PA(s) and in consultation with the specific PA(s) to move the project forward. Whole Building Assessment Based on the outcome of the screening process, the appropriate technical resources will be assigned to conduct a whole building (fuel blind) assessment. The lead vendor or local CAP agency will attempt, through the screening process, to identify all resources required for the assessment. However, there may be instances where additional expertise is required and therefore more than one site visit is necessary. Technical assessments and engineering studies will be conducted as needed. At the time of the assessment, education will be provided to participants and instant saving measures will be installed, as appropriate. Integrated Proposal for Energy Efficiency Services Using the findings from the site-specific assessment, the appropriate parties will draft a project proposal that will include gas and electric cost-effective measure opportunities and other available services where applicable. Where appropriate, the project proposal will be forwarded to the appropriate PA(s) for approval. Once the comprehensive offer has received PA approval (if necessary), it will be presented to the participant by the parties required to help the customer fully understand the offering. Delivery of Measures and Services The lead vendor or CAP agency will coordinate the delivery of the measures and services. The installation contractors will strive to have

LOW-INCOME	**<u>CORE INITIATIVE</u>** **MULTI-FAMILY**
	all dwelling unit measures installed in a single visit to minimize disruption for the tenants; however, multiple visits may be required for the installation of common area measures. All installations are coordinated with the owners, property managers and the tenants. <u>Quality Assurance/Quality Control</u> Quality assurance will be performed in support of this initiative. Quality assurance is completed by the CAP agencies, as well as by a PA-funded independent third party vendor. The delivery mechanism serves to minimize lost opportunities and encourage deeper savings in the following ways: • The increased incentive amounts may allow for achieving energy savings that would not be possible if this customer sector had to provide a significant co-payment. • Having the PHAs and CDCs and other owners of non-institutional low-income multi-family housing involved in the process helps facilitate access to the tenant spaces, which has been traditionally cited as a potential barrier in the multi-family market.
Marketing Overview	Demand for the Low-Income Multi-Family core initiative will be managed jointly by the PAs and the Multi-Family Advisory Committee. The PAs will engage in outreach efforts to notify customers of the availability and value of energy efficiency services to stimulate interest in the initiative and operate within budgets. Marketing will consist of contacting landlords or property managers of income-eligible tenants as needed. Direct mail, bill inserts, case studies and literature distributed through social service agencies, housing funders, government offices, community outreach, and other networks can also be used to market the initiative. PAs will use their relationship with PHAs, CDCs, community based outreach and other income-eligible property managers to market the benefits of the initiative. In addition, PAs are participating in statewide marketing efforts to encourage all customers to participate in energy efficiency initiatives. Those efforts will assist in driving income-eligible customers to take advantage of not only energy efficiency programs but also discount rates, fuel assistance, and other social programs when appropriate.

LOW-INCOME	**<u>CORE INITIATIVE</u>** **MULTI-FAMILY**
Three-Year Deployment Strategy/Roadmap	The PAs will coordinate efforts via LEAN to ensure consistent implementation throughout the state and retain the advantages of the existing infrastructure of central coordination while avoiding the creation of a new or central entity. Participants may enroll through a CAP agency, statewide website, low-income multi-family website, multi-family statewide toll free number, PAs or other venue. Many leads will be generated through the Low-Income Multi-Family Advisory Committee; however, leads coming in via other venues will be screened by the MMI and/or the PAs and forwarded to the lead vendor/CAP agency for eligibility confirmation. Once eligibility has been confirmed, the Low-Income Multi-Family Advisory Committee prioritizes the low-income multi-family projects for each PA as needed. Training and workforce development will be accomplished by the PAs working with LEAN, DHCD, and CAP agencies to increase the number of qualified contractors, energy auditors, and administrative staff. The PAs in conjunction with LEAN and the CAP agencies will continually review and evaluate new measures and technologies. Through marketing and outreach efforts, the PAs will attempt to broaden participation. PAs will attempt to deepen efficiency penetration consistent with a comprehensive, whole building approach. PAs welcome continued dialogue with Massachusetts affordable housing stakeholders to evaluate opportunities to maximize the opportunity for capturing energy efficiency savings at the time of financing and refinancing of affordable housing properties. PAs have committed to engaging with these stakeholders to jointly explore and scope these opportunities via planning meetings. The PAs are excited to learn from the experts within the Massachusetts Housing community about the timing, scope and processes of affordable housing finance and refinance, to share the PAs technical resources and understanding on efficiency programming, and to work together to identify critical moments of potential opportunity in the finance and refinance process to secure additional savings. The PAs look forward to receiving additional and more specific information from the MA affordable housing stakeholders so that the PAs can explore opportunities to incorporate program design and implementation refinements that result from these dialogues within the 2016-2018 Plan term. In accordance with the Resolution, the PAs will continue to work with the Commonwealth's housing financing agencies and LEAN (with mutual expectations and deliverables) to develop and implement enhanced approaches to leverage multi-family refinancing events to maximize retrofit potential. The parties will specifically consider

LOW-INCOME	**CORE INITIATIVE** **MULTI-FAMILY**
	performance-based retrofit products. The PAs will present the results of these efforts and specific proposals derived from them by the close of Q1 2016.
Special Notes	

G. Commercial & Industrial Programs

1. Overview of C&I Programs – New Construction & Retrofit

As discussed in greater detail below, the Program Administrators organize their programs, and the outreach and marketing that support them, according to the way the non-residential marketplace is organized – *i.e.*, there is the built environment and the environment being built or renovated. The built environment encompasses existing buildings and the market actors that own, service and occupy them and includes property owners and managers, facility managers, the manufacturers and vendors of products and services that address building or occupant needs, and the occupants and tenants who work in the space. In the environment being built or renovated the key actors include developers (for both owner occupancy and tenancy), architects, engineers, equipment specifiers, equipment suppliers, and many others who serve specialized niches.

The two umbrella programs that serve these markets, Retrofit and New Construction, are mature and well developed. Their lineage extends as far back as the mid-1980s. They were among the first utility-based energy efficiency programs in the country. The design, organization, and delivery structure of the Massachusetts programs have served as models for most of the other non-residential energy efficiency programs developed throughout North America today.

While these programs have been, and continue to be, highly successful, the PAs continually seek ways to improve delivery of the services they offer, to enhance program reach into relatively under-served markets, and to engage customers they have served in the past with new offerings and technologies to further increase the efficiency and performance of their buildings. Examples of sources for program improvement concepts are described below.

2. Sharing Innovations in Program Design, Marketing, and Delivery

The C&I Management Committee ("C&IMC") serves as the ongoing venue for sharing individual PA innovations in program design, marketing, and delivery. The C&IMC regularly reviews its processes and operations in order to continuously optimize the balance between innovation and consistency and will continue these efforts throughout 2016-2018.

Consistency in offerings, eligibility and incentives is fundamental to all PA program design and delivery. Consistency assures customers that they will receive uniform services no matter where their facilities are located in the Commonwealth and ensures that the benefits of ratepayer funded programs are distributed both widely and equitably. That said, it is important to recognize that innovation by individual PAs in program design and delivery is equally important. The flexibility of individual innovation allows PAs to respond to the variations of local markets and market conditions, but more importantly it is through this experimentation – be it in program design, product promotion, or a unique focus on distinct market segments of local importance – that concepts that might have statewide applicability can be tested and evaluated in a limited low-risk/low-cost environment, with the results then shared and scaled up statewide as appropriate and practicable.

- *Independent Evaluations of our own Programs:* For many years, third-party evaluations, both process and impact, have been conducted on many of the key components of the Massachusetts C&I programs. The results and recommendations from these evaluations are reviewed and, when appropriate, incorporated into PA programs going forward.
- *Evaluations of Programs in Other Jurisdictions:* Due to the fact that efficiency program designs in other leading jurisdictions (such as California, Oregon, New York) are so similar to Massachusetts programs, PA staff often review evaluations from programs in these states to glean improvement concepts that could be applied locally.
- *Review of Industry Best Practices and Other Studies and Conferenced Proceedings:* Organizations like the ACEEE produce a wealth of useful studies and industry best practice reviews, and also publish and archive professional papers and presentations from their numerous conferences and study sessions. Similar studies are available from the Department of Energy's network of national research laboratories, regional efficiency organizations, such as the Northwest Energy Efficiency Alliance, and industry collaborations like the Consortium for Energy Efficiency. Additional sources of thought leadership and information include the Rocky Mountain Institute, the Institute for Market Transformation, the New Buildings Institute, and E Source.
- *Peer Networks:* Energy efficiency programs do not compete with each other; therefore, there is a culture of collaboration among the staff and managers of these programs across the country. PA staff members know many of their counterparts, and there is a regular exchange of information and advice among peers for the mutual benefit of the industry.
- *The EEAC and Other Stakeholder Input:* The PAs are active and engaged participants in Council proceedings and in various Council-facilitated public participation processes. PA staff has participated in over 100 Council-related public meetings since 2013. Further, PA staff have invited Councilors, as individuals and small groups, to participate informally in C&IMC meetings and other internal team meetings in order for them to develop a fuller understanding of how the PAs work together to administer and advance the programs.

The PAs have benefitted from both the formal Council and stakeholder input processes and the informal exchange of ideas and concepts that comes from this form of continuing close engagement. Many of the concepts advanced in these venues and exchanges are reflected in the detailed program designs that follow.

Going forward, the PAs are fully committed to continuing this dialogue and communication regarding program developments and progress towards goals throughout the entire Three-Year Plan term, including, in accordance with the Resolution, regular and specific updates to the Council on C&I program progress and penetration (including segment specific approaches - especially for challenging subsectors such as small and mid-size commercial, small hospitals, non-profits, and multifamily - measures such as street lighting and LED costs and conversion, and innovations such as strategic energy management) through semi-annual presentations to the Council. The PAs will collaborate with DOER by the end of 2015 to consider how best to present this information (*e.g.*, potential use of roundtables, webinars, etc.) and to develop a schedule for updates on specific topics. Also, in accordance with the Resolution, the PAs will demonstrate a clear commitment to Combined Heat and Power ("CHP") installations, and tracking CHP project savings and expenditures (subject to customer confidentiality requirements) against PA's CHP Plan projections in semi-annual presentations to the Council and in data sets provided on Mass Save Data. The PAs are also committed to providing, in accordance with the Resolution, more detail about the PA's Massachusetts Technology Assessment Committee, and semi-annual updates to the Council on progress reviewing and implementing new technologies into programs.

The PAs believe this thoughtful, prioritized, and systematic approach will ultimately result in a greater visibility into the programs and their progress and at the same time will be respectful of the valuable time resources of all parties and provide the Council with considerably greater appreciation and understanding of the major program developments and drivers.

Over the course of the development of this plan, PA staff accessed, or re-accessed, many of these sources of program innovation. In addition, the PAs contracted with a highly-respected independent consultancy, E Source, to conduct targeted research on best practices and emerging trends and technologies in areas of particular importance to the Council and the PAs. E Source also provided independent verifications that the PAs internal research and conclusions did, indeed, reflect the most current assessments of industry best practice.

Lastly, it is important to recognize that the process of program improvement and adjustment of delivery to incorporate new technologies, new delivery modes, and changing market and economic conditions is continuous and ongoing. In that context, a Three-Year Plan is, by necessity and practicality, a strategic document. In discussing our commercial and industrial programs, the PAs attempt to outline a reasoned and balanced path forward into the future in an industry where technologies and programs are evolving at an exponential pace. In areas where there exists reasonable certainty about the precise nature and timing of the program enhancements being proposed, the plan sets forth that detail. In other areas, the necessity or desirability for program changes are identified and discussed along with a proposed path forward, but the exact details and schedule, of necessity, require more investigation and planning. The PAs take the position that a well-conceived strategic plan is one that captures future program details and schedules when those can be confidently stated, and lays out the scope of the issue and the plan of attack when they cannot. For example, the last three-year plan had no discussion of "big data" because no one in 2012 – PAs or stakeholders – could have imagined its 2015 implications regarding program design and delivery, market segmentation, evaluation, behavior tracking, etc. Undoubtedly, three years from now the drafters of the 2019-2021 Three-Year Plan will be discussing in some detail program concepts and technologies that are unknown to us today.

3. Accomplishments During 2013-2015 Plan Term

The program plans for 2016-2018 rest on the solid foundation constructed during the previous three-year planning cycles. At the macro level, key C&I accomplishments during the 2013-2015 Plan Term (through the end of 2014) include the following:

- *Energy Savings*
  - 9.5 Million therms per year – equivalent to the usage of roughly 10,000 residential homes
  - 720 Thousand MWh per year – equivalent to the usage of roughly 100,000 residential homes
- *Benefits*
  - 40 percent increase in gas benefits to $200 Million
  - 16 percent increase in electric benefits to over $1.4 Billion
- *Participation*
  - 88 percent increase in gas participation – equivalent to roughly 4,500 additional businesses
  - 27 percent increase in electric participation – equivalent to roughly 3,800 additional businesses
  - 25-30,000 total C&I customers participating annually
- *Green House Gases*
  - Reduction in CO_2 emissions equivalent to the removal of nearly 115,000 automobiles from Massachusetts roads

In addition, the PAs have successfully evolved their C&I programs and produced many notable achievements including:

- Economy and weather adjusted statewide C&I electricity sales have declined and are projected to continue declining over the three consecutive years of this plan, for the first time ever;[25]
- Conducted 20 code compliance training sessions, attended by almost 700 code officials, architects, and contractors;

[25] US Energy Information Agency and ISO-New England.

- Completed a redesign and rewriting of the C&I section of Mass Save® website, improving organization, navigation, and customer-oriented language;
- Grew C&I customer awareness of Mass Save® precipitously to its highest point ever (66 percent); and likewise grew C&I customer use of the Mass Save® website nearly tripling traffic over the last two years (from 13 percent to 34 percent).[26] Brand awareness among C&I customers even outpaced that of residential customers (66 percent to 54 percent);[27]
- Drove explosive growth of the LED lighting market – broadening and deepening penetration in virtually every end use principally as a result of the upstream approach to lighting initially launched in 2012. The PAs success has been documented in the recent LED market effects evaluation[28] which found that as of 2014, 63 percent of Massachusetts commercial customers reported having installed at least one type of LED lighting in their facilities versus just 46 percent in California. Similarly, 42 percent of Massachusetts commercial customers reported installing screw-based LEDs versus only 12 percent of their counterparts in California;
- Developed a new delivery mechanism – the Upstream Approach – that reaches and engages significantly more customers and influences manufacturers to produce more of their premium efficiency products and distributors to stock and promote them;
- Achieved substantial growth in the number of CHP participants, driven by rapid uptake of smaller customers identified and prescreened by the PAs as good candidates for the technology. In addition, positive realization rates and comparatively low rates of free-ridership have both fostered a favorable environment for CHP expansion and proven that the programs are meeting customers' needs and achieving desired results;
- Expanded the Upstream portfolio to include additional lighting products and technologies, as well as HVAC and water heating equipment – with a tremendous increase in participation and savings;
- Completed a significant body of best practices research – in Commercial Real Estate, Retro-commissioning, etc. – some successfully conducted in collaboration with EEAC Consultants and others including involvement from various PAs, third party subject matter experts, and external stakeholders;
- Consolidated Residential & C&I MTAC into a single entity and the addition of Connecticut representation to increase efficiencies, improve coordination, and expand reach;
- Added many cutting-edge measures/technologies to the portfolio of offerings – including ductless fume hoods, green cooling towers, drain water heat recovery, pump coatings, window glaze, diaphragm pump control, polymer bead laundry, etc.;
- Statewide implementation of a standardized approach to serving Municipal customers;

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[26] *2014 Massachusetts Statewide Marketing Campaign, Post-Campaign Report*, Opinion Dynamics February, 2015, at 2.

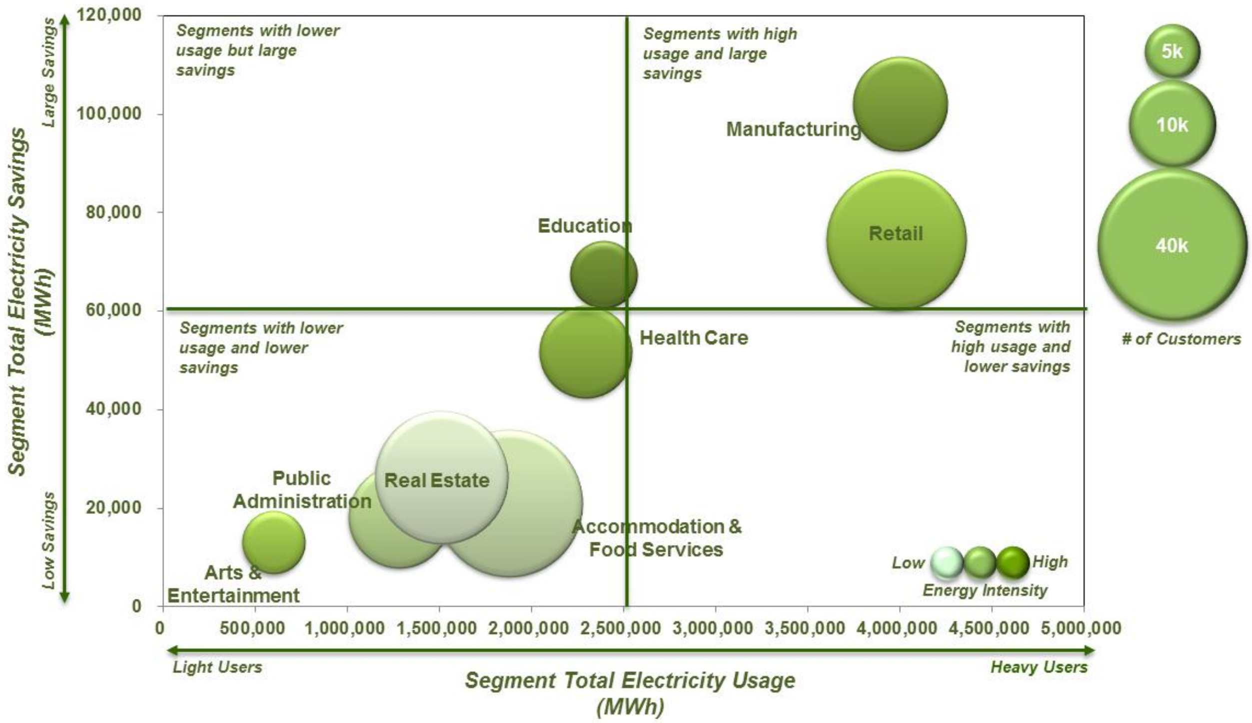
[27] Id. at 16.

[28] *Final Draft Report of Massachusetts LED Market Effects: Baseline Characterization*, DNV GL, March 1, 2015.

- Delivered specialized best practices in EE sales training through a nationally-recognized firm to improve the level of commercial excellence both among PA sales staff and trade allies including manufacturers, distributors, and contractors;
- Launch of the Sustainable Office Design initiative to capture greater market share in leased office space;
- Developed a number of segment-specific approaches to serving customers – grocers, municipalities, offices, etc.;
- Collaborated with DCAMM to dramatically increase penetration of high efficiency equipment in state owned/operated buildings.

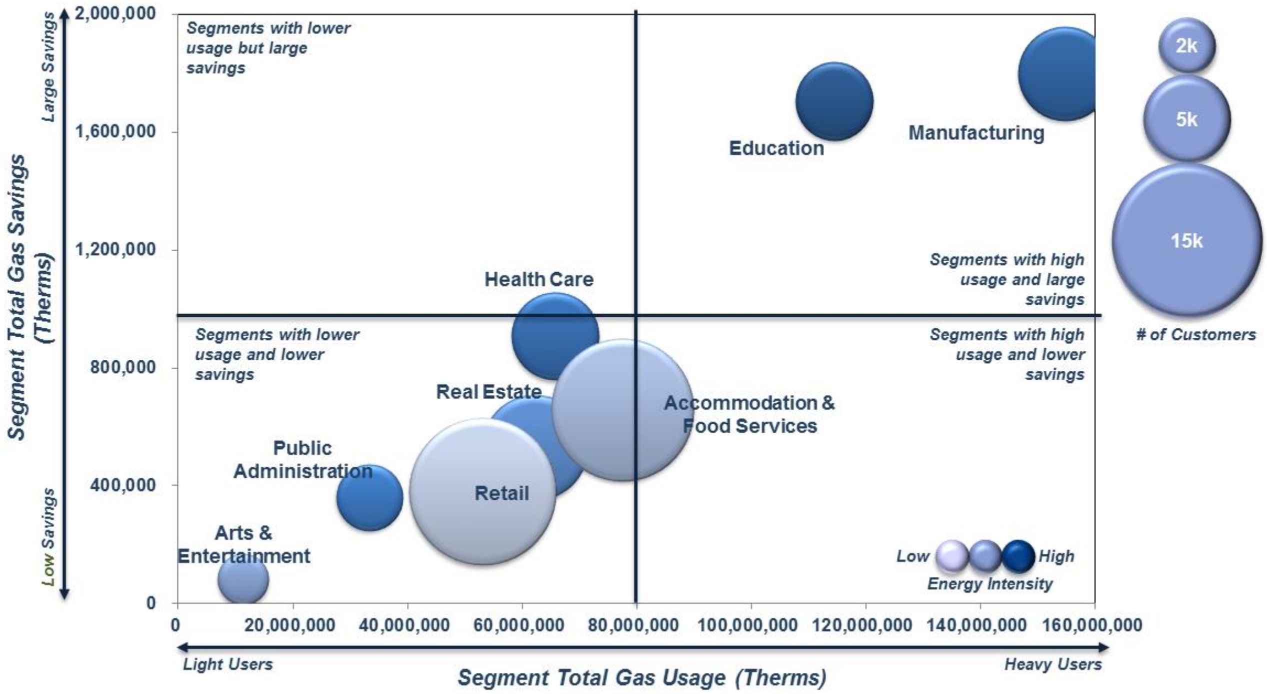
For reference purposes, the following exhibits provide a high level snapshot of the composition of the statewide C&I customer base including the size of each customer segment in terms of customer counts and usage as well as the gas and electric savings generated from each segment historically.

a. C&I Electric Savings & Usage by Segment: Historical Overview



Source: ***2013 Commercial & Industrial Customer Profile Report, DNV GL, March 27, 2015***

b. C&I Gas Savings & Usage by Segment: Historical Overview



Source: ***2013 Commercial & Industrial Customer Profile Report, DNV GL, March 27, 2015***

4. <u>Highlights of 2016-2018 Enhancements</u>

The sections below provide descriptions of a number of new initiatives or improvements the PAs plan to implement over the next three years. The level of detail varies as some elements are more conceptual in nature at this juncture and are planned for introduction in the out years of the Plan. In those cases further study and/or evaluations of field testing (either in Massachusetts or in another jurisdiction) may be warranted before the enhancement is introduced as a full program element.

The following is a representative listing of some of the proposed program or administrative enhancements discussed in further detail in the sections following, or elsewhere in the plan:

- An online incentive application portal with a menu driven interface enabling the creation and submission of customer applications for incentives. This will reduce application errors, accelerate the review process, and greatly enhance the overall customer experience. The PAs expect that this added functionality will be particularly helpful for mid-sized customers, as studies often conclude they lack the technical expertise to fill out the current application forms. This menu based, all-in-one system will make it easy for anyone to fill out and submit an application for incentives.
- A thorough analysis of the current Small Business program model. This long-standing program is regularly cited as a best-in-class model and is now widely copied by other program administrators around the country. Here in Massachusetts, it continues to be highly successful in reaching small business customers, and evaluations repeatedly show that these

customers are very satisfied with the services they receive. However, the PAs recognize that in order to continue with this success they will need to anticipate the ever-changing needs of small commercial customers and assure that new technologies and new delivery options are available to address these needs.

- Expansion of the portfolio of upstream offerings where appropriate – including water heating technologies, beginning in fall of 2015.
- Staged revisions to retro-commissioning services based on the findings of the joint PA/EEAC consultant best practices study.
- Encouragement of Net Zero Buildings as the premium option in the Whole Building path in the New Construction Program.
- Improved comprehensiveness in mid-sized new construction buildings through the use of Advanced Buildings and other tools. Broader application of Sustainable Office Design as a means of delivering integrated and comprehensive technical solutions to the leased commercial office market.
- Increased focus on gathering early intelligence on the efficacy and cost-effectiveness of emergent energy efficient technologies – both as they enter the market and earlier when they are in the market readiness testing mode.
- Evolving formal and informal cooperation within the region and beyond through joint R&D and cooperative exchange of information regarding emerging technologies.
- Expanded segment-based delivery approaches to broaden participation, increase comprehensiveness and depth of savings, and enhance the customer experience.
- A broader menu of training offerings for customers, trade allies, vendors, and PA staff and contractors that provides services to the PAs, as well as the use of new modalities for delivering trainings.
- A reorganized and refreshed Mass Save® website that better directs customers to information specific to their needs in their business segment. The new design will focus less on technologies and programs and more on customers and their end uses. It will also feature new materials directed to specific segments and their needs.

5. Mechanisms for Program Collaboration, Continuous Improvement, Incorporating Emerging Technologies, and Sharing and Incorporating Best Practices Information

a. Introduction

The vital feedstock for PA program advancement is a continuing stream of new energy-efficient technologies that can produce demonstrable, repeatable, verifiable, and cost-effective savings. A robust process to identify and screen candidate technologies is not only critical to meeting savings goals, it also facilitates innovation, provides a platform for technological development, and addresses customer expectations that the PAs will rigorously and impartially vet manufacturer and vendor savings claims on their behalf. And, over time, it transforms the market.

The PAs identify prospective new technologies through multiple sources and streams of information including the following.

b. In-house R&D

Many of the PAs provide efficiency services in several states, each of which has a similar need for a pipeline of new efficiency measures. These PAs have in-house staff of technical and engineering professionals with expertise in such areas as energy codes and standards, building energy simulation tools, lighting technology and controls, assessment of energy efficiency products, and product development who are dedicated to new technology research and, in collaboration with their evaluation colleagues, savings verification. Examples of products in various stages of vetting by individual PA technical staff include the following:

- Air source and water source gas engine driven heat pumps;
- Several proprietary gas fired heat pumps with variable refrigerant flows;
- Removable jackets for valves, fittings and specialty piping in boiler rooms and other mechanical spaces;
- Advanced rooftop unit controllers that may have application in big box stores;
- A pipe, valve and tank insulation tool that can be used to calculate savings for insulating steam or hot water piping, valves and tanks for customers with usage of less than 50,000 therms per year;
- Distributed refrigeration that can reduce the pounds of refrigerant used and increase usable floor space in supermarket applications;
- Electrically commutated ,motors for pumping applications;
- Drain water heat recovery;
- Heat pump dryers;
- Automatic temperature control which provides thermostat optimization, load shifting and demand response control as well as communication and bill estimation capabilities;
- Thermal storage optimization control strategies to shift hot water load;
- A boiler QI tool which optimizes the heating system performance and boiler sizing;
- Smart communicating appliances which allow communication and utility control of appliances;
- Advanced buildings net energy optimizer (NEO) building energy modeling;
- Analytics to assess post construction zero energy building performance;
- Existing building HVAC retrofit controls;
- Emerging HVAC technologies;
- Automated window shades;

- Exterior performance lighting;
- Existing space performance lighting;
- LED integrated control logic;
- Smart grid controlled street lighting;
- A variety of emerging lighting technologies
- Window glazing;
- Highly efficiency filtered fume hoods;
- Smart plugs;
- Ozone laundry;
- Air operated double diaphragm (AODD) pump control;
- Washing with polymer beads;
- Hand dryers;
- Building insulation;
- Energy recovery filters.

The companies also cross-pollinate information gathered from research and field testing between the states they serve. For example, National Grid in Rhode Island is engaged in piloting several commercial sector behavior initiatives the results of which will be made available for review and consideration in Massachusetts. The synergies generated by this multi-jurisdictional sharing of information reduce R&D costs for the Commonwealth, and for the other states.

c. Partnerships with MOU customers

In 2013, as a byproduct of its confidential MOU relationship with Proctor & Gamble ("P&G"), Eversource learned that P&G was in the process of developing a new cold water washing product for commercial applications that had potential for significant gas and water savings for customers with large laundry operations, such as hotels, institutions, assisted living, etc. In 2014, Eversource partnered with P&G to test the product in a controlled setting with an Eversource lodging customer, using both gas and water metering equipment. When the product's savings were proven and quantified, the PAs could add the product as an approved measure, and P&G could promote nationally that the savings value of its new product, the Tide® Professional Coldwater System, had been verified by a highly-credible independent authority on efficiency – Eversource. In another case, National Grid and Eversource are helping EMC Corporation (a joint MOU customer) develop an RFP to select a monitoring-based commissioning ("MBCx") contractor to implement MBCx across its entire U.S. real estate portfolio. EMC Corporation will apply the lessons from its Massachusetts experience in their North Carolina and California facilities.

d. Cooperative relationships with similar technical bodies at other program administrators or regional efforts

The PAs have established formal and informal working relationships with such organizations as the Consortium for Energy Efficiency ("CEE"), the Northwest Energy Efficiency Alliance ("NEEA"), the California Emerging Technologies Coordinating Council ("ETCC"), the Northwest Regional Technical Forum ("RTF"), NYSERDA's Emerging Technologies Accelerated Commercialization initiative, Southern California Edison's Lighting Research Program, the Fraunhofer Center for Sustainable Energy Systems, the Food Service Technology Center, several of the Department of Energy's National Research Laboratories, etc. These relationships can involve a continuum of activities from simple information exchange to participation in jointly funded and managed research, technology assessments, or field tests.

For example, the development of the Sustainable Office Design ("SOD") initiative started as a joint project to develop technical specifications for energy-consuming office spaces initiated by Eversource, National Grid, and Southern California Edison, and ultimately involved several other West Coast utilities. Also, the PA-sponsored training delivered to the Massachusetts Water and Wastewater facility operators by faculty from the University of Wisconsin ("UW") originated in training developed by UW for the Wisconsin program administrators. Additionally, Eversource and National Grid co-sponsored new insulation research at the Fraunhofer Center for Sustainable Energy Systems with the goal of reducing barriers to insulating older building types in the Northeast.

As a forward-looking example, in 2016 the PAs will convene a meeting between peer leading energy efficiency program administrators, both regionally and nationally, and a select group of lighting industry experts for the purposes of: (1) identifying LED technologies that are market ready (*i.e.*, reliable and cost-effective) or will be in the near term; and (2) exploring potential common approaches to integrating these technologies into efficiency programs in a manner that simultaneously aligns with policy objectives and serves the best interests of customers. In addition to the obvious value of sharing implementation experience between jurisdictions, the PAs believe there is potential benefit in developing common messaging about program expectations to the lighting industry.

Many PA engineers are also involved as technical experts on regional and national committees (*e.g.*, establishing national standards for commercial kitchen equipment, designing an Advanced Roof Top Unit Controllers program, etc.). National Grid staff in New York collaborate with NYSERDA staff in the latter's emerging technologies program, and the two have collaborated in a sustainability and efficiency program for hospitals, the lessons from which will be shared with Massachusetts. Eversource recently participated in CEE's Connected Committee to develop a coordinated national response to the new ENERGY STAR® Program Requirements for Connected Thermostat Products specification.

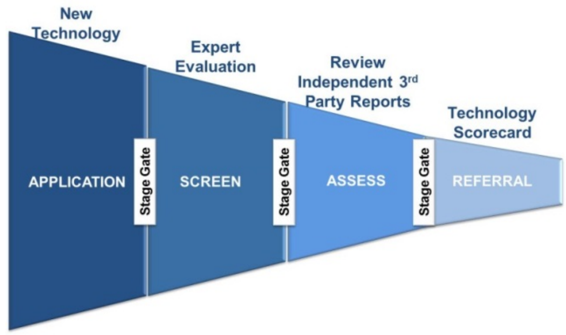
e. Supplier and manufacturer product submissions

Manufacturers and distributors of energy-consuming equipment regularly submit product information, and accompanying savings claims, to the PAs and petition to qualify them for program eligibility and incentives. All such requests are referred to the MTAC, as described below.

6. The Massachusetts Technology Assessment Committee

MTAC consists of key technical and evaluation staff from each of the PAs. A Project Manager designated by the PAs coordinates the work of the Committee. Also, the chair of the Connecticut Joint Utility RD&D Program attends monthly MTAC meetings for the purpose of sharing information about ongoing technology research, tests, and results from that state.[29]

The Committee addresses both residential and commercial/industrial technologies, drawing on the subject matter experts on the Committee, other subject matter experts at the various PAs, and outside expertise as necessary. MTAC meets monthly while a variety of ad hoc technology or issue-specific subgroups meet as required.



MTAC is both a proactive and a reactive body. It proactively identifies emerging technologies that may have proven savings, are reliable, and generally available and market ready to include in the programs. It does so by keeping abreast of industry literature and by coordinating and networking with groups around North America who have missions similar to that of MTAC. It also manages inbound requests for consideration of a new or unfamiliar technology that come from manufacturers, vendors or customers. These requests are generally made to an individual PA and then forwarded to the Committee, or are received through a process accessible via the Mass Save® website.

MTAC establishes and publishes threshold eligibility requirements that must be met to qualify products or processes as program-eligible. MTAC documents its findings in a standardized manner and disseminates them to the PA program managers, technical staff, account managers, and outside parties such as vendors, customers, and other program administrators beyond Massachusetts, as appropriate. After MTAC qualifies a product or process, the appropriate PA subcommittee (lighting, non-lighting electric, or gas) then leads efforts to determine how to actually integrate it into the program (incentive levels, application requirements, quality control, etc.) offerings. Documentation of recently reviewed technologies is always posted on the Mass Save® website at:
http://www.masssave.com/en/professionals/business-opportunities/assessment-of-new-efficiency-technologies

29 The Connecticut Joint Utility RD&D Program reviews technologies submitted to the Connecticut Energy Efficiency Board for potential inclusion in programs in that state. The RD&D group meets monthly for application review with a Policy Working Group ("PWG") comprised of professionals from the energy efficiency, science and technology, economic development and legal communities.

MTAC provides quarterly status updates to internal stakeholders such as the C&I and Residential Management Committees as well as the Energy Efficiency Advisory Council along with semiannual updates to other external stakeholders.

MTAC has the following principal functions:

- It provides information, documented technical interpretations and technology assessments to the PAs and is the authority for consistent program interpretation of technical matters;
- The Committee reviews candidate technologies according to industry-standard protocols, documents its decisions in a consistent and unbiased manner and disseminates its conclusions and technical interpretations in a standard format;
- It determines whether a specific new technology is program-eligible, and then refers it to the appropriate PA subcommittee to develop implementation requirements;
- When appropriate and directed by the PAs, it develops common program implementation materials or procedures including: technical specifications, technical study/commissioning protocols, equipment baseline reference sheets, inspection forms, and other technical and administrative support materials, for use by PA staff and contractors;
- It coordinates its work with the EM&V staff at each PA in order to support the determination of program savings values;
- It responds to inquiries from third parties, primarily vendors and manufacturers, who wish to have their products considered as incentive-eligible through the Massachusetts programs.

Over the next three years the PAs will continue to build upon the technology identification and vetting systems and cooperative alliances discussed above. The PAs will seek opportunities to both expand collaboration with existing partner organizations where the sharing of expense and/or technical expertise has added value for Massachusetts ratepayers, as well as seek out new opportunities for collaboration with other program administrators, government and university research laboratories, and regional technology development organization.

7. C&I Program and Core Initiative Descriptions

a. C&I New Construction: New Buildings & Major Renovations; Initial Purchase & End of Useful Life

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Overview &	The New Construction Program has two core initiatives. The objective of the first – New Buildings & Major Renovations – is to offer developers

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Key Objectives	of new buildings, and the owners of existing buildings that are undegoing major renovations or additions, a menu of efficiency services and incentives that are tailored to complement their unique ownership objectives and investment criteria, and can add value no matter where their building is along the design and construction continuum and can do so without impacting the design/build schedule. The second – Initial Purchase & End of Useful Life – encourages customers purchasing new energy-consuming equipment, or replacing equipment that has reached end of useful life or failed, to opt for the most efficient choice within each product category. When new buildings are designed and constructed, and when existing ones are renovated or expanded, there is a window of time to increase the efficiency and reduce the demand profile of the project dramatically at relatively modest incremental cost. The greatest potential to achieve savings, and to add value to the customer, occurs when PA new construction representatives, and the team of pre-screened energy design experts at their disposal, can engage with designers and their projects in the initial conceptual phase. Here the project can be examined comprehensively, allowing for design assistance, scenario modeling, and whole building equipment specification. At this early stage measures that can commonly be considered include orientation and site considerations, envelope improvements (*e.g.*, insulation above code), motors and drives, HVAC equipment and system design, and lighting design and controls, including daylighting. These fundamental early design decisions can shape the energy and demand costs of a building for its entire life, which in New England can be a hundred years or more.[30] Similarly, initial equipment choices may establish energy consumption patterns for decades, until that equipment fails and must be replaced, or until a more costly retrofit project is proposed. If this narrow and fleeting window of opportunity to influence building design and equipment specification is missed, it is not hyperbole to say that it is lost for a lifetime. The services provided through the New Construction program help lower building operating and maintenance costs throughout its entire life cycle while increasing comfort, health, and productivity for building occupants. If the design process is well underway when program representatives engage, a more prescriptive approach to individual measures, or a custom approach to discrete building systems, can still

[30] Approximately 70% of the building stock in Massachusetts is more than thirty years old.

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	capture considerable efficiency, again at relatively modest expense. The objective of the New Construction program is to offer building owners and designers a menu of efficiency services and incentives that are tailored to complement each customer's ownership objectives and investment criteria, can add value no matter where their building is along the design and construction continuum, and can do so without impacting the design/build schedule. The PAs aggressively seek out and recruit owners and designers involved in the construction or major renovation of all non-residential buildings. This process requires multi-faceted strategies, because development is, by its nature, a competitive process that largely takes place out of the public eye, often until a construction trailer and fence appears on site. The challenge is to gain market intelligence – from a myriad of sources – so that program representatives can intersect with customers as early as possible in their process, preferably at the time when the fundamental design decisions that most impact future energy use are being made. PA services range from a package of expert design and engineering assistance and incentives at the level of the whole building (when the project is in early design), to similar assistance within discrete facility systems, components, or processes in cases where the project is more advanced, to prescriptive incentives for a large menu of pre-selected premium performance lighting, HVAC, and other mechanical measures – or a mix of all of these options. For many participants, the value of this program is not just in the incentives, but also for the opportunity to access the expert, impartial, unbiased technical assistance provided by PA staff and through the stable of technical experts with whom they collaborate. Thousands of similar, but smaller, time-dependent opportunities occur whenever energy-consuming equipment fails in existing buildings. Just as in new construction, there is a brief window of opportunity for the program to intervene to present a more efficient option when the customer is focused on purchasing replacement equipment quickly and returning their facility to full operation. In these cases, the PAs work with equipment vendors and suppliers – often using an upstream approach – to ensure that premium alternatives are available and promoted in that brief window.

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	Target Market Program staff aggressively attempt to identify and influence decisions affecting all non-residential new construction, renovation, and addition projects in the Commonwealth, as well as businesses replacing outmoded or failed equipment outside of a more comprehensive construction or upgrade project.
	New Enhancements The New Construction program is a mature and successful offering with broad market recognition, understanding, and acceptance. Nonetheless, the PAs constantly monitor peer programs in other jurisdictions (many of which are duplicates of the Massachusetts program model) in search of ideas for delivery or administrative improvements. Among the areas the PAs will consider for inclusion in their New Construction program during the coming plan term are the following: <u>Net Zero Buildings</u> Massachusetts, California, the Pacific Northwest, and New York are the leading jurisdictions advancing Net Zero – the vision that a building could have no energy impact on its environment; that is, a building can be designed to consume dramatically less energy than current practice, and then produce its reduced requirements on site using renewable sources. There are many challenges to achieving this vision, as set forth in the report of the Massachusetts Zero Net Energy Task Force.[31] Nevertheless, the path to a visionary goal almost always consists of numerous incremental steps – steps that change building design and technology, owner and developer investment approaches, government regulation and tax policy, etc. Because each of these steps towards Net Zero is likely to introduce technologies, concepts, and policies that carry the potential to make all new buildings (and renovations of existing ones) incrementally more efficient, even for the vast majority of owners who are not driven to achieve Net Zero, the PAs have an interest in staying closely engaged in the Net Zero movement. This engagement will take place on several fronts.

[31] *Getting to Zero Final Report of the Massachusetts Zero Net Energy Buildings Task Force*, March 11, 2009.

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	First, the PAs will continue to closely monitor developments in Massachusetts with the DCAMM/DOER ZNE Advisory Council and Working Group, as well as in other states, like New York, which have recently evaluated ZNE pilots and may sponsor further building science/NZE research and demonstration projects going forward. Second, the PAs will assess opportunities for joint NZE R&D efforts with other jurisdictions or program administrators, particularly where Massachusetts participation can be used to leverage additional resources from these entities, or in government research investments. Lastly, for the prospective owner or a developer who wishes to take up the Net Zero challenge, the PAs will continue to provide, as they have historically, technical and modeling assistance and incentives for all the efficiency measures towards Net Zero Ready that are cost-effective through the Whole Building Path of the New Construction Program. This path is explicitly designed for the purpose of promoting high performance buildings with lower energy use intensities ("EUIs") and ongoing operational costs than code compliant buildings. Indeed, the PAs view a Net Zero Ready ("NZR") Building as the ultimate expression of this path – driving the energy use intensity of the building to the lowest practical and cost-effective level before considering renewables. This concept of "rightsizing" the building is very similar to the efficiency services proved by the PAs for facilities considering CHP, because energy efficiency measures will always cost the customer less than another increment of generation capacity. The PAs will also help customers with the necessary coordination with the Clean Energy Center in order to qualify for renewables incentives and inform them of the interconnection process to move the final step to Net Zero. It is important to consider NZE efforts within the perspective of overall efforts of the PAs to reduce energy consumption and greenhouse gas emissions. The actual number of market-based and cost-effective non-residential Net Zero buildings constructed in the Commonwealth over the coming three years is likely to be exceedingly small, and those that are undertaken are likely to be quite modest in size, if historic patterns persist.[32] However a larger cohort may be interested in pursuing

[32] A recent national survey of Net Zero buildings by the New Buildings Institute found a total of 39 Net Zero buildings have been verified since 2000; 14 of these are in temperate climate zones in California. Thirty-two are less than 25,000 square feet. It appears that only 6 are private sector buildings; the

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	Near Net Zero, or highly efficient, status. The overall goal of the PAs in this arena is to establish a basis of technical knowledge and expertise, and develop a framework for program support, for projects that wish to aspire to a ranking anywhere along the NZE continuum. <u>Expanding Upstream Offerings</u> The upstream delivery model leverages existing distributor and manufacturer networks and infrastructure to influence the thousands of equipment purchasing decisions that customers and contractors make every day. To date, the PAs have offered an upstream approach for select lighting and HVAC products, with considerable success. As described in greater detail below, the PAs are researching other products that might fit the special set of unique circumstances that are required for an upstream approach to succeed. The PAs plan to add a variety of products to their overall upstream portfolio such as water heating equipment as well as a number of other equipment categories including boilers, furnaces, circulator pumps, some component motors in HVAC systems, and some commercial kitchen equipment. <u>Improved Comprehensiveness in Small/Midsized Buildings</u> All of the PAs have developed streamlined approaches to encourage comprehensiveness in smaller (<100,000 square feet) buildings where: (a) full-scale scenario modeling is often cost-prohibitive, and/or (b) where building systems are often less complex. It is important for the PAs to focus efforts on comprehensiveness on this segment of new construction as 95 percent of the US non-residential building stock is less than 50,000 square feet.[33] National Grid and Cape Light Compact use the Advanced Buildings ("AB") approach in this market. AB was designed by the New Building Institute ("NBI") as a comprehensive, prescriptive program for small commercial new construction in the 10,000–100,000 square foot range. Eversource has developed its own approach using engineering

remaining 33 are either public buildings or buildings in the non-profit/philanthropic/higher education sectors.

33 *Industry Research and Recommendations for Small Buildings and Small Portfolios*, Langner, et al, National Renewable Energy Laboratory and Huppert, et al, Preservation Green Lab, National Trust for Historic Preservation, December, 2013.

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	assumptions and an analysis approach that are very similar to those used by NBI. Under both models, the customer receives a set of recommendations that guides them to a more comprehensive approach to their building project without the necessity of a complex and often expensive modeling process. The gas PAs have adopted these models as well, which has reduced overall program administrative costs, due to the sharing of resources. In the future, the PAs plan to streamline these approaches and strive to adopt a single approach statewide. The PAs will increase their focus on the building types that are most amenable to this approach; specifically, small office, retail, public assembly, and school/preschool applications.[34] Sustainable Office Design National Grid and Eversource have introduced a new offering called Sustainable Office Design ("SOD") as a means of delivering integrated technical solutions to the leased commercial office market.[35] The goal is to capture the energy savings and demand reduction potential that becomes available in the period when office space is vacated by one tenant and refitted for occupancy by a new one (the tenant improvement, or TI, process) or when a new office building, constructed for tenant occupancy, is in the initial leasing phase (tenant fit-out). At least 20 percent of all energy used in commercial buildings is in office space and estimates show that the average commercial office building could reduce its energy use by 20 percent.[36] During the TI/fit-out process, the office space is typically vacant and decisions are made regarding lighting fixture selection and a design to fit the needs of the new occupants. This creates an opportunity to significantly influence energy and demand elements of a building, as well as enhance aesthetics of a space and increase the likelihood of higher levels of comfort and productivity for future occupants, in that unique

34 The economics of both approaches are based on buildings with central mechanical cooling systems.

35 The smaller PAs will consider adoption to the degree applicable once experience with the larger PA effort has produced results for consideration.

36 *Office Real Estate Value Proposition*, Northwest Energy Efficiency Alliance.

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	moment when both the tenant and owner are actively thinking about both the space and the financial considerations around it while the space is vacant and the parties already assume and accept some level of construction disruption in their planning. Owners typically have a set-aside for TI, which is negotiable based on market conditions, lease terms, or plans for general property improvements or market repositioning.[37] Tenants can contribute funding to the TI process as well, either in cash, increased rent, or longer lease terms, to ensure that the space is suitable for their needs. In other words, there is both a financial negotiation and space design process in play, which creates an opportunity to get deeper energy savings without the typical owner/tenant "split incentive issue" dominating the financial discussion and with minimal construction-related disruption to the occupants. The SOD offering provides enhanced services to building owners and prospective tenants, aligning on the market-based TI/initial fit-up opportunity. SOD provides both technical assistance and incentives designed to motivate the parties to think beyond simple lamp and ballast replacements to consider function-based integrated lighting and controls solutions, designed for the specific proposed occupancy activity. This approach offers a predictable incentive at $1.00 per square foot of leased space (net of common areas) for qualifying light fixtures and controls projects, with a guaranteed fast-track timeline for application review and approval. SOD combines aspects of the prescriptive and performance lighting options to promote thoughtful, innovative, and controls-rich lighting designs. The effective lighting power density ("LPD") of SOD qualifying projects will be significantly below code requirements, which can make important contributions toward obtaining critical LEED energy credits and Energy Star® certification. Key elements of SOD include: • Lighting solutions that emphasize efficiency and occupant comfort and productivity; • Low Lighting Power Density;

[37] According to a GSA survey, allowances can range from $2/SF for paint only to $50/SF for extensive TI.

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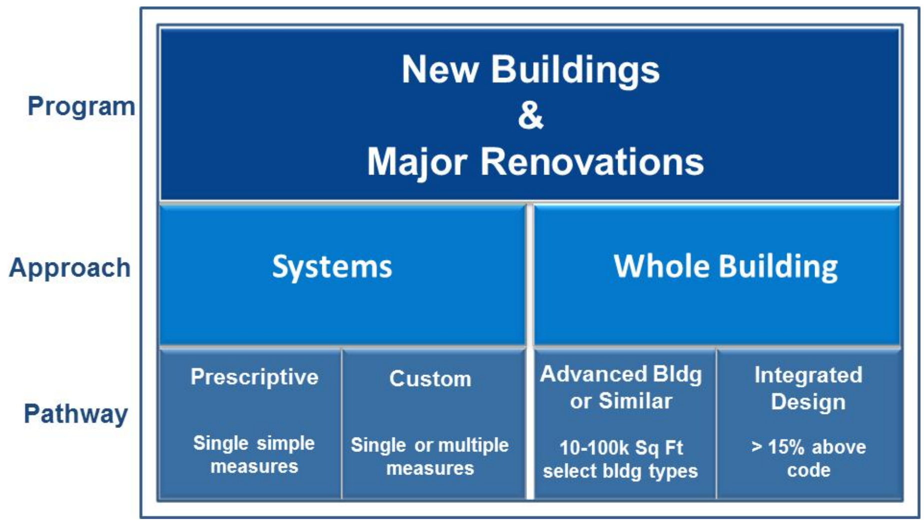
	• Exceptional lighting energy savings (>2 kWh/square foot, on average); • Thoughtful, integrated application of lighting controls (*i.e.*, programmable sweep, tuning, vacancy, etc.); and • Daylight harvesting, where possible.
Program Design	**Participation Options** The New Construction program has multiple participation options, depending both on where the building is in its construction or renovation schedule and the owner's investment criteria and goals for the project. Assistance can range from simple plan review and efficiency upgrade recommendations to complete technical assistance studies performed by leading energy engineering firms.  • *The Whole Building Approach* allows the customer, the design team, and program-supported experts to work together from the conceptual design stage of a new construction or substantial renovation project to consider holistic design and equipment options that will improve the overall efficiency of an entire building and its operating systems. This path is explicitly designed for the purpose of promoting high performance buildings with lower energy use intensities and ongoing operational costs than code compliant buildings. Under this path customers can elect to pursue cost-effective options that drive the energy use intensity of their building to the lowest practical level

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	possible – including going all the way to a NZR building. Eligible customers may take advantage of both program-sponsored technical assistance to help define and quantify cost efficiency options, as well as reimbursement to the customer's own design team for additional design work or analysis necessary to accommodate program recommendations. The customer's financial incentive is calculated to help offset increased design interaction and potential costs of construction and is awarded based on an analysis of the entire project design and the interrelationship between the various building energy-consuming systems. In order to encourage such a comprehensive approach, incentives are usually calculated at a significant percentage of incremental cost. The Whole Building Approach provides technical support and incentives which allow building owners and their design teams to aggressively pursue high efficiency options that fully integrate building envelope, lighting and mechanical systems to produce a building that is as efficient as current technology and design techniques allow. The combination of technical consultation and incentives provided by the program will cover a significant portion of the additional design, modeling, and equipment costs required to turn an average building into an exemplary one. • *The Systems Approach* focuses on one or two aspects of a building's energy systems during new construction, a remodel, or a change in space use. Program experts encourage customers to think broadly as systems are frequently interrelated and may be more economical to install when walls and ceilings are open or down, or large equipment is being installed. Customers who select the Systems Approach will receive Prescriptive incentives for each measure for which one exists, or Custom incentives for site or use-specific measures. • The *Custom* path is designed to facilitate creative and deeper energy savings in systems of a new construction or major renovation project. Custom projects rely on engineering calculations to estimate energy savings and evaluate whether or not a project is cost effective and, as a result, eligible for financial incentives. The custom path is designed to encourage non-standard energy efficiency measures and allows customers to request a technical assessment of measures of their own choosing that are not on the prescriptive list. This option allows for a

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	more comprehensive and creative consideration of projects that are more complex than the prescriptive option allows, but involve less than a whole building design. It also encourages and rewards customer initiative and creativity. Often the savings generated by these measures are site and end use-specific, and thus a detailed analysis is required to qualify them for incentives. Project viability, eligibility and incentives are assessed on a case-by-case basis, and are determined by a technical study, which details energy and demand savings, and project costs. The study is conducted according to program specified procedures and is subject to review and approval by PA technical staff. The baseline standard practice against which each proposal is judged is determined on a case-by-case basis, using such resources as: current baseline studies and other market research, program experience with similar projects, as well as utility or public program experience from other comparable jurisdictions. The measures eligible for the custom path include, but are not limited to, lighting and lighting systems, HVAC systems, water heating, motor systems, building envelope and refrigeration measures, and a variety of industrial process end uses. Incentives are related to a number of site or use-specific variables, total project costs, and associated savings. • The *Prescriptive* path is a standardized, streamlined approach for energy efficiency incentive delivery. It allows customers to choose equipment from a prequalified list of measures and receive an incentive that covers a significant percentage of incremental cost (adjusted for consideration of market barriers, baseline construction practices and market transformation objectives). This path is designed for customers who have projects that are beyond the design phase, and perhaps are in actual construction, and can include new construction, renovation, remodeling, and equipment replacement projects. Prescriptive measures are available for those technologies for which energy savings can be predicted with reasonable accuracy across all applications (as compared to counterpart technologies of lesser efficiency). These technologies include: lighting equipment and controls, unitary HVAC equipment, water heating equipment, chillers, motors, and variable speed drives, as well as food service equipment. This path often serves as the customer's initial exposure to the program and, following an initial experience, customers may choose the more sophisticated comprehensive or custom paths for subsequent projects.

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	Component and Ancillary Services Technical Assistance ("TA") Services Providing high-quality, independent technical advisory services to customers and their design teams in a timely manner is essential to achieving comprehensive savings in new construction as well as system-based savings in industrial or process-related projects or in discrete building systems such as HVAC or lighting. In this market, time is money, and any perception that program participation will cause delay is a deal-breaker. TA Services provides technical support, and a technical support services provider, that is matched to the specific requirements of each project and the needs of each design team. Service can range from comprehensive and detailed energy modeling of the performance of an entire proposed building, using various configurations of design and equipment, to targeted studies and recommendations for specific building components or systems, or specialized technical studies, such as proposed industrial process improvements and compressed air projects. In general, study proposals are referred to TA consultants who have been pre-screened by the PAs. TA consultants are assigned to a project based on an assessment of their expertise and experience with the technologies under consideration. It is vital to program credibility that the customer has confidence that the TA provider assigned to their project is truly an expert whose recommendations will add value (and, conversely, will not introduce risk and delay) to their project. Customers can also elect to use a TA provider of their own choosing, subject to the co-funding PA's approval of the firm's qualifications and cost estimate. Non-preferred vendors must comply with the same level of detail and quality in their TA studies as pre-screened vendors. In many instances, customers have both gas and electric equipment options that require analysis. In these cases the gas and electric PA will co-fund the TA studies, and gas and electric program staff will work as a team to implement the recommendations. Performance Lighting The PAs promote high performance lighting technologies and design

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	practices that are either more efficient than standard practice and/or the requirements of the Massachusetts Building Energy Code through incentives for better lighting design. The Performance Lighting option promotes the thoughtful combinations of energy efficient lighting fixtures and lighting controls in site-specific lighting designs that produce quality lighting using lower watts per square foot than the current code. By encouraging, and rewarding, the market to move away from simple prescriptive incentives that reward customers for simply substituting one piece of hardware for another the PAs hope to shift the focus to using more efficient equipment (with controls) within the context of a more thoughtful and efficient lighting design that actually utilizes the full potential of the technology to achieve lighting that reflects the functional requirements of occupants in their workspaces. Thus, Performance Lighting is both a resource acquisition and a market transformation initiative. Building Energy Codes and Appliance Standards Incorporating high levels of efficiency in buildings during design and construction is the least expensive and most practical and equitable way to achieve broad scale energy efficiency in the built environment. The PAs will continue to focus on both advancing adoption of progressive energy codes, including voluntary stretch codes, and improving levels of compliance with these codes in new construction and major rehabilitation, through training and technical assistance. Sound energy codes are practical and cost-effective because the additional time and expense to produce an efficient building design, and to specify efficient equipment for it, is negligible when compared to the cost and inconvenience of retrofitting an inefficient building once it is in place. Also, most of the fundamental design decisions that dictate a building's efficiency are irreversible, and the costs of a non-code compliant building can burden future owners throughout the life of the structure. Strong energy codes that are uniformly enforced are also equitable because they establish a high standard for all construction. In a competitive building market, particularly when space is designed for a speculative building for tenant occupancy, efficient design and specification of efficient equipment can take a back seat to first cost, and default to code minimum requirements. Value engineering can also squeeze out efficiency options that may reward over time, but have a

C&I NEW CONSTRUCTION	<u>CORE INITIATIVES</u> NEW BUILDINGS & MAJOR RENOVATIONS INITIAL PURCHASE & END OF USEFUL LIFE
	higher first cost. A progressive energy code ensures that at least the floor requirements for efficiency are high. It should be noted that PA programs also indirectly support code advancements. The programs serve to introduce new technologies into the marketplace and lower their cost through volume sales. The PAs also help introduce the building design community and specifiers to new technologies and, by endorsing and incentivizing them, instill confidence that they are reliable and actually save energy. Education and incentives bring about large-scale adoption and subsequently lower product incremental costs. When advanced technologies achieve broad market acceptance and become common practice, they can be codified and PA attention and incentives can be redirected to the next emerging technology. Massachusetts is considered a leading state for advanced energy codes, and a model for cooperation between PAs and government to improve code compliance in commercial and residential construction. However, recent baseline studies have shown that code compliance rates remain well below 100 percent in the Commonwealth. Efforts to improve compliance rates were increased in 2014 with the Energy Code Technical Support effort. The effort supports training for building code officials and for the building design and construction communities. It also offers circuit rider technical assistance to increase on-the-ground compliance to the code in actual underway building projects. The PAs organize and offer code training sessions throughout the state in partnership with the DOER and the Department of Public Safety, with the training directed to both design professionals and local code officials. In 2014, the program reached 174 percent of its target attendance goal and has received high marks with attendees in post-session evaluations. The PA supported circuit riders provide technical assistance to building design professionals on energy codes and energy efficient building design and best practices. They help interpret and explain code requirements and serve as liaisons between designers, builders, contractors and public code officials. By helping building industry professionals interpret and apply the code to the actual day to day projects they have in front of them, circuit riders help instill the understanding necessary to apply the requirements to the next project, when the circuit rider will not be there. Circuit riders cover the entire state and can provide on-call technical

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	assistance to project teams, as well as to local code officials. The PAs will continue to support DOER's efforts to encourage more Massachusetts cities and towns to adopt the stretch code, and provide education and training on compliance. In addition, the PAs plan to work with the DOER and other stakeholders to develop the technical and economic case for a variety of proposed state level appliance standards. In addition to progressive energy codes, well-targeted increased efficiency standards on widely used appliances represent a significant low-cost energy efficiency source for the Commonwealth, and for the citizens who occupy its buildings and use appliances sold in the state.
Delivery Mechanisms	The portfolio of program services and incentives to new building construction, renovation, and expansion market actors – owners, developers, architects, engineers, equipment specifiers – is marketed and delivered by PA staff and contractors. This includes account managers and, in the case of the larger PAs, dedicated new construction program professionals. Responsibilities include identifying and capturing construction leads, and then identifying and managing delivery of the mix of participation options and core and ancillary services that best fits the customer's business needs, project type, and development schedule. Products eligible for the upstream approach are marketed and delivered through a statewide network of equipment distributors, supply houses, and manufacturer's representatives. For the upstream delivery model to succeed, a special, and limited, set of special circumstances are required: (a) The premium equipment must be suited for either one-for-one replacement for a less efficient measure in a failed equipment scenario or in new construction; (b) the equipment purchase decision must be almost entirely driven by first cost, with no real amenity or reliability distinctions between the products; (c) the substitute premium equipment must be stocked and available at distributors at the time of the purchase decision; and (d) there must be no, or minimal, additional or unique installation requirements that distinguish it from the product for which it is substituted. That is, it must be "plug-and-play." The upstream model leverages existing distributor networks and infrastructure to influence the thousands of equipment purchasing decisions that customers and contractors make every day. Under the upstream model, the PAs provide incentives directly to distributors and

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	manufacturers rather than end users, with the end users benefiting from the significant reductions in retail product costs that this enables. The incentives are structured to entirely remove the price premium between conventional and premium products at the point of purchase, thereby placing premium product in direct competition with the conventional product on the basis of attributes of quality and efficiency alone – with the assumption that the purchaser will make the wise choice.
Marketing Overview	The target market for the New Construction program is all "time-dependent" gas and electric energy efficiency opportunities in the non-residential sector, which includes commercial, industrial, institutional, and governmental customers and their buildings. Time dependent opportunities exist when new buildings are being designed and constructed, and when existing ones are expanded, remodeled, or renovated. Time dependent opportunities are also available when existing equipment fails, and must be quickly replaced to restore the building to full functionality. In the new construction market key market actors include architects, engineers, equipment specifiers, manufacturers, distributors, suppliers, commissioning agents and the owners or developers of new buildings. In the replacement market key decision-makers include building owners or managers, facility staff, and equipment supply houses. The non-residential development process has a number of characteristics that make it difficult to influence from the outside. First and foremost, with the exception of government or institutional projects, or very large projects that require some form of planning body approval, most of the process occurs in an environment that is outside of public view. Decisions to develop particular buildings on particular sites, and subsequent agreements for financing, real estate purchase, design and construction services, and, ultimately, sale or rental are, after all, private business. The participants do not reveal that a development is even contemplated because they do not wish to alert potential competitors to their intentions or because there is simply no need or requirement to do so. Also, the process itself often does not proceed along a seamless continuum. Development can be an episodic process, with flurries of activity around securing permitting or financing for example, followed by periods of dormancy until the next hurdle is addressed. And with many hurdles, a significant number of projects never move from the conceptual

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	stage to actual completion, and from all the projects that are proposed, it is often difficult to determine which proposed projects will materialize, particularly at the earliest conceptual phase. Yet it is at the conceptual phase, when all plans are fluid that the greatest potential exists to influence the project in the direction of a comprehensive, holistic energy efficient design. When earth gets moved, the plans have long since been functionally complete and all attention is then and from that point forward on the projected completion and occupancy date. Millions of dollars have been borrowed and no revenue is generated to repay these loans until the tenants or owners move in. A change to incorporate efficiency, or any change for that matter, is perceived to mean delay, and delay costs money. Additionally, it is estimated that between 40 and 50 percent of small commercial buildings are built for tenant occupancy. This creates two very daunting barriers to the consideration of more efficient design or equipment. First, the typical lease model (the so-called “triple net” lease) flows all operating costs, including utility bills, through to the tenant. Sometimes this is accomplished through direct metering of the tenant premises as in a freestanding retail space. In other cases, there is a master meter with a pro-ration of costs to all tenants as in the case of a strip-mall or a small office building. In neither case does the tenant have the incentive to upgrade the landlord’s property except in the limited instances where the payback term is significantly less than the remaining life of the lease. Thus, lowest first cost often rules the day in the development process. If there is additional money to be spent on building systems, the developer and his design engineer will often invest it to oversize HVAC equipment and over-light spaces as a shield against future tenant complaints or litigation. A retrofit project typically involves a turn-key vendor selling a project specifically on efficiency attributes. By contrast, in the new construction market, products are specified in the design process, not sold. Among the market actors whose interests must be considered are: • Owner/occupants, who expect to be long term tenants in their own buildings, and therefore are more likely to be receptive to the concept of life-cycle costing and to longer payback measures, or to an “inspiring” design; • Larger architectural and engineering firms, who tend to design

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	from a library of "typical" building packages. Once their template design and equipment specifications are modified, they will be reapplied in numerous similar buildings in the future; • Leading design firms who tend to establish the new market standards that are then followed by more conventional firms; • Chain and franchise owners, who often use one design template, which can be varied according to site requirements, and who often use in-house architects and engineers; • Public sector owners, who often have regulatory requirements that include life-cycle costing and legislated goals for energy efficiency; • Environmentally conscious owners, who wish to promote their building as an extension of their corporate ethic; • Speculative developers to the extent they can be persuaded that a low-energy-cost building has a promotion value to attract tenants; • Equipment manufacturers and suppliers who need to be persuaded to stock energy efficient equipment so that it will be available to meet program-generated demand. Specific outreach strategies are designed for each of these groups, but for all, one-on-one communication is the primary approach that has produced results over time. Building relationships by partnering on an initial successful project and showing added value, leading-edge technical expertise and rapid response to the client's needs puts the program top-of-mind when the next project comes along. This direct marketing is facilitated and supplemented through other channels including brown bag educational seminars, formal training seminars and webinars particularly when they qualify for continuing education unit credits, case studies, open houses, etc. For time-dependent projects involving replacement of failed or end-of-life equipment, the PA's marketing efforts focus on customers and their facility managers and on equipment vendors, again using extensive one-on-one communications. This communication is supported by case studies and other promotional pieces, participation in a variety of trade shows and industry conferences, breakfast meetings, and other customer and vendor focused training seminars. The PAs continually engage with equipment distributors and installers to help them promote

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	energy-efficient equipment and systems to their customers and to explore innovative ways to work together to mutual advantage. With specific regard to the upstream delivery approaches, the existing distributor networks and infrastructure are leveraged to influence the thousands of equipment purchasing decisions that customers and contractors make every day. Under the upstream model, the PAs provide incentives directly to distributors and manufacturers rather than end users. The incentives are structured to entirely remove the price premium between conventional and premium products at the point of purchase, thereby placing premium product in direct competition with the conventional product on the basis of attributes of quality and efficiency alone, with the assumption that the purchaser will make the wise choice. Removing the price premium is critical because, without explicit direction to the contrary, equipment specifiers in new construction or renovation projects and building maintenance personnel when replacing failed equipment will usually select the lowest cost option that can fulfill code requirements. Similarly, the trades that compete on construction or equipment replacement work are under market pressure to offer the lowest cost bid. For lighting products, the target markets are: (a) electrical contractors ordering commercial lighting products or purchasing them over the counter; (b) facility managers ordering commercial lighting products or purchasing them over the counter; and (c) engineers and other specifiers who dictate commercial lighting product specifications in new construction. For HVAC products, delivery is primarily through the contractor network that replaces failed equipment in existing facilities and installs new equipment in construction projects.
Three-Year Deployment Strategy/Roadmap	For the 2016-2018 term, the program will concentrate on continuous improvement and refinement to core program elements and expansion of more customized services into relatively underserved markets such as the tenant fit-up/TI processes and deeper savings in small and medium building markets as described above. The PAs will examine market data to determine if additional segments can be identified that would benefit from discreet, targeted approaches such as the potential opportunity that

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	exists when hotels are either rebranded or "refreshed" to keep customer amenities current and competitive.[38] With the recession now largely behind us, forecasters are seeing tightening vacancy rates in the large commercial markets of Eastern Massachusetts. This means new construction starts, at least in the Eastern part of the state, will continue to accelerate, with a mix of both build-to-suit and speculative office space, as well as a growing laboratory/life sciences presence. [39] One recent respected study placed Metro Boston as the number nine (of 75) U.S. Markets to Watch for real estate development prospects.[40] The study advises investors to particularly focus on opportunities in the lodging, retail, and office markets, with an eye to the growing life sciences/laboratory market as well. National-level analysis ranks the strongest overall development prospects in warehousing and limited-service hotels. This forecast serves as a good guide to priorities for PA focus in the Commonwealth's largest commercial market area for the intermediate term. With regard to the upstream delivery model, the PAs have achieved considerable success with lighting and HVAC equipment. The PAs have, and will continue to, research additional products that might fit the special set of unique circumstances that are required for an upstream approach to succeed. In addition to water heating equipment, which will be offered during or before the start of this Plan term, potential candidates include: boilers, furnaces, circulator pumps, some component motors in HVAC systems, and some commercial kitchen equipment measures.

[38] National Grid in Rhode Island and Southern California Edison are engaged in a joint research project to better understand the hotel renovation/refreshment market dynamic, and the potential to present efficiency options to customers when they are about engage in a renovation/refreshment project.

[39] New England Market Outlook 2015, CB Richard Ellis New England Partners

[40] *Emerging Trends in Real Estate United States and Canada 2015*, the Urban Land Institute and PwC, October 2014.

b. C&I Retrofit: Existing Building Retrofit, Small Business, Multi-family Retrofit, Upstream Lighting

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Overview & Key Objectives	The Retrofit Program consists of two sets of core initiatives. The first consists of Existing Building Retrofit, serving all non-residential customers, along with two additional specialized initiatives -- Small Business and Multi-family Retrofit – each of which serves specific subsets of non-residential customers. The second, Upstream Lighting, is primarily a marketing channel approach, but is presented here separately primarily for accounting purposes, as it has provided a large share of the commercial lighting savings in recent years, and is expected to continue doing so in the coming plan term. <u>Existing Building Retrofit</u> This broad core initiative promotes a menu of equipment incentives and technical services to encourage building owners to replace functioning, but outdated and inefficient equipment with premium efficiency counterparts. Because this program accounts for a significant share of C&I savings, the PAs continuously monitor its performance and refine delivery approaches, the product mix, and incentive levels to reflect changing market expectations and evolving technologies. As the program has matured and customers have become more aware of the variety of energy-saving investment opportunities available to them, the PAs have encouraged a transition away from episodic equipment-based retrofit events to engaging customers in a thoughtful series of building upgrades that move their property towards a "building renewal". Mature efficiency programs, those that have harvested the easiest and less expensive savings opportunities and have established trusted relationships with customers, are often characterized by a preponderance of more sophisticated custom projects and a lesser number of simpler prescriptive ones. The Massachusetts C&I Retrofit program fits this mature program profile. The program offers prescriptive incentives for widely-applicable electric and gas technologies, and a custom approach which focuses on unique opportunities that are customer, site, or process specific. Prescriptive incentives are offered for measures that provide predictable energy savings in virtually all applications where they replace a similar technology of lessor efficiency. These incentives are available for a long

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	list of electric and gas technologies such as lighting equipment and controls, HVAC controls, chillers, motors and drives, spray valves and steam traps, etc. This commodity-based path often serves as the customer's initial exposure to the program and may lead to more complex custom projects. To identify and quantify custom opportunities, the PAs provide customers with expert technical assistance, using both their own technical staff and subject matter experts drawn from a pool of prequalified expert private sector engineering consultants. To move customers to action once opportunities have been identified, the PAs offer financial incentives that are calibrated to match customer investment criteria. The overarching goal is to instill customer confidence in projections of project savings and the reliability of equipment performance, in order to make the financial investment attractive, and to provide a delivery process that makes the upgrade process as simple and seamless as possible. In addition to periodic equipment upgrades, the PAs offer a suite of ongoing services to business customers, including subsidized training for building operations and maintenance tasks and access to retro-commissioning ("RCx") services to ensure that energy-consuming equipment operates as designed, and that all low-cost/no-cost opportunities for energy and electrical demand savings are fully exploited. <u>Small Business</u> Small businesses[41] account for about 45 percent of the energy consumed in Massachusetts, but that potential for savings is scattered in small segments located in over 330,000 facilities scattered across every community in the Commonwealth. Moreover, small businesses have many well-documented barriers that impede their investment in efficiency: the landlord/tenant split incentive, lack of capital, short planning horizons, lack of awareness/expertise, perceived complexity of the technology and mistrust of savings claims, etc. Small Business customers can access any of the incentive and service options available to all C&I customers depending on their needs and

[41] The "Small Business" category also includes a majority of the non-profits and houses of worship in the Commonwealth. These entities can – and do – fully participate in all of the program offerings described under this heading.

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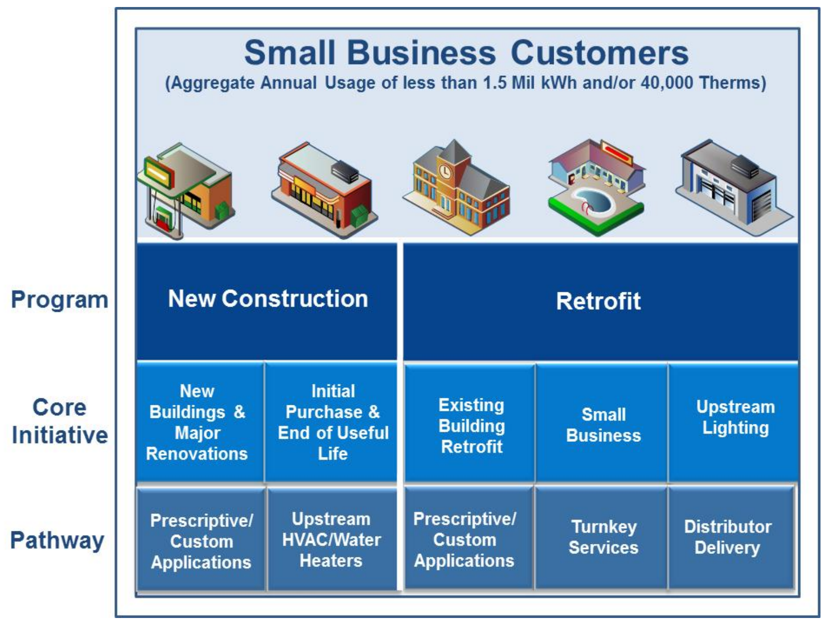
preferences. In addition, they have a unique ability to access the Small Business core initiative, which has features that are explicitly designed to address the unique barriers and limitations in this market.

Small business customers will continue to have full access to the custom and prescription offerings of both the New Construction program and Existing Building Retrofit Initiative. Small businesses also often access new technologies through the upstream channel for lighting, HVAC or water heating equipment. Thus, as the graphic below illustrates, the turnkey delivery model that underpins the Small Business core initiative should be seen as but one of the multiple means by which small business customers in the Commonwealth are supported by the PAs in their efforts to improve the efficiency and productivity of their buildings and businesses.



The Small Business core initiative was designed to specifically address each of the above mentioned barriers by offering a package of services – assessment, installation, incentives, financing, and repayment methods – that make it easy for a customer to say yes.[42] As noted elsewhere, this

[42] The Small Business core initiative is simply a subset of the Retrofit Program. In addition to this specialized service, Small business customers can also participate in the full range of other retrofit options, including custom electric and gas measures. In addition, small business customers can receive incentives to upgrade to the most efficient option when they replace furnaces, boilers, water heaters, kitchen equipment, etc.

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	Massachusetts delivery model has been widely imitated and is accepted as an industry best practice program delivery model for small business customers. Delivery to this market segment through this initiative will continue uninterrupted, with refinements identified through the program review process incorporated into delivery as soon as practical. There will be increased attention on streamlined services to micro-businesses and customized offerings to market sectors with unique business needs and measure opportunities. Multi-family Retrofit As described in greater detail in the Residential Section of this Plan, Section III.E, because multi-family buildings may contain residential and commercial metering and, as a result, technologies more associated with commercial buildings, services and incentives are also provided to this sector through the C&I Retrofit Program. However, as the beneficiaries of the Multi-Family Retrofit core initiative are primarily the residents of individual units, and the measures and services associated with this core initiative are primarily residential in nature, the PAs residential program managers have taken a leadership role in delivering the cross-sector Initiative. The MMI assures that cross-sector services are delivered seamlessly to customers, including services provided by commercial sector service providers. The commercial sector services are then attributed to commercial sector budgets and goals at each PA. These C&I measures may include: • HVAC high efficiency equipment upgrades and controls; • Variable speed drives, motors; • Chillers; • Air compressors; • Water heating equipment; • Energy management systems; • Building envelope measures; and • Custom measures.

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	Target Market The potential market for the C&I Retrofit Program is the entire non-residential built market in the Commonwealth. In addition to typical commercial office buildings, this includes schools (K-12 and colleges and universities); public and institutional buildings and facilities (state and municipal buildings, water and wastewater facilities, hospitals, and a variety of not-for-profit enterprises); and industrial facilities (including factories, warehousing, agriculture, storage and processing, etc.), as well as common area spaces in multi-family buildings. For submarkets of special interest, beyond small business and multi-family, there are added participation services or features in addition to the core program offering.
	New Enhancements <u>Further Market Segmented Delivery</u> Market segmentation is the process of defining and subdividing the class of C&I customers into identifiable segments that have similar needs, wants, or usage and demand characteristics, who are likely to respond to similar program approaches and marketing or outreach messaging. The process is a means to an end for the PAs: to inform design and delivery of a mix of program offerings, with appropriately tailored outreach and delivery that will resonate with and match the expectations of customers in the targeted segment, and will motivate them to action. PA markets can be defined by business type (*e.g.*, health care, education, government, agriculture, industrial, hospitality, etc.), building type (*e.g.*, hospital, university, retail, hotel, factory, etc.), by geography, size (of energy use or demand), by ownership type, or any of a number of ways. The PAs segment their customers according to the unique mix of customers of each PA service territory. For example, National Grid has a large number of industrial customers, so the company has developed the organizational and technical capacity to serve industrial needs and investment horizons. It further subdivides manufacturing into process, fabrication, food and heavy industry in order to better target its services to the different needs of each of these sub-segments. Eversource has a heavier concentration of commercial real estate, and organizes its delivery to effectively serve that market. Likewise, Cape Light Compact has a large number of hospitality customers and thus is targeting segment-specific services to them.

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	The PAs continue to evolve customized approaches for these and other markets, making use of local EM&V studies, the experience of peer programs around the country, and data reported in studies and program evaluations from other jurisdictions. For example, the "Mid-Size Customer Needs Assessment"[43] which looked at a snapshot of customers in the 300-750 kW range in a single year found that these customers require more complex solutions than are customarily available through the Small Business core initiative alone, and yet may require different financial incentives and application requirements than they experience in the C&I Retrofit Program as a whole. That study was followed by the *2013 C&I Customer Profile Report* which looked at customer trends longitudinally. The study revealed that on average these customers comprised about 23 percent of both statewide electricity usage and statewide savings in 2012 and 2013. The PAs will continue to develop a more detailed understanding of the various sub-sectors contained within this mid-sized sector in order to develop marketing and delivery strategies that will resonate with customers who have similar energy use, business requirements, and investment criteria. This will also involve reviewing the definition of mid-sized customers across all PAs and develop more contractors who are trained in providing comprehensive solutions to this midmarket, including providing more comprehensive leads to the current pool of preferred trade ally contractors. An example of a specific submarket sector analysis is the profile of small and medium sized food stores conducted in 2014.[44] This study reported the results of interviews with key decision-makers in this market with the goal of providing more and better information about this customer segment to inform PA program design and delivery. The PAs plan to incorporate recommendations from this study during the 2016-18 Plan term. The chart below is illustrative of the energy using characteristics as well as the motivations and barriers with regard to efficiency investments experienced by key PA customer segments:

[43] Final Report Mid-size Customer Needs Assessment, for the Council Consultants and Massachusetts Energy Efficiency Program Administrators, KEMA, December 22, 2013.

[44] Market Sector Profile: Small and Medium-Sized Food Stores – Final, for the Massachusetts Program Administrators and EEAC Consultants, DNV GL, September 26, 2014.

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NOTABLE SEGMENTS		Education	CRE / Office	Grocery	Houses of Worship	Lodging	Municipal	Restaurant
Metrics	Avg Bldng Size (Sqft)	45,644	25,020	11,704	17,588	37,296	24,643	4,710
	Electric Usage per Sqft (KBtu)	58.0	60.4	204.4	5.1	41.3	48.8	45.4
	Electric Usage per Building (KBtu)	7,902,069	770,842	1,581,889	70,703	1,865,726	601,164	168,259
	Gas Usage per Sqft (KBtu)	1.0	38.1	4.2	6.0	35.9	1.9	18.4
	Gas Usage per Building (KBtu)	479,471	1,658,321	109,941	275,209	5,545,605	81,158	231,344
Drivers	Energy Intensity	Extreme	Medium	Extreme	None	Medium	Medium	Extreme
	Cost Conscious	Medium	Low	Extreme	Medium	Medium	High	Extreme
	Personnel Productivity	Low	Low	Low	None	Low	None	None
	Customer Satisfaction	None	Low	Medium	Low	Medium	None	High
	Brand Value	High	Medium	High	None	High	None	None
	Property Value	None	Extreme	None	None	Medium	None	None
Barriers	Lack of Available Capital	Low	Low	Medium	Extreme	Medium	Extreme	Extreme
	Limited Resource Availability	Low	Medium	Medium	Extreme	Medium	Medium	Extreme
	Landlord / Tenant Split Incentives	None	Extreme	None	None	None	None	None
	Limited Opportunity Awareness	Medium	Medium	Low	Extreme	High	High	High
	Lack of Technical Expertise	Medium	Medium	Medium	Extreme	High	High	Extreme

LEGEND

Level of Importance: Extreme, High, Medium, Low, None

Source: ***2003 Commercial Building Energy Consumption Survey (CBECS), U.S. Department of Energy***

The above drivers, barriers and metrics are all taken into consideration, in conjunction with information about purchasing behavior and procurement practices, supply chain dynamics and past efficiency investment patterns when developing a customized strategic approach to serving these, or any other, segment of C&I customers. These factors underpin the PAs choices regarding a wide range of design and implementation elements such as product/technology offerings, incentive levels and structure, marketing and messaging mix, channel selection and engagement, staffing, etc.

Using this thoughtful, strategic, holistic approach to serving C&I customers can lead to considerable improvements in participation rates, comprehensiveness and depth of savings, and improved customer experience and associated satisfaction. The PAs, individually and/or

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	collectively have actively pursued, or are developing plans to pursue, such strategies targeted to a number of C&I customer segments including grocery, hotel, restaurant, local and state government, houses of worship, industrial, lodging, offices, tenants, and medium commercial customers in general. The chart below is illustrative of the market segmented approaches that have been and will continue to be deployed by the PAs or are in active development for deployment in the 2016-2018 Plan term.

Program Administrator	Segment	Why this Segment	New, Existing, Expansion of Existing, Extension of Existing?	Market Test or Full Deployme nt
Cape Light Compact	Grocery	Common measures, business model and barriers, can benefit from provision of industry expert technical assistance. Also, potential for economies of scale in marketing and delivery.	Expansion of existing test	Full
Cape Light Compact	Lodging	Similar to Grocery, high density of this segment in territory.	New	Full
Cape Light Compact	Grocery	Common measures, business model and barriers, can benefit from provision of industry expert technical assistance. Potential for economies of scale in marketing and delivery.	Existing	Test
Cape Light Compact	Municipal	Common significant barriers, higher incidence in customer base	Existing	Full
Cape Light Compact	Tenants	Common barriers and lower participation rates. Seasonal small business tenants prevalent in territory.	Existing	Full
Columbia Gas	Hospitality	Higher and more gas opportunities relative to other segments	Existing	Full

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Columbia Gas	Office spaces	Confirming if there is truly a potential in this segment or not	Existing	Full
Columbia Gas	Customers in moratorium areas	Policy and regulatory	New	Full
Unitil	Municipal	Have unique budgeting process and require one on one attention from the PA.	Existing	Full
Unitil	State	Have unique budgeting process and require one on one attention from the PA.	Existing	Full
Unitil	Medium Customers (< 300 kW)	Could benefit from one on one approach	Existing	Full
Liberty Utilities	Grocery	Common measures, business model and barriers, can benefit from provision of industry expert technical assistance. Economies of scale in marketing and delivery with electric utility	Existing	Full
Liberty Utilities	State	Have unique budgeting process and require one on one attention from the PA.	Existing	Full
Berkshire Gas	Grocery	Common measures, business model and barriers, can benefit from provision of industry expert technical assistance. Economies of scale in marketing and delivery with electric utility	Existing	Full
Berkshire Gas	State	Have unique budgeting process and require one on one attention from the PA.	Existing	Full

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National Grid	Grocery	Very energy intensive, very sensitive to costs, very homogenous and concentrated usage requiring specialized technical expertise, scalable because of centralized decision making	Extension of Existing	Full
National Grid	Municipal	Have unique budgeting process and require one on one attention from the PA.	Existing	Full
National Grid	Industrial	Very energy intensive, very heterogeneous requiring specialized technical expertise, large customer base with high savings potential	Existing	Full
National Grid	Restaurant	Extremely energy intensive, very sensitive to costs, very homogenous, large customer base, scalable because of centralized decision making	New	Full
National Grid	Houses of Worship	Awareness, technical expertise, resource availability, and access to capital all limited. Many different building types which cross residential & C&I, gas & electric requires strong program knowledge.	New	Test
Eversource	Healthcare	Very energy intensive, very sensitive to costs, scalable to other customer of varying sizes.	Expansion of existing	Full
Eversource	College & University / Biotech / Healthcare	Very energy intensive. Green Labs- maximizing savings in high energy intensity buildings. Reduce EUI and maintain safety	New	Full

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Eversource	University / College	Common business models, energy intensive, capable of cross fertilization and learning forums, sustainability	New	Full
Eversource	Small Business	Sub-segment targeted approach	Expansion of existing	Full
Eversource	Commercia l Real Estate	BERDO/BEUDO - Access to tenant space and helping class B/C property owners	New	Full
Eversource	Municipal	Have unique budgeting process and require one on one attention from the PA to overcome barriers.	Expansion of existing	Full
Eversource	Grocery	Very energy intensive, very sensitive to costs, concentrated usage. All quartiles	New	Full

During the course of the Plan term, the PAs will continue to identify additional segments that may best lend themselves to these more targeted approaches.

Expand Strategic Energy Management

The concept of Strategic Energy Management ("SEM") is fluid and evolving, and can encompass a number of interconnected and mutually reinforcing activities. A common definition of SEM is that it is "a comprehensive set of business practices that establish energy management as a standard operating procedure."[45] While there are different variations in SEM programs, they all focus on business practice change - shifting how organizations get things done, improving their capacity to reduce energy waste, and reducing energy intensity throughout the entire organization.

Within the Massachusetts programs, activities that contribute to Strategic Energy Management include:

- Retro-commissioning;
- A variety of broadly-available and ongoing facility owner,

45 http://neea.org/docs/default-source/default-document-library/nw-industrial-sem-collaborative-overview.pdf?sfvrsn=2

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	manager, and operator training and education opportunities; and • Customized process and behavioral approaches within the broader context of a customer-specific MOU/Strategic Energy Management Plan ("SEMP") Over the 2016-2018 Plan term, the PAs plan to refine and expand these existing approaches, as well as examining methods to expand SEM to a broader market as the concept becomes a more familiar model in the business community. Additional areas to be explored to support and reinforce SEM activities include the use of benchmarking and the variety of proprietary tools known as remote or "virtual" or "no-touch" audits. Retro-commissioning ("RCx") The majority of buildings in Massachusetts are more than 30 years old, and many are much older.[46] Since being built, most have changed in occupancy and function. Also, over time, HVAC and electrical systems have become less efficient in operation, often because of outdated operational approaches, lack of maintenance, and changes to equipment that do not integrate well with existing systems. To address this inevitable process of degradation by building systems left unattended, the PAs offer an RCx service within the C&I Retrofit Program. RCx is defined as "the process of applying a rigorous testing, verification, and upgrade protocol to an existing building control system to identify and correct operational inefficiencies."[47] RCx can be coupled with a monitoring system which uses metering and software to provide ongoing energy performance feedback directly to building operators and/or the PAs. RCx that is facilitated by such a monitoring system is called monitoring based commissioning ("MBCx").[48] Generally, RCx consists of identifying (through an RCx study) a number of no-cost/low-cost maintenance or operational improvements that can, when systematically implemented in a facility, produce improved performance and energy savings without significant capital investment.[49]

46 National Grid's data indicates that almost a third of their building stock (31%) predates 1940.
47 *Retro-commissioning Best Practice Study*, Revised Draft for C&IMC Review, May 22, 2014.
48 Id.
49 As well as identifying promising capital measures that can be implemented through regular program channels.

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	Historically, delivery of RCx services in Massachusetts has been relatively expensive and persistence of savings has been low. For these reasons the PAs supported undertaking a best practice study to learn of improvements that could be made, based on the experiences of other program administrators. In 2013-2014, a joint team of PA technical staff and EEAC consultants conducted a "Retro-commissioning Best Practice Study." The study produced recommendations for consideration to revise the current structure of Massachusetts' programs. These recommendations were based on the design features and actual performance results of a number of industry leaders (primarily Pacific Gas and Electric, BC Hydro, and Commonwealth Edison). Based on the experience of the studied programs, the PAs expect that implementing many of the recommended modifications to current efforts will result in more savings through RCx in the Commonwealth and that savings persistence will increase. The final RCx report identified five "programs and elements that should be investigated for applicability in the Massachusetts existing building market." These were elements that were common to most of the leading RCx programs examined. The report also recognized that "(b)ecause there is an existing program being delivered, the process and timeline for program changes will need to be managed by the PAs to limit market disruptions." [50] The following summarizes the report recommendations around each of the five "elements", as rank ordered in the report, and planned PA actions in response: (1) "RCx provider gives on-going support through implementation and operation including: commissioning for measures implemented as a result of the RCx study; M&V; and building operator training." The PAs expect to implement these recommendations, commencing with new RCx projects. As noted in the Training discussion elsewhere in this section of the Plan, several programs in other regions have integrated the Building Operator Certification ("BOC") training into their retro-commissioning services offering, and the PAs will examine this

[50] Id. at 4.

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	experience to date for Massachusetts application. (2) "Savings estimates (are) developed by RCx providers using a consistent statewide set of approved tools; reviewed by program administrator and validated through M&V provided by RCx provider." The detailed recommendation in the Best Practices report was to explore adopting and/or adapting the suite of tools developed for the California Commissioning Collaborative, with the hope that using or revising these existing tools would be relatively less expensive than creating them anew for Massachusetts. However, this appears unlikely to be the case,[51] and the PAs will need to develop an alternative plan, which is expected to involve development of a proposal for a competitive procurement of services tailored to Massachusetts needs. (3) "Control costs of RCx study with an in-house budgeting tool and a joint scoping exercise with the customer, PA, RCx provider and controls contractor." The PAs exercise many of these controls now, but expect to implement all of those suggested in the Best Practices study. RCx contractors will work under contract to the PAs, so scope of work and budget will be directly manageable. The PAs will either develop an in-house budgeting tool or investigate the possibility of purchasing and adapting a proven existing tool from another program administrator. (4) "Aggressive screening of potential participants to reduce risk, combined with up front incentives covering study cost." The PAs are implementing the former already, and will test application of the latter before making a full implementation decision. (5) "Energy Management Information System ("EMIS")/interval meters directly funded by PA. Ongoing support to assure savings and measure persistence." The PAs recognize that maintaining the outcomes of the RCx process over time is critical to cost-effectiveness, customer confidence, and

51 The estimate provided to the PAs by the firm which maintains the California Commissioning Collaborative materials and website on behalf of the cooperating utilities was in the range of $250,000.

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	achieving verifiable savings throughout the projected measure lives for the actions taken. The PAs plan to develop a methodology for integrated delivery of RCx services and post-service follow-up and follow-through that addresses the issue of maintaining persistence of savings. In addition to the Best Practices study, the PAs reviewed a very similar study conducted by E Source during the same time period. The study was even more comprehensive, looking at a total of 15 RCx programs. E Source reached very similar conclusions and recommendations regarding best practices, to: "(1) offer generous study incentives; (2) get commitments from customers; (3) cultivate qualified commissioning providers; (4) keep program messaging simple; and (5) expand the participant universe."[52] Since both studies were issued, the PAs have engaged in RCx market tests that are consistent with their findings. For example, some of the PAs are now delivering a consistent experimental RCx approach to the hospital segment, applying many of the recommendations of the study. The enrollment eligibility period for this test was the first half of 2015. Any hospital of 100,000 square feet or greater using at least 2,000,000 kWh or 150,000 therms per year and equipped with a DDC Energy Management System was eligible, provided that the facility also: (a) had access to sufficient funding to implement agreed RCx measures within 12 months; and (b) had an internal "champion" who could ensure timely decision making and access to needed systems and data. These PAs provided no-cost engineering resources (capped at a value of $5,000 per site) from a PA selected and pre-approved Technical Assessment ("TA") vendor to perform scoping studies to identify and analyze potential energy savings from RCx measures. The PAs also agreed to pay incentives based on annual energy savings at the rate of $0.12 per kWh and $1.20 per therm with scoping studies required to be completed between January 1 and June 30, 2015. Uptake thus far has been relatively modest and the PAs are discussing possible modifications or alternatives to this approach. In addition, National Grid is testing three different turnkey RCx services provided by three different companies. One firm is targeting medium and large buildings using whole building and system level analytics that

52 *Retro-commissioning Programs, Five Tips for Boosting Participation*, E Source Focus Report, Merson, et al, December 9, 2013.

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	enables targeting and implementation; one is targeting small and medium buildings using whole building level analytics and training building operators (this test has behavioral aspects); and one is targeting medium and large buildings using whole building level analytics and trade ally expertise. The Company is examining additional options with other firms, but will await initial results from the first three tests. The PAs are also testing an "RCx lite" concept, targeting smaller buildings and the firms that currently provide EMS services to these buildings. The objectives were to: (a) reach a smaller set of buildings with a streamlined set of high-value services that could be delivered cost-effectively; and (b) attempt to expose smaller, traditional EMS firms to a potential new line of service offerings – a potential market expansion/market transformation exercise. National Grid found many of these providers were reluctant to step out of their traditional business models, and that many of their systems had operational or functional limitations that inhibited their value for even limited RCx applications. <u>Education and Training for Customers, Trade Allies, and PA Staff and Contractors</u> *<u>Customer Education</u>* Every year the PAs sponsor and participate in hundreds of training or educational events around the Commonwealth to reach and influence all the parties who own, manage, or operate and staff buildings in Massachusetts. Some of these events provide customers with a broad exposure to a number of energy-savings technologies and service providers, such as the annual PA-sponsored Vendor Open Houses, while others are more focused and specialized, such as presentations to meetings of the local ASHRAE and IES chapters. The following are examples of local organizations with which the PAs have regularly partnered and collaborated in the past, and expect to continue to do so in the future, to deliver educational and training content that fits the unique energy concerns of their members and constituents: • Advanced Manufacturing Collaborative ("AMC") • American Society of Heating, Refrigerating, and Air-Conditioning Engineers ("ASHRAE")

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	• Association of Energy Engineers ("AEE") • BOMA – Boston, the Greater Boston Real Estate Board • Boston Green Ribbon Commission • Boston Green Tourism • Boston Society of Architects ("AIA") • Boston Redevelopment Authority • Illuminating Engineering Society ("IES"), Boston and Rhode Island Section • International Facility Management Association ("IFMA"), Boston Chapter • Massachusetts Clean Energy Center ("CEC") • Massachusetts Lodging Association • Massachusetts Restaurant Association • Municipal Solid-State Street Lighting Consortium ("MSSLC") • Northeast Sustainable Energy Association • U.S. Green Building Council ("USGBC"), Massachusetts Chapter At the local level, the PAs give countless program presentations – both general and specific to specialized audiences. For example, in a given year, Cape Light Compact: • Strives to make at least one general C&I program presentation each month, with the goal of reaching every town or regional chamber on Cape Cod each year; • Makes specialized segment-relevant presentations at both the Cape Code Chamber and at the Martha's Vineyard Chamber; • Makes one or two presentations at the Lower Cape Community Development Partnership as part of their Cape & Islands Green classes for Cape Cod businesses; • Presents periodically to town Energy Committees, as well as to Boards of Selectmen, and in particular when rolling out Three-Year Plans or other new initiatives;

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	• Presents at the annual Massachusetts Facilities Managers when it takes place on the Cape; and • Has a booth at Cape and Plymouth Business Connect trade show; and at many other regional events, trade shows and town meetings, where program staff have the opportunity to interact with local officials, business owners and employees, as well as residential ratepayers. The CLC listing is offered as an illustrative example -- a full composite list of all PA activity would be too voluminous for this document. However, just like CLC, each of the PAs is constantly on the lookout for opportunities to reach potential new business program participants, or remind past participants that there are always new options for participation, so each maintains a presentation or public speaking schedule that is similar to CLC's. *Vendor, Trade Ally, External Energy Professional and PA Staff Training* The PAs offer regular specialized training sessions for all their trade allies, other energy professionals who support or participate in the programs, and for their own program and technical staff as well. For example, over the course of the current Three-Year Plan, National Grid has held dozens of such sessions, with a total attendance of over 3,200 individuals. Common formats include webinars and live presentations at multiple sites around the service territory. Subjects have included: • Trade Ally & PA Staff Sales Training (by EEFG/Mark Jewell); • Changing technology and Energy Efficiency in Data Centers; • Laboratory safety and EE can work together to reduce cost; • Changing opportunities in exterior lighting as technology rapidly advances; • CHP opportunities and advances; • High Efficiency water heating solutions; • Impact of steam system O&M on energy expense and often overlooked EE opportunities; • Advances in lighting control technology; • New accelerated pre-inspection service;

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	• Energy Management Systems as a tool to improve building environment; • Hospitality industry efficiency day event; • Often overlooked opportunities to save energy in C&I heating systems; • Commercial leased space rapid project turnaround – advanced lighting system and technology incentives; • VFD opportunities on HVAC systems; • Introduction to scope of New Construction services; • Introduction to National Grid energy saving solutions and incentives; and • National Grid Customer & Partner Summit. Similarly, the gas PAs, using a contractor retained through GasNetworks®, conducted 79 training events, often technology-specific and co-hosted by a vendor/trade ally and located at their site. *End Use-Specific Training* In addition, the PAs offer very specialized training to the operators of commercial facilities and specialized industrial equipment. Like any complex machine, a commercial building, or wastewater plant, or a compressed air system, requires constant regular attention to run well and serve the needs of its owners and the occupants or users that rely on them every day. According to E Source, "providing trade allies and contractors with training and certifications can serve as a powerful marketing and outreach tool, and help ensure program standards are met."[53] Examples of specific PA-sponsored targeted training, each of which has been a long-standing component of the PA menu of service offerings, include those listed below. Each offering is regularly updated and refreshed by their sponsoring organizations to meet the needs of a changing workforce and updates to technology.

[53] *Best and Emerging Practices and Technologies in Energy Efficiency Program Delivery: Phase One Findings*, Memo to the Massachusetts Program Administrators, March 20, 2015.

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	• *Building Operator Certification* ("BOC") is a nationally recognized, competency-based training and certification program.[54] It is designed to give facility staff practical skills and knowledge that they can apply to make their buildings more comfortable, energy-efficient, and environmentally friendly. BOC credentials are recognized by employers across the country. BOC courses are delivered throughout New England using locally-based instructors approved by the parent organization.[55] Building operators earn certification by attending training classes on a variety of topics, including electrical lighting systems, HVAC, indoor air quality, sustainability, and energy efficiency. Classroom instruction is combined with required hands-on projects in the students' own facilities, making the experience more relevant and practical. There are two sequential certifications: BOC Level I and Level II. The Level I course series offers eight one-day classes and Level II offers seven one-day classes. In most cases, the sponsoring PA has one class day to brief participants on the features, requirements, and procedures of the energy efficiency programs and services specific to their area. Both series include classroom training and project assignments to be completed at the participant's facility. The PAs actively recruit BOC participants and some provide partial tuition reimbursement upon course completion and certification. In many instances PAs provide an additional incentive for submitting a proposed energy efficiency project within a year of certification. The PAs work with the national sponsoring organization, the Northwest Energy Efficiency Council ("NEEC"), to continually update BOC training and materials to ensure that they are relevant to local Massachusetts conditions and also incorporate the latest advancements in the industry. In addition, the national BOC administrator conducts an annual curriculum review to ensure that all materials reflect the latest technologies and practice innovations. In recent years NEEC has made significant updates to the Level I and II. In 2013, almost 40 percent of the content was updated or replaced. The new content focuses on low-cost opportunities to

54 http://www.theboc.info/index.html

55 http://www.theboc.info/

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	improve energy performance, building scoping and tune up, retro-commissioning, high performance HVAC systems, energy diagnostics using data loggers and BAS, selling efficiency projects, occupant engagement, and water conservation.[56] Additional new products include: • A six-part continuing education webinar series to help BOC operators maintain their certification. Maintenance of certification (MOC) increases persistence of BOC savings based on third party impact evaluations; • One day MOC events provided in partnership with sponsoring utilities for BOC certified operators in their service areas; and • A blended, online Level I course offering a mix of classroom and online training to earn the BOC Level I credential. NEEC has also developed sector-focused BOC collateral which targets commercial offices and is preparing collateral targeting the Healthcare sector. Several utility sponsors in other regions have fully integrated BOC with core programs such as retro-commissioning and SEM, and the PAs will examine those options as well. BOC was the subject of a very recent evaluation in Massachusetts.[57] The evaluation suggests that the PAs can best promote BOC enrollment and increase the savings attributable to BOC by: • Employing multiple channels to promote BOC - e-blasts to eligible customers, direct outreach by account executives promotion of BOC at trade events, etc. • Working with NEEC to ensure that the program collateral, website, and registration systems serving the Northeast are clear to prospective Massachusetts participants. • Crafting messaging that conveys the value proposition of

56 Detailed curriculum outlines are at: http://www.theboc.info/h-course-descriptions.html.

57 *Comprehensive Review of Non-Residential Training and Education Programs, with a Focus on Building Operator Certification*, Prepared for the Massachusetts Program Administrators and the Energy Efficiency Advisory Council, Navigant Consulting, June 19, 2015.

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	certification and maintenance of certification to high-level managers, who must authorize staff training. The value proposition should include that energy savings will offset the training cost and that additional benefits accrue as well, such as reduced emergency failures and more effective use of maintenance contractors, and these benefits are documented in BOC evaluations, • Promoting and explaining to participants the benefits of all the other energy efficiency programs offered by the PAs.[58] The findings also suggest that the level of effort put into promoting BOC affects training uptake.[59] Some PA sponsors currently provide tuition reimbursement upon course completion and certification. In other instances the PAs provide an additional incentive for submitting a proposed energy efficiency project within a year of certification. The PAs will be guided by the above findings and recommendations when sponsoring BOC or its derivative options over the next three years. • *Compressed Air Challenge* training has also been offered by the PAs for a number of years. The Compressed Air Challenge is a voluntary collaboration of industrial users, manufacturers, distributors and their associations, consultants, state research and development agencies, energy efficiency organizations, and utilities.[60] Training is led by subject matter experts who provide facility managers with strategies for proper configuration of a compressed air system, system operation, maintenance requirements, and user accountability. Instructors also help participants develop a compressed air system management action plan for the unique processes in their home plant. CAC regularly updates its Best Practices for Compressed Air Systems manual, and its Level 2 Revision Working Group is finalizing a next phase of revisions to the Advanced Management of Compressed Air Systems training. Also, its New Training Working Group continues work on a new one-day "strategies"

58 Sponsoring PAs currently use one class day to brief participants on the features, requirements, and procedures of the energy efficiency programs and services specific to their area.

59 Id. at 2.

60 https://www.compressedairchallenge.org/

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	course. Two Massachusetts PAs, Eversource and National Grid, sit on the CAC Board of Directors, so Massachusetts experience with the program, and expectations for the future, are integrated into this planning. • *Water/Wastewater Plant Operator Training:* Every year since 2010 the PAs have partnered with the nationally-known experts in water and wastewater at the University of Wisconsin – Madison to deliver annually-updated best practices training for water and wastewater plant operators, tailored to the needs and conditions of the Commonwealth. The course combines engineering principles, best practices, case studies, and current technologies to help plant personnel manage their energy budget and improve energy efficiencies in water and wastewater treatment plants and pumping systems. The curriculum for this training is tailored to Massachusetts self-identified needs, as reflected in past participant evaluations and through direct communications between the PAs and the UW faculty. In turn, UW brings its expertise to the table, suggesting content revisions to reflect the latest technologies and techniques they encounter in their research and practice. • *Building Owners and Managers Association High-Performance Sustainable Building Principles:* BOMA has recently launched this new course, which provides a comprehensive treatment of high-performance sustainable buildings and exposes learners to the critical components of sustainability – "where building systems and the ecosystem intersect."[61] The course is taught both on-line and in a classroom setting and covers such issues as identifying and overcoming the hurdles to achieving true high-performance, attaining full organizational buy-in for sustainable building initiatives, resource management concepts, benchmarking value and standards for design review, integrated systems and commissioning concepts (HVAC, lighting, and electrical), water and wastewater system considerations, renovation and tenant improvement guidelines, sustainable contracting and vendor management principles (maintenance and purchasing), finance/portfolio considerations, etc. The course has not yet been offered in the Northeast, and the PAs have contacted

[61] http://www.bomi.org/Courses/High-Performance-Sustainable-Building-Principles

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	BOMA to explore development of a partnership to do so in 2016 and beyond. • *California Advanced Lighting Controls Training Program* ("CALCTP"): was developed by Southern California Edison and has now been adopted by all the California utilities, as well as program administrators in other jurisdictions. CALCTP provides electrical contractors and electricians with training and a certification in Advanced Lighting Controls (ALC). The curriculum covers the proper programming, testing, installation, commissioning and maintenance of advanced lighting control systems, including dimmers, occupancy sensors, photo-sensors, relay modules and communication-based control devices. CALCTP graduates receive certification that permits them to work on ALC projects, which are then eligible for incentive programs. • *Site-Based Facility Management Initiative:* The PAs are exploring development of an on-site facility tune-up and operator training concept. The idea would be to work with a facility's on site staff and existing equipment and maintenance support contractors to identify opportunities for low-cost/no-cost system improvements, undertake those improvements, and then follow up at intervals to ensure that enhancements do not degrade and that facility staff continue to implement identified operational improvement procedures. *Memoranda of Understanding/Strategic Energy Management Planning - Based Training* Some PAs offer MOUs or SEMPs, which contain behavioral and process improvement components, with incentives awarded for verifiable reductions in energy use that can be attributed to each action. Each agreement is customer-specific and structured through an exchange of ideas between the PA and customer staff. It is dependent on the nature of each of the customer's facilities and the demographics of their users/occupants. For example, the operational improvement opportunities and the customer tolerance for deviation from the current operational norms are very different between a university and a critical care hospital. Similarly, the "customers" of these buildings – students and faculty in the former and medical staff and patients in the latter – will likely respond differently to the behavioral strategies and prompts. Submetering will

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	always be incorporated into these agreements when, in the judgment of the principals, it will help identify and prioritize opportunities at the outset of the relationship and it will lead to customer action. Submetering will also be offered to other customers when, in the judgment of the PA, it can be cost-justified because it will help identify and prioritize opportunities and it will lead to customer action. In addition, submetering is integral to the EM&V process, particularly when attribution and verification of behavior-based savings must be established. When considering expanding SEM efforts, much as with retro-commissioning, it will be critical for the success of recruitment efforts to understand what individual customer characteristics or categories of customers can be identified that will identify them as those who are most likely to see a value proposition in SEM. As the PAs consider SEM expansion opportunities (both in number and in kind) they will integrate the growing body of knowledge from their own local MOU/SEMP experiences and engage with SEM early adopter jurisdictions and their allies (such as the Pacific Northwest and the Northwest Industrial Strategic Energy Management Collaborative[62]), and incorporate the results of their research activities and field experience.[63] *Increased Use of Interactive and Web-Based Learning* Training in the energy efficiency domain, as in society at large, has moved more and more into the mode of distance learning. The advantages for participants are obvious: convenience and flexibility as well as avoided travel and time away from the facility. For the PA's distance learning can more effectively reach busy facility operators and allows for creation of niche-specific training modules that would be too expensive to deliver to a limited audience in the conventional classroom /instructor model. During the last Plan term the PAs moved aggressively into multiple new modes of education and training. During the 2016-2018 Plan term the PAs will investigate and implement even more distance learning training techniques – from scheduled webinars to on-demand materials that can be archived and accessed online.

[62] http://neea.org/get-involved/northwest-industrial-sem-collaborative

[63] For example, *NW Strategic Energy Management: Guide to SEM Customer Segmentation*, Northwest Industrial Strategic Energy Management Collaborative, Market Analysis and Planning Team, December 2014

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	As a part of the planned Mass Save® website upgrade, a calendar feature will be added that shows all scheduled trainings, and provides contact information to register or participate. Small Business Core Initiative The Small Business Core Initiative, often referred to as the direct install or turnkey program, is a long-standing PA offering, and one of the most successful in the nation, with very high rates of customer uptake and satisfaction.[64] In Massachusetts, each PA began offering some kind of specialized efficiency services for small business customers roughly 25 years ago. The turnkey model was first offered by National Grid in 1990 for customers 50 kW and smaller. It was subsequently adopted by all the PAs and, with experience, it has evolved, expanded, and improved over time, with the addition of gas measures specifically and more measures generally. The core initiative is regularly cited by independent industry organizations, such as ACEEE, as the most successful program directed to the small business sector in in the country[65], and it has served as the template for dozens of imitators in other states and provinces. In 2013, 4,646 customers statewide participated in this program, saving, on average, 17.3 percent of their prior electric consumption and 5 percent of gas consumption.[66] Since its initial introduction, over 50,000 small businesses in Massachusetts have taken advantage of the Small Business offerings.[67] Its success notwithstanding, the PAs have jointly embarked on a thorough review of every aspect of the program – administration and delivery, target markets, measures, marketing, etc. – with no preconceived notions or limits as to outcomes. Many of the options under consideration by the

64 87 percent of program participants are satisfied with program overall. *DI Process Evaluation: Final Report for the Massachusetts Program Administrators*, DMV.GL, February 2015, at 51.

65 Exemplary Program Award in the Small Business category: National Grid Small Business Services, *Leaders of the Pack ACEEE's Third National Review of Exemplary Energy Efficiency Programs*, York, et al, June 2013. The program also received Exemplary awards in the First and Second ACEEE national reviews of program.

66 Id. at 59.

67 As conservative estimate, as National Grid's participate count can only be traced back to 2003, and the predecessor companies – New England Electric and Massachusetts Electric – had offered the program since 1990.

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	PAs were also subsequently raised by the EEAC consultants in their briefing memo to the Council.[68] The recent process evaluation of the program pointed to some potential process and delivery improvements that will also be explored.[69] Examples of the options under consideration include: addition of more gas measures, including thermal measures; better and more referral follow-up services for measures not amenable to the direct install delivery model (such as thermal measures and heating systems, for example, so that deeper treatments can be undertaken); further segmentation to reach the smallest of the small customers through consideration of web portals, self-service delivery concepts, further development of the Main Streets or other geographically-focused delivery models, adaptation of successful residential delivery models such as HES, and more targeted marketing and measure mixes by business type. Examples of the tests currently underway and continuing into the next Plan term or targeted to begin in 2016 are: • Eversource will be working in the greater Boston area to test ways to increase tenant space improvements, particularly those tenants who are located in buildings that fall under the scope of the Boston Building Energy Reporting and Disclosure Ordinance (“BERDO”) and the Cambridge Building Energy Use Disclosure Ordinance (“BEUDO”). The test will involve local turnkey contractors, working in coordination with Eversource’s C&I teams to engage property management customers. For purposes of this test, the initial audit will be done by a firm that is independent of the turnkey contractor, who will focus on comprehensive recommendations, with particular focus on lighting controls. The post-audit will also be conducted by this independent firm or an Eversource internal auditor. Incentives are to be delivered through the usual turnkey process. • In a second test, focused on Cambridge and Framingham, Eversource will focus on getting more customers to adopt more controls-enabled retrofit kits and fixtures. Customer installation will include LED lighting retrofit kits or fixtures, enabled with controls (daylight, dimming, occupancy sensors, etc.). Installation will be performed by product vendors with standard program

68 *Effective Practices for the Small Business Sector*, February 11, 2015

69 Small Business Program Process Evaluation Final Report, DNV GL, March 23, 2015.

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	incentives. Post installation will be conducted by an independent firm or an Eversource internal auditor. • National Grid plans to experiment with the EnergySavvy[70] platform as an online portal to guide small and medium businesses to the program offerings applicable to their business. EnergySavvy walks customers through a five to ten minute online assessment whereby they learn what is available/applicable to them from the full C&I menu, and National Grid learns a bit about them and their needs. Theoretically, this should allow for more efficient and targeted deployment of resources. The experiment will move from improved customer experience in the lead intake phase, to a greater awareness of the range of options available, to conversion of this customer interest into additional tangible projects and savings. • To better serve the smallest customers and niche customers, National Grid will also continue to experiment with variations of the "Main Street" delivery model. • Cape Light Compact is launching a new effort for its smallest and most numerous C&I customers – those using less than 100,000 kWh annually. The new initiative will be modeled after the HES program and will include a BEA (Business Energy Audit) and a core offering of deemed savings measures, many of which can be installed in the first visit. Factors that must be balanced when considering the results of these or other tests in any redesign include: • *Cost of delivery:* The transaction costs of serving small customers are high relative to the savings potential contained in their facilities. Small Business has been successful because of the mix of incentives. Financing, on-bill repayment (where technically available), and turnkey delivery make it easy for customers to say yes, thereby creating the cost advantages of a high sales closure rate and commoditized delivery at scale. Some of the proposals to reach more and smaller customers, and achieve deeper savings, are likely to increase the cost of acquisition; • *Equity:* All business customers, including the smallest of

70 http://www.energysavvy.com/

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	businesses, contribute to the efficiency fund, and thus all should have easy access to measures and services that will lower their gas and electric bills, and improve comfort for them and their customers. In order to open the discussion to the widest range of ideas, the PAs are conducting an ongoing national best practices inquiry to identify any creative features in other small business programs, as well as additional gas or electric measures beyond those currently offered in Massachusetts. In addition to research elements, the PAs are also discussing operational and delivery insights with their peer program administrators around the country. This inquiry may produce recommendations for a series of incremental program improvements that can be incorporated serially into the existing delivery structure through amendments to existing contracts with delivery contractors. Any larger modifications would likely be incorporated in the contractor rebid process. Further Engage the Commercial Real Estate Sector In the last Plan, the PAs committed to engage in a stakeholder process with the goal of better identifying any unique barriers that could inhibit full participation by the Commercial Real Estate ("CRE") community in the Massachusetts programs. In 2013, a representative Commercial Real Estate Working Group was convened and conducted primary and secondary research throughout 2013 and 2014.[71] This research led to the development of several tentative strategy proposals to broaden and deepen CRE program participation, which were then vetted in late 2014 in a series of roundtable discussions involving representatives of owners of large buildings and their tenants, as well as later interviews with small building owners. The strategies explored included: turnkey service delivery to small and mid-size customers, pre-packaged prescriptive options that could be quickly implemented, "energy dashboards", and promotion of "Green Leases." The research and subsequent discussions revealed that in the most common lease structures energy costs are passed through to tenants, creating the classic split-incentive problem. Owners are generally the

[71] Secondary research included: C&I Customer Profiles & Market Sector Profiles, Mid-Size Customer Needs Assessments, A Better City Reports, NEEA - Existing Building Renewal/Commercial Real Estate Research.

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	primary decision-makers with regard to energy matters, and the majority do track their energy use and compare it to peer buildings. However, as with most non-core business issues they face, owners lack the time, knowledge, and resources to pursue strategies to increase the efficiency in their facilities comprehensively and effectively. To the extent that efficiency upgrades are considered, the best opportunity is when office space is fitted out for initial occupancy or when existing space is in transition from one tenant to another. These tenant fit-up/refit decisions occur rapidly, and the window of opportunity to consider energy efficiency improvement opportunities is very narrow. The research also found that CRE firms are open to more regular contact from the PAs, and some owners do have an interest in more complex solutions, and PA assistance in assessing and executing them. The PAs plan to pursue the following potential strategies due to the considerable interest received from industry representatives: • *Tenant build-out/refit offerings:* Clearly, the best time to install efficiency measures is during the build-out for new tenants or the refit when old tenants depart and the new ones have yet to arrive. The Sustainable Office Design ("SOD") initiative, discussed in a preceding section of this Plan, was launched by Eversource and National Grid to address just this market-driven opportunity. As the SOD initiative is further developed, and is adopted by other PAs, it could be augmented with additional enhancements recommended by the industry such as: o Packages of lighting, space conditioning, refrigeration and commercial cooking offerings. This could also include bonus incentives for installing multiple measures in the package, which was of interest to both owners and tenants. o Offerings could also be provided on a tiered – good, better, best – basis to cater to firms' varying interests, needs and budgets, and overall expectations for the building's aesthetics and operations. This approach was viewed favorably by both owners and tenants with tenants also suggesting the addition of plug load monitoring and controls. o Packages could also vary according to the space types,

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	particularly in market sectors where CRE firms are more prominently represented, such as retail and hospitality.[72] • *Turnkey-delivery models for CRE customers*: With research showing that_much of the CRE property in Massachusetts is small – on average half the size of non-CRE property[73]-- and as a result having limited resources to identify potential improvements and keep track of available incentives, the turn-key approach would reduce cost and the time and resources required for CRE customers to benefit from energy efficiency. To be successful, however, the PAs need to train vendors, particularly their small business vendors, to better identify, understand, and capture CRE specific opportunities such as fast-moving fit-up opportunities.[74] • *Dashboards and building labeling*: Roundtable participants indicated that displaying energy usage at the tenant and building level through dashboards can contribute to energy efficiency and real-time tracking can improve occupants' awareness of energy use and behaviors. o There are a variety of tools in this area, more appearing on the market with regularity, and the PAs will experiment and compare the effectiveness of some of the most promising.[75] o Most feel that Boston's benchmarking requirement has been successful. It has allowed consumers to track the heretofore untrackable, provided enlightening comparisons between buildings. PA support of benchmarking will become increasingly important, particularly as a number of communities beyond Boston are adopting commercial building energy disclosure ordinances. At a minimum, it heightens awareness and sets the stage for action. o Presenting consumption in terms of end use intensity ("EUI") and usage per square foot (kWh/sf and/or

72 "Massachusetts Commercial Real Estate Survey Analysis-Final Report", DNV-GL, March 18th, 2015, p. 4.

73 <u>Id.</u> at 5.

74 The CRE Report suggested partnering with key trade associations, such as BOMA and NAIOP that are active in this marketplace.

75 http://www.linkcycle.com/review-of-top-energy-management-software/

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	KBTU/sf) metrics is most useful, as are peer level benchmarking comparisons.
	
	• *Additional program improvements*
	  o Process improvement – CRE customers would like reduced paperwork and streamlined application processes. The PAs will be implementing online incentive applications to address this need.
	  o Collaboration with building operators – in order to build awareness and expertise, the PAs will continue to support a variety of training offerings such as building operator certification ("BOC") and seek opportunities to expand and/or augment the array of trainings available.
	
	In general, the specific elements and approaches of a successful CRE strategy include:
	• Developing marketing strategies that resonate with the distinct submarkets within CRE;
	• Developing unique technical solution sets for each distinct building type in CRE, with accompanying financial incentives that are both sufficient and presented in a manner that make them attractive to subsector decision-makers;
	• Streamlining PA paperwork and decision making to meet the pace of decisions being made in the sector;
	• Delivering better CRE training for all channel partners, particularly Small Business contractors.
	
	Additional Planning Input
	
	The NEEA also released an assessment of the CRE Market this year.[76] The Northwest research plan also involved extensive interviews: 21 executives representing 18 CRE firms and 17 representatives from five CRE-related trade associations. This study reached substantially the same conclusions as the Massachusetts report, with the additional caveat that "The primary market motivations to invest in energy efficiency vary greatly based on the business structure of the firm. When it comes to the

76 "Commercial Real Estate (CRE) Market Test Assessment: Understanding Delivery, Partnership Strategies and Program Channels", New Buildings Institute for NEEA, March 16, 2015

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	promotion of energy efficiency we believe it to be beneficial to tailor strategies and approaches to the following three types of firms: (1) Larger Investor/Owners and Real Estate Investment Trusts ("REITs"); (2) Third-Party Property Managers; and (3) Smaller Independents." Perhaps most significant for the Massachusetts programs, our neighbors at NYSERDA in New York have recently announced that as a part of their Commission-ordered program redirection they will "(p)artner with large commercial portfolio owners and receptive tenants, service providers, industry trade and research associations, and governmental organizations to pilot standardized tenant energy efficiency packages."[77] In 2016-2018, NYSERDA will develop and conduct a set of replicable pilot studies of efficiency packages in key building types and market segments. The objective of these pilots will be to acquire building data for analysis and to conduct M&V studies to provide insights into the actual performance of these packages. Results will be used to produce case studies that will be shared with the efficiency industry. Also in 2016-2018, NYSERDA will partner with large portfolio owners in key building segments (CRE, medical centers, colleges/universities, etc.) and providers of various Real Time Energy Management ("RTEM") service providers to conduct a set of replicable pilots using a variety of these tools that monitor data and use analytics to identify where, when, and how energy is being used in a building. In addition to the direct technical and financial support to the participants, NYSERDA will acquire building data for analysis and will conduct M&V and persistence studies "to provide insights into the technical/operational underpinnings of RTEM and to develop credible models and case studies to support a clear value proposition for owners of similar buildings."[78] The PAs will discuss with NYSERDA management the potential for collaboration in these two test areas, and potentially others as well. These discussions will be led by National Grid, as the PA whose operations span both jurisdictions. At a minimum, the PAs own test designs can be informed by NYSERDA experience.

[77] NY PUC Case 14-M-0094, "Proceeding on Motion of the Commission to Consider a Clean Energy Fund, Clean Energy Fund Information Supplement", submitted by the New York State Energy Research and Development Authority, June 25, 2015, at 46.

[78] Id. at 50.

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	<u>Maintain/Improve Services for Financing Energy Efficiency Investment</u> The PAs have partnered with the Massachusetts Bankers Association to make available heavily subsidized financing for business, multi-family, and non-profit commercial customers who need capital beyond the value of the PA incentive to implement a project. Loans can range from $5,000 to $500,000, and can extend to 7 years. For the PAs, the ability to link customers to capital where that is the barrier to project execution is an invaluable sales tool. For participating lenders, the partnership opens up a new market to attract new customers, with the assurance of receiving a market rate interest payment from the PAs. Mass Save® Financing for Business has had a modest uptake, and is best viewed as a useful, but niche, tool in the energy efficiency sales toolkit. To many observers, the importance of making additional outside financing available for energy efficiency investments seems intuitive: even when investments in retrofits and new equipment pay off in future energy savings, the up-front expenditure is often substantial. It would seem that many building owners would welcome financing. However, larger sized businesses in the Commonwealth have indicated that access to outside capital financing is not a primary barrier to program participation.[79] As the 2012 “Massachusetts Large Commercial & Industrial Process Evaluation” concluded: “Lack of financing activity appears to be due mostly to very few organizations relying on outside financing in general.”[80] A PA review of recent studies of financing programs revealed two trends. First, the Massachusetts experience is consistent with the financing experience of most other program administrators.[81] Second, because of

79 In 2012, KEMA surveyed 354 companies or organizations who were recent program participants (2010 or 2011). 68% of respondents reported they “never” or “rarely” depend on outside financing. Only 2% said capital availability was a barrier, and only 6% said they always or most of the time rely on outside financing. Massachusetts Large Commercial & Industrial Process Evaluation, DNV KEMA, Inc., May 17, 2012

80 <u>Id.</u> at 3-17

81 Borrowing to Save Energy: An Assessment of Energy-Efficiency Financing Programs, Karen Palmer, Margaret Walls, Todd Gerarden, Resources for the Future, April, 2012

> “In our experience examining efficiency programs across the country, lack of financing is seldom the primary reason that efficiency projects do not happen. Financing is only useful once the “product” has been sold to the customer, just as a car loan can only be appealing once you want a car (and then only if there are no better payment options

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	this disappointing performance there is a new surge of interest in investigating alternative and creative financing vehicles, such as commercial PACE.[82] New financing options may have the potential to improve customer uptake of project financing and reach more customers who heretofore may not have participated in energy efficiency programs due to capital constraints. The PAs will continue to review new studies and proposed mechanisms as they emerge and participate in financing policy forums.[83] They will also closely watch financing pilots and initiatives being conducted in other jurisdictions to determine which emerging models, if any, show promise for replication in the Commonwealth.[84] More Tools for Customer Engagement Surveys indicate that consumers have tremendous expectations that they will have an abundance of choices in energy services in the future.[85] However, the surveys also indicate that consumers are also largely unaware that they will need to take a more active role in managing energy decisions for their expectations to become a reality.[86] In many cases, business consumers lack essential knowledge of how they use energy and what steps they can undertake to use it more efficiently to accomplish their same business objectives. The PAs fully understand the value of expanding the channels of information transfer to customers, and building and deploying communications tools that allow for a more interactive experience between customers and their suppliers of energy and energy efficiency services. While evaluations have indicated high levels of

available.", The Limits of Financing for Energy Efficiency, Borgeson, Zimring, and Goldman, Lawrence Berkeley National Laboratory, 2012 ACEEE Summer Study

82 A unique, and potentially attractive, feature of the PACE model is that allows for longer terms – potentially up to 20 years, which allows more opportunity for a positive cash flow on capital-intensive or long payback measures.

83 Leading policy forums include: the Yale Center for Business and the Environment, "Blueprint for Efficiency Project", the ACEEE Energy Efficiency Financing Forum, PACE Now, etc.

84 *E.g.*, The Connecticut Green Bank, various public and private PACE finance programs (YGreen Energy Fund, the Florida PACE Funding Agency Program, Energize New York Finance, etc.).

85 "Knowledge is Power: Driving Smarter Energy Usage Through Consumer Education", IBM Institute for Business Value, January 2012.

86 Id.

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	satisfaction among Massachusetts businesses that have participated in Massachusetts programs,[87] and that customers view the PAs as trusted sources of information,[88] it is also clear that more customers need to be engaged. Customers that have participated on a project-by-project basis must be engaged on a more continuing and comprehensive basis in order to fully realize the efficiency capabilities in their properties. All of the PAs are examining ways to connect the power of data and data analysis with the increasingly interactive capabilities of their customer website portals. An illustrative example here is the Eversource Customer Engagement Platform that is being implemented in phases across all of its operating companies. This platform will provide tools that will enable Eversource to more efficiently identify, target, and reach all customer segments and provide each customer with customized energy efficiency recommendations. Eversource is implementing three customer-facing tools: Residential, for all residential customers; Commercial, for micro, small, and medium business customers; and Enterprise, for the largest customers. The project plan calls for a phased roll-out of these portals, with full functionality in place in the first year of the Plan, 2016. An example of the platform's capabilities is the online tool, *Energy Savings Plan*. *Energy Savings Plan* is an interactive tool within Eversource.com that enables residential and business customers to learn how they currently use energy, how they compare to other similar customers, and, most importantly, practical steps they can take to reduce their energy consumption and costs. *Energy Savings Plan* utilizes the customer's usage data, collects additional information through a series of easy-to-answer profile questions, and then makes customized, actionable energy efficiency recommendations. Features of the online tool include potential savings estimates, "learn more" case studies, and links to solution resources. In addition to the foregoing, the PAs will also be building an entirely new capability for customers, or their agents, to create and submit project

[87] 89 percent of participants gave the PAs a four or a five on five-point scale for overall satisfaction. "Massachusetts Large Commercial & Industrial Process Evaluation", KEMA, May 17, 2012.

[88] When asked about trust in a variety of different sources of information, from community and business organizations to the press and other media, 78 percent of Renew Boston Business program participants had the greatest level of trust in NSTAR/National Grid – second only to the City itself. "Massachusetts Special and Cross-Sector Studies Community-Based Partnerships 2011 Evaluation, Final Report", Opinion Dynamics Corporation, July 2012, at 56.

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	applications using an on-line or web-based incentive application portal. This portal will not only greatly enhance and simplify the user experience but will also increase the likelihood that more applications would be submitted while increasing the satisfaction of those that submit applications. Beyond the potential benefits to customers, and their contractors, the PAs expect the application portal will also result in considerable efficiencies in terms of reviewing, approving and performing data entry on the roughly 10,000 gas and electric applications that are processed each year. Combined Heat and Power During the 2016-2018 Plan term the PAs will aggressively explore more ways to increase CHP installations in Massachusetts while maintaining the high standards for project screening, qualification, and performance for which PA programs are known. The PAs will initiate this process by commissioning a best practices review of other programs nationally and a reassessment of the CHP market in Massachusetts in 2016.[89] Among the areas that the latter investigation must consider are the following: (a) are there barriers to doing more CHP projects with customers of each size; (b) are the barriers technical, policy, financial, legislative, or market issues; (c) can potential solutions to overcome the barriers be identified; and (d) is it feasible and cost-effective for the PAs to implement the solutions. The PAs have developed a network of over 50 vendors, developers, and installers who want to sell CHP in the Commonwealth. As a result, the issue-identification process can be initiated by the PAs in advance of contracting for studies, and this conversation will help shape the study directions. Initial areas for investigation include: (a) the challenges posed by natural gas availability and volatility in fuel prices for installing CHP systems and potential programmatic approaches to mitigating those risks; and (b) continued work to seek ways to safely install CHP in urban settings.[90] Lastly, the PAs will enhance the education campaign for CHP technology, including providing technical assistance on determining cost-effectiveness and navigating the DEP permitting process, when applicable. Customers will receive information on the efficiency of the

[89] The last assessment was conducted in 2009.

[90] CHP on spot networks has been resolved in NY, Chicago, and San Francisco., but remains a concern in New England. The Institute of Electrical and Electronics Engineers (IEEE) has had a standard under development, but it has not been finalized.

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	systems, carbon reduction, payback formulas, and incentives.
Program Design	The Retrofit Program targets customers who have functioning, but inefficient, equipment in their facility, or their older building's performance is not code compliant and can be upgraded to higher efficiency without undergoing major renovation. The program uses a variety of sales and delivery strategies to educate customers about the true cost of continuing to operate inefficient equipment, including the "cost" of reduced customer or employee satisfaction with the building environment they experience. The program provides customers with information on the cost saving and ancillary additional benefits of a more efficient building and/or equipment, and then provides an easy path to the upgrade, including streamlined incentives and direction to a skilled contractor who can perform the work. In some cases all of these services are provided through turnkey service providers working under contract to and supervision by the PAs, as with trade allies and Small Business delivery firms. In other cases, particularly with larger customers or property management firms, the outreach, sales, and service coordination is conducted by PA Account Managers. The core elements of the program are the Prescriptive and Custom path options. The Prescriptive path offers fixed incentives for purchase and installation of a broad menu of prescriptive measures. Prescriptive measures are those for which the energy savings can be predictably assumed in a wide variety of building types and business environments. Many are lighting and lighting control measures, but there are also prescriptive incentives available for variable speed drives ("VSDs"), HVAC controls, spray valves, steam traps, etc. Some of the richest sources of energy savings potential are found in equipment or processes that are unique to a customer's premises and/or operational requirements. These unique, or custom, opportunities require a site-specific engineering analysis to determine costs and benefits. Custom opportunities account for a large share of PA savings. When a promising efficiency opportunity has been identified, often by a PA Account Manager, an appropriate technical expert, drawn from a pool of pre-qualified engineering consultants selected as preferred vendors through a competitive procurement process and matched to the specific needs and capabilities of the customer, is assigned to further define and quantify the potential. These highly skilled, unbiased, and independent

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	technical experts can conduct walk-through audits, perform detailed energy-efficiency studies of whole buildings systems or building components, or conduct specialized technical studies, such as studies of industrial or manufacturing processes. TA consultants are assigned based on their recognized expertise with the technology area under consideration. Customers can also elect to use their own TA consultant provided that the partnering PA approves of the firm's qualifications and cost estimate. Non-preferred vendors must comply with the same level of detail and quality as preferred vendors. Often customers will have both gas and electric savings opportunities. In these instances the relevant gas and electric PA will instruct the TA consultant to examine all savings potentials. The two PAs share the study costs and coordinate delivery of the recommended improvements.
Delivery Mechanism	The Retrofit program is largely delivered through a mature and growing network of trade allies. These include contractors providing retrofit services directly under contract to the PAs, such as the Small Business and preferred trade ally contractors, and the hundreds of independent lighting and HVAC contractors, supply houses, electric and gas equipment vendors, RCx service providers, etc., who service their customers' needs and, in the process, assure that those customers install the best possible equipment and facilitate program participation on their behalf.
Marketing Overview	Collectively, the PAs serve approximately 350,000 electric and 154,000 gas C&I customers. These run the gamut from the one-chair barbershop and corner bodega to massive manufacturing, health care, and educational facilities. Serving this diverse and large population of business customers effectively requires an understanding of their unique attributes. Based on that understanding, the PAs have designed and implemented a number of marketing strategies specifically targeted to various sub-segments of C&I customers. Examples of current strategies to serve the diversity of submarkets, and some proposed enhancements are detailed below. <u>Segments of Special Interest</u> <u>*Large Customers*</u> In Massachusetts, as in most states, a relatively small number of customers account for a disproportionately large share of the state's energy consumption. These customers – hospitals, universities, industrial

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	complexes, owners of building portfolios, etc. – often present more opportunity for efficiency, but usually these opportunities are found in more complex systems that require unique analysis and customized solutions. The conventional trade ally-driven approach of a mix of prescriptive and custom equipment-based incentives, designed for a volume-based mass market, does not adequately address the needs of these customers, nor is it equipped to systemically harvest the vast saving potential that exists in these facilities. From the PA perspective, large customers also have many beneficial attributes that make them ideal long-term partners. They generally have sophisticated in-house engineering and facility staff and sophisticated financial analysis capabilities. They also tend to have longer term planning and investment horizons. For the very small subset of customers with this combination of high savings potential and sophisticated in-house technical and financial resources, the investment of more program technical and financial resources can be warranted and, where there is owner or corporate commitment, the PAs will invest significant staff and consultant technical expertise, as well as financial incentives, to execute multi-year arrangements that meet the business needs of both parties. An MOU or SEMP partnership is the culmination of a process that begins with discussions between senior level decision makers from the customer and the PA. Over the course of these discussions PA management develops an understanding of the customer's intermediate and long-term business intentions, motivations, and limitations. The customer, in turn, comes to a better understanding of what technical and financial resources are potentially available to that match their objectives. When there are sufficient commonalities of interest and an accompanying willingness to dedicate staff and financial resources, both parties ultimately capture their commitments and objectives in an MOU. This document details with specificity the commitments and actions required of each party to achieve the agreed efficiency resource goals. The PAs will only move forward when there is a match between their acquisition requirements and a clear customer commitment to engage their resources as well. Early in the process a joint team of customer and PA subject matter experts is convened. This team must include a representative from the customer's organization who is both committed to the effort and has the appropriate stature to represent it to his/her upper management. The team may also include finance, sales, technical, implementation, procurement,

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	corporate/public relations, or any other internal stakeholders deemed critical to ensure success. This joint team should be small enough to remain functional and be empowered to make decisions, including engaging third party expertise when necessary. The team is responsible for designing the details of the MOU/SEMP partnership, establishing the implementation framework, and managing progress towards established goals. Depending on the maturity of the customer/PA relationship, it may take from three to 12 months to establish the terms of an MOU agreement. From agreement forward, the implementation progress is tracked monthly at the project level. This frequent reporting encourages progress and momentum and flags roadblocks or loss of momentum quickly. These partnerships are significant undertakings and require very real ongoing commitment by both parties. However, the experience so far is that significant energy/cost savings can and will be achieved – often on the order of 20-30 percent – and achieved at a lower cost to both parties, as compared to traditional implementation methods. In addition, these partnerships often have intangible but valuable benefits to the customer, such as positive public visibility as an environmental steward. These intangibles help maintain lasting relationships between PAs and customers. By way of example, past MOUs/SEMPs have included such features as: • Customer access to utility equipment procurement processes to achieve volume pricing; • Turnkey installation services using PA contractors, pre-selected for price and competence; • Joint engineering reviews and installation inspections, eliminating duplication and costs; • Simplified incentives, such as $/kWh saved; • Tiered incentives for higher, deeper savings; • Expansion of eligible technologies/strategies beyond the common portfolio; • Support for staff behavioral efforts; • Facility staff and user training; • Joint application for outside federal and state funding/grants;

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	• Sharing of company-specific expertise; and • Test bed for new technologies and promotions. Based on their respective organizational commitments and internal resources, PAs may incorporate other components to address customers' energy needs and interests, and broaden the scope of these partnerships beyond energy efficiency. For example, these components may include technical assistance for on-site renewables and alternative fuel vehicles, with the idea of bringing integrated energy solutions to customers, with energy efficiency as the foundation. *Cities, Towns and Special Purpose Districts* Local public bodies have unique challenges and opportunities with regard to efficiency investment. The needs, opportunities, and capabilities vary widely across the Commonwealth's 351 cities and towns, 400 hundred school districts, and 350 water/wastewater treatment plants. Very often they have staffing and capital limitations as well as statuary restrictions on how they can raise capital and contract for delivery of efficiency services. Historically, these restrictions had limited the ability of governmental units to participate in PA programs that were primarily vendor-driven and designed to meet the requirements and expectations of private sector decision-makers. Until recent years, this had resulted in lower public sector program participation, with the result that many public facilities had very antiquated building energy systems in place. In recognition of these special barriers, the PAs developed a tailored approach that includes a single point of contact within each PA's staff[91] funding for engineering assessments of opportunities, and financial assistance structured to meet their needs and constraints.[92] Services can be tailored to the needs of individual municipalities, and services are delivered through a group of installation contractors who are experienced in navigating state law regarding municipal procurement. The long-standing working partnership between the Program Administrators and DOER has been invaluable for the implementation of these services. PA and DOER's Green Communities Division staff meet

[91] The larger PAs, with many municipal accounts, coordinate these resources through a fully dedicated municipal account manager.

[92] Reporting data indicates that municipalities and other public entitles now receive at least their fair share of funding.

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	regularly to discuss issues of common concern and to leverage the unique resources of each partner on an ongoing basis. On an ongoing basis, DOER's resources can also be accessed through their team of Green Communities Regional Coordinators, who work in close coordination with their PA counterparts. In addition, the PAs maintain a regular routine outreach schedule with municipalities, schools, and water treatment facilities to keep PA efficiency services top of mind with municipal leaders and to develop and implement projects as local resources and priorities allow. A statutory change to the municipal procurement process contained in the Green Communities Act has greatly expedited the process of delivering efficiency services to government entities. Because the PAs select their contractors through a competitive procurement, cities and towns can avoid a redundant competitive process and sole-source efficiency projects to a PA or the PA's delivery contractors if the project is less than $100,000. By providing this upfront competitive bidding, enhanced financial incentives, and additional financing options, including on-bill payment in some cases, the PAs have been able to provide a turnkey service with incentives structured to create positive cash flow and encourage comprehensive municipal projects. Water and wastewater facilities are a unique public sector market segment because the energy savings potential exists in measures that are more industrial in nature – motors, drives, pumps, fans, etc. These plants are very energy-intensive. A wastewater treatment plant can spend as much as 30 percent of its operational budget on electricity. Since 2006, the PAs have collaborated on almost 350 distinct water/wastewater facility improvement projects in 120 towns, and with the MWRA on more than thirty projects. They have awarded nearly $10 million in incentives to save municipal ratepayers almost 37 million kWh, and $4 million in costs, annually. In this market, DEP is the PA's key public-sector ally. The PAs work with DEP to conduct equipment screening of facilities aeration and pumping system assets in order to identify potential energy-saving opportunities in high electric use areas. Facilities with opportunities are eligible for incentives and technical assistance, as well as preferential scoring when applying to the State Revolving Loan Fund to finance proposed energy efficiency project components, making efficiency-related proposals more competitive in the selection process.

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	The PAs stay current in the water/wastewater area by monitoring other best practices programs nationally[93] and by routinely reviewing emerging technologies and refinements to existing technologies.[94] Also, PA staff who advise facility operators are expected to know both the state of the art and the state of the shelf. Eversource staff, for example, has received annual water/wastewater training updates every year since 2010. The PAs also provides best practices training to facility operators, using recognized industry experts, such as the University of Wisconsin School of Engineering. *<u>Industrial</u>* There are almost always a wide variety of cost effective energy efficiency investment opportunities present in industrial facilities, and industrial participation in PA programs is consistent and strong.[95] Industrial energy use is usually tied closely to the production process itself. As such, it is generally a significant cost and tied closely to profitability. Facility managers must always balance the potential cost savings advantages of equipment improvements against the risk, of disruption to the production process itself. To provide the highest level of confidence in their recommendations the PAs seek out skilled TA service providers who are recognized as subject matter experts, and thus trusted, by the industrial decision-makers in their service territories. The PAs engage these expert service providers to compressively examine all the savings opportunities in a facility and quantify the potential electric and/or gas savings streams in each. To support deeper savings with industrial processes, the PAs also help customers reduce operation and maintenance costs, improve productivity, equipment reliability, asset value, throughput, and profitability while managing their carbon footprint. When the potential savings warrant it, and there is customer commitment, a MOU/SEMP approach (as detailed

93 *E.g.*, Wisconsin Focus on Energy, Energy Trust of Oregon, NYSERDA.

94 *E.g.*, the PAs commissioned an E Source "Best Practices" review in 2013, and PA staff regularly review reports and activity from the Northwest Energy Efficiency Alliance (NEEA), EPA, the California utilities. A recent example is the "California "Water/Wastewater Market Characterization Study" (for PG&E and SCE), KEMA, January 2012.

95 "Manufacturing Savings are consistently high year-over-year….As in past years, Manufacturing contributed the largest proportion of participant savings in 2013." 2013 Commercial & Industrial Customer Profile Report, at 22 and 26.

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	above) may be appropriate. Typical industrial projects may incorporate lighting, compressed air, HVAC, and process heating or cooling, as well as industry specific measures, such as injection molding measures for plastic molding manufacturers. When they are present, non-gas/electric energy benefits are quantified and their costs and benefits estimated. Examples can include savings in raw material inputs, scrap economies, increased through-put efficiencies, and potential water and/or wastewater savings. As noted above, the PAs also offer a range of training programs specific to the needs of the industrial and manufacturing sectors. In addition, they collaborate with organizations focused on improving industrial efficiency and productivity, such as Massachusetts Energy Efficiency Partnership ("MAEEP"). The PAs also collaborate with their peer efficiency programs around the country, and incorporate the best practices experiences of others. In addition, National Grid, which has a large industrial sector, is testing a targeted effort for medium and large industrial customers (> 500 kW) to augment their core industrial efficiency services. The effort funds a team of "industrial energy advisors," available at no cost to the customers, to provide industrial subject matter expertise and help explore energy-savings as well as process improvement opportunities. This team then assists the customers in following through with the identified opportunities by offering a range of support activities such as technical support, assessments, basic project management support, or simply helping navigate through the programs. It also facilitates continuous strategic energy management as a tool to influence a culture change with regard to energy use in the customer's facility. Additionally, for customers where known energy projects are stalled due to lack of staffing resources, National Grid offers a co-pay to fund a staff position to oversee the implementation of such projects. The results of this effort will be shared with all PAs, and depending on an assessment of its effectiveness, it may be expanded statewide. *Commercial Non-Profits* Non-profit commercial customers are unique in that the barriers to being effectively served can be quite different than typical commercial customers. Lack of awareness, limited time and resources, insufficient in-house technical expertise, and limited access to capital are all barriers that must be addressed to successfully serve non-profits. Drawing on delivery models from other programs and initiatives such as

C&I RETROFIT	**<u>CORE INITIATIVES</u> EXISTING BUILDING RETROFIT, SMALL BUSINESS, MULTI-FAMILY RETROFIT, UPSTREAM LIGHTING**
	multi-family and the residential home energy services effort, as well as experiences of other PAs around the country, National Grid is developing a prototype approach for serving a particular subset of non-profit commercial customers – houses of worship. That prototype will be developed and tested within National Grid's own service territory using a phased approach over a number of months. The results of that effort will be analyzed and shared, as are all such efforts, with the other PAs as an approach that could possibly be extended and adopted statewide. <u>Combined Heat and Power</u> During the 2013-2015 Three-Year Plan term, CHP continued to expand, both in number of participants and in realized savings. Massachusetts continues to have one of the most successful CHP offerings in the country. In each of the last five years, ACEEE has ranked Massachusetts as first in the nation for CHP policies and implementation success.[96] That success is largely attributable to a fair but rigorous screening process that gives customers the information necessary to make an informed decision regarding CHP and energy efficiency investments in their own individual and unique circumstances. The PA's CHP Guidebook provides clear and complete information that delineates the process to achieve a successful CHP project and qualify for an incentive. CHP projects can produce dramatic savings and can have a significant positive impact on overall PA goals and savings results, with a low cost per kWh. Thus, a good CHP installation is highly desirable. Despite the potential for significant savings and generally very favorable economics, CHP projects often do not move forward. Recent market research indicates that the majority of commercial customers will not move forward with CHP projects having a simple payback of three years or more, and, surprisingly, almost 40 percent of surveyed customers would not accept paybacks of just one year.[97] At the same time, CHP systems typically have a benefit cost ratio between 1.0 and 1.5, which means that it is critical that potential opportunities identified are impartially qualified and that installations are properly engineered. A number of key lessons have emerged from the

96 ACEEE, "The 2014 State Energy Efficiency Scorecard," October 2014, Report Number 01408.

97 Combined Heat and Power: Policy Analysis and 2011-2030 Market Assessment. ICF International. February 2012.

C&I RETROFIT	CORE INITIATIVES EXISTING BUILDING RETROFIT, SMALL BUSINESS, MULTI-FAMILY RETROFIT, UPSTREAM LIGHTING
	past six years of experience in implementing CHP projects. These include: • Good CHP candidates have a year-round thermal load requirement in excess of 5,000 hours annually to ensure cost-effectiveness. Good candidates include facilities with significant daily laundry requirements like hospitals, nursing homes and some hotels, as well as others with thermal process requirements like food processors and other manufacturers. • CHP projects require significant customer investments in time, engineering planning, and capital commitment. Thus they require greater customer attention and involvement than more common energy efficiency projects. PA account executives play a vital role in enabling CHP projects, as they can help guide informed customer choices and maintain customer momentum through the several stages of the CHP process, which are: (a) initial identification and quantification of the CHP opportunities; (b) advocacy for the appropriate CHP projects for the customers circumstance and needs; and (c) managing the customer through the process to successful conclusion, including interconnection. PA involvement has been designed to assist the customer throughout the process (see below). • Proper sizing of CHP systems is essential to cost-effectiveness; which requires that virtually all thermal output be used by the facility. Key to correct sizing and assuring that any significant opportunities to reduce load through energy efficiency is identified and pursued prior to final sizing of the CHP system. Absent this step, the customer may install an oversized system that produces excess heat, and thus will not be cost-effective. Accordingly, the PAs emphasize to the customers that prior to conducting a CHP engineering study, they should first implement electric and thermal energy efficiency measures as their first priority, as efficiency is by far the more cost-effective savings opportunity and will reduce the size and cost of the CHP system. Through this experience the CHP offering has evolved to ensure more successful targeting, quantification, and completion of CHP installations. The PAs survey customers for CHP potential and offer significant technical assistance where appropriate. The process begins with an initial scoping assessment of electric and thermal loads and where reasonable potential exists, the customer is offered a co-funded in-depth engineering

C&I RETROFIT	CORE INITIATIVES EXISTING BUILDING RETROFIT, SMALL BUSINESS, MULTI-FAMILY RETROFIT, UPSTREAM LIGHTING
	analysis. The PAs' staffs provide continuous active assistance and are objective and unbiased partners to the customer throughout the process. LED Street Lighting During the last Plan term the PAs worked with a number of cities and towns to facilitate a transfer of ownership of the street lighting in their communities and convert it to LED technologies. For example, in 2014, the Cape Light Compact converted almost 16,000 municipally-owned street lights in 20 towns. Similarly, Eversource and National Grid worked with the Metropolitan Area Planning Council Conversion Program to convert 58,000 lamps in 21 municipalities. The PAs remain committed to providing their municipal customers with the most up-to-date street lighting technology options – including lighting and controls – as well as providing options for them to assume ownership and maintenance of lighting where it is cost-effective and they so desire. More than 75 of the Commonwealth's 351 cities and towns have purchased their streetlights from their local utility and others are in process. The PAs are also committed to working with any community wishing to explore the process of conversion to municipal ownership. Experience to date has indicated that the municipal process for consideration, analysis, decision-making, and actual conversion can be quite extended, and that the local conditions and priorities of the local governing body in each unique city or town will control the rate at which the conversion can be accomplished for the Commonwealth.[98] Conversion of utility-owned street lighting to LED is inherently a more complex topic than many realize. First and foremost, it requires a new tariff, approved by the regulators, to be in place that allows the utility to account for and recapture its existing capital investment. For the actual conversions themselves to take place, multiple utility departments – engineering, operations, billing, purchasing, and inventory/stocking – must establish procedures and coordinate so that the conversions take place in a manner that is safe, fiscally responsible, and seamless to a public that depends on adequate street lighting for safety and

98 The City of Boston's conversion has been underway for five years.

C&I RETROFIT	**CORE INITIATIVES** **EXISTING BUILDING RETROFIT, SMALL BUSINESS, MULTI-FAMILY RETROFIT, UPSTREAM LIGHTING**
	security. Further, all of the costs of the process must be tracked and accounted for in a manner that satisfies regulatory requirements. Both National Grid and Eversource will be proposing rate cases during the Plan term that will allow all these issues to be considered and addressed, and rate policies to be established by the Department that will facilitate and expedite the conversion process. The PAs have always given high priority to serving the needs of their municipal customers, have staff and/or account managers dedicated to cities and towns, and will continue to keep these customers advised of new developments such as the implementation of new street lighting tariffs that result in opportunities to convert streetlights to more efficient LED technologies. The PAs will also continue to collaborate with the field staff of DOER's Green Communities Division to support these efforts.
Three-Year Deployment Strategy/Roadmap	For the 2016-2018 Plan term, the program will concentrate on continuous improvement to our processes and exploration of targeted additions.

c. C&I Retrofit: Existing Building Retrofit

C&I RETROFIT	**CORE INITIATIVE** **EXISTING BUILDING RETROFIT**
Overview & Key Objectives	This broad core initiative promotes a menu of equipment incentives and technical services, along with associated financial incentives, to encourage building owners to replace functioning, but outdated and inefficient equipment with premium efficiency counterparts. Because it accounts for a significant share of C&I savings, the PAs continuously monitor its performance and refine delivery approaches, the product mix, and incentive levels to reflect changing market expectations and evolving technologies. As this core initiative has matured and customers have become more aware of the variety of energy-saving investment opportunities available to them, the PAs have encouraged a transition away from episodic equipment-based retrofit events to engaging customers in a thoughtful series of building upgrades that move their property towards a "building

C&I RETROFIT	**CORE INITIATIVE** **EXISTING BUILDING RETROFIT**
	renewal". Mature efficiency programs, those that have harvested the easiest and less expensive savings opportunities and have established trusted relationships with customers, are often characterized by a preponderance of more sophisticated custom projects and a lesser number of simpler prescriptive ones. The C&I Retrofit Program generally, and this Existing Building Retrofit core initiative specifically, fits this mature profile. This core initiative offers prescriptive incentives for widely-applicable electric and gas technologies, and a custom approach which focuses on unique opportunities that are customer, site, or process specific Prescriptive incentives are offered for measures that provide predictable energy savings in virtually all applications where they replace a similar technology of lesser efficiency. These incentives are available for a long list of electric and gas technologies such as lighting equipment and controls, HVAC controls, chillers, motors and drives, spray valves and steam traps, etc. This commodity-based path often serves as the customer's initial exposure to energy efficiency and may lead to more complex custom projects. To identify and quantify custom opportunities, the PAs provide customers with expert technical assistance, using both their own technical staff and subject matter experts drawn from a pool of prequalified expert private sector engineering consultants. To move customers to action once opportunities have been identified, the PAs offer financial incentives that are calibrated to match customer investment criteria. The overarching goal is to instill customer confidence in projections of project savings and the reliability of equipment performance, in order to make the financial investment attractive, and to provide a delivery process that makes the upgrade process as simple and seamless as possible. In addition to periodic equipment upgrades, the PAs offer a suite of ongoing services to business customers, including subsidized training for building operations and maintenance tasks and access to RCx services to ensure that energy-consuming equipment operates as designed, and that all low-cost/no-cost opportunities for energy and electrical demand savings are fully exploited.
Design and Delivery Mechanism	The Existing Building Retrofit core initiative targets customers who have functioning, but inefficient, equipment in their facility, or their older building's performance is not code compliant and can be upgraded to higher efficiency without undergoing major renovation. The core initiative uses a variety of sales and delivery strategies to educate

C&I RETROFIT	CORE INITIATIVE EXISTING BUILDING RETROFIT
	customers about the true cost of continuing to operate inefficient equipment, including the "cost" of reduced customer or employee satisfaction with the building environment they experience. It also provides customers with information on the cost saving and ancillary additional benefits of a more efficient building and/or equipment, and then provides an easy path to the upgrade, including streamlined incentives and direction to a skilled contractor who can perform the work. In some cases all of these services are provided through turnkey service providers working under contract to, and supervision by, the PAs. In other cases, particularly with larger customers or property management firms, the outreach, sales, and service coordination is conducted by PA Account Managers. The core elements of this core initiative are the Prescriptive and Custom path options. The Prescriptive path offers fixed incentives for purchase and installation of a broad menu of prescriptive measures. Prescriptive measures are those for which the energy savings can be predictably assumed in a wide variety of building types and business environments. Many are lighting and lighting control measures, but there are also prescriptive incentives available for VSDs, HVAC controls, spray valves, steam traps, etc. Some of the richest sources of energy savings potential are found in equipment or processes that are unique to a customer's premises and/or operational requirements. These unique, or custom, opportunities require a site-specific engineering analysis to determine costs and benefits. Custom opportunities account for a large share of PA savings. When a promising efficiency opportunity has been identified, often by a PA Account Manager, an appropriate technical expert, drawn from a pool of pre-qualified engineering consultants selected as preferred vendors through a competitive procurement process and matched to the specific needs and capabilities of the customer, is assigned to further define and quantify the potential. These highly-skilled, unbiased, and independent technical experts can conduct walk-through audits, perform detailed energy-efficiency studies of whole buildings systems or building components, or conduct specialized technical studies, such as studies of industrial or manufacturing processes. TA consultants are assigned based on their recognized expertise with the technology area under consideration. Customers can also elect to use their own TA consultant provided that the partnering PA approves of the firm's qualifications and cost-estimate. Non-preferred vendors must comply with the same level of detail and quality as preferred vendors.

C&I RETROFIT	**CORE INITIATIVE** **EXISTING BUILDING RETROFIT**
	Often customers will have both gas and electric savings opportunities. In these instances the relevant gas and electric PA will instruct the TA consultant to examine all savings potentials. The two companies share the study costs and coordinate delivery of the recommended improvements. The Existing Building Retrofit core initiative is largely delivered through a mature and growing network of trade allies. These include the contractors providing retrofit services directly under contract to the PAs as well as the hundreds of independent lighting and HVAC contractors, supply houses, electric and gas equipment vendors, RCx service providers, etc., who service their customers' needs and, in the process, assure that those customers install the best possible equipment and facilitate participation on their behalf.
Marketing Overview	Collectively, the PAs serve approximately 350,000 electric and 154,000 gas C&I customers. These run the gamut from the one-chair barbershop and corner bodega to massive manufacturing, health care, and educational facilities. Serving this diverse and large population of business customers effectively requires an understanding of their unique attributes. Based on that understanding, the PAs have designed and implemented a number of marketing strategies specifically targeted to various sub-segments of C&I customers. Examples of current strategies to serve the diversity of submarkets, and some proposed enhancements are detailed earlier in the Retrofit Program description.
Three-Year Strategy/Roadmap	For the 2016-2018 Plan term, the Existing Building Retrofit core initiative will concentrate on continuous improvement to our processes and exploration of targeted additions.

d. C&I Retrofit: Small Business

C&I RETROFIT	**CORE INITIATIVE** **SMALL BUSINESS**
Overview & Key Objectives	Many small businesses have low energy consumption and are tenant occupied. In rental situations there is little incentive for landlords to improve the energy efficiency of their buildings because the tenants pay utility costs. In instances when the small business is owner-occupied, there is little incentive for energy service companies or other vendors to target these businesses because individual building savings opportunities are small, potential customers have little discretionary capital, and transaction costs are high. As a consequence small business customers frequently

C&I RETROFIT	**CORE INITIATIVE** **SMALL BUSINESS**
	have outdated energy consuming systems and are effectively excluded from any market-based opportunity to correct the situation. However, from a Program Administrator perspective, while energy use in each of these businesses is modest, there are tens of thousands of these customers in Massachusetts, each pays into the energy efficiency fund, and in aggregate their savings potential is significant. The Small Business core initiative provides a simple, streamlined path for these customers to reduce their energy use, and for the Commonwealth to acquire the energy savings cost-effectively.[99]
Design and Delivery Mechanism	The core initiative is designed to provide seamless full service delivery for small business customers from opportunity identification (the "audit') to turnkey installation of measures, to financing of the customer's share of the project cost. Because of the low savings potential per transaction, the program model has been refined over the years to take full advantage of economies of scale. Installation costs are reduced by the competitive procurement of vendors who specialize in comprehensive service delivery to small customers. These vendors keep costs low by mastering the art of streamlined service delivery through repetitive installation of similar measures and the ability to purchase competitively priced equipment due to their high volume purchasing power. Assigned franchise sales territories and the ability to market large PA incentives (with attractive financing and, where available, on-bill repayment options for the customer portion) reduce marketing costs and produce high sales closure rates, further reducing overheads.
Marketing Overview	Vendors can choose marketing options that they find the most successful and are suited to their business model. These include direct mail, cold calling, and word-of-mouth referrals. The ability to identify themselves as agents of the Program Administrators elevates their credibility and provides customers assurance that the assessments of opportunities and estimates of project costs will be objective and fair, that the installations will be quality-controlled, and that there will be recourse if there are subsequent performance issues.
Three-Year Strategy/Roadmap	As described in greater detail above, the PAs have begun a thorough review of the Initiative. Many of the opportunities under consideration by the PAs include those identified in recent evaluations. In addition to basic

[99] Small business customers are fully eligible for all of the services and incentives available through the Retrofit Program in addition to the targeted services described here.

C&I RETROFIT	**<u>CORE INITIATIVE</u> SMALL BUSINESS**
	delivery improvements and economies, the PAs hope to identify additional gas measures and processes to encourage better identification of, and referral follow-up services for, measures not amenable to the direct install delivery model (such as thermal measures and heating systems, for example) so that deeper treatments can be undertaken. They will also conduct further segmentation to reach the smallest of the small customers through consideration of web portals, self-service delivery concepts, further development of the Main Streets or other geographically-focused delivery models, adaptation of successful residential delivery models such as HES, etc. and more targeted marketing and measure mixes by business type.

e. C&I Retrofit: C&I Multi-Family Retrofit

C&I RETROFIT	**<u>CORE INITIATIVE</u> C&I MULTI-FAMILY RETROFIT**
Overview & Key Objectives	As more fully described in the Residential section of this Plan, the Multi-Family Retrofit core initiative provides comprehensive energy efficiency services to market rate properties with five or more dwelling units, including the common area spaces of these properties. The core initiative offers energy assessments which identify energy savings opportunities throughout the facility. An EAP is developed for each facility, identifying all energy efficiency opportunities regardless of fuel source. Because multi-family buildings may contain both residential and commercial meters, residential services and incentives are supplemented by applicable commercial program services and incentives. However, because the primary beneficiaries of the services of this offering are the occupants of the units within the building, and both the measures and services are predominately residential, oversight and management is assigned to the residential program managers at each PA, with appropriate commercial services provided at the direction of a contracted MMI.
Design and Delivery Mechanism	The PAs strive to deliver a fully integrated offering to participants, regardless of fuel type, service territory, or rate class. An integral part of the core initiative's design involves the services of the MMI, who provides a single point of contact at intake, guides participants, and coordinates delivery of resources, including both residential and commercial-sector services, through the effort's phases. The goal is to provide a seamless customer experience, mitigate the potential for customer confusion, and minimize or eliminate lost opportunities. Commercial Retrofit measures may include:

C&I RETROFIT	**CORE INITIATIVE** **C&I MULTI-FAMILY RETROFIT**
	• HVAC high efficiency equipment upgrades and controls; • Variable speed drives, motors; • Chillers; • Air compressors; • Water heating equipment; • Energy management systems ("EMS"); • Building envelope measures; and • Custom measures. A commercial sector PA representative fully participates in the joint PA committee assigned to plan and oversee the delivery of the core initiative. This process is more fully described in the Residential section of this Plan.
Marketing Overview	Please refer to Residential Multi-Family Retrofit core initiative description.
Three-Year Strategy/Roadmap	Please refer to Residential Multi-Family Retrofit core initiative description.

f. C&I Retrofit: Upstream Lighting (electric)

C&I RETROFIT	**CORE INITIATIVE** **UPSTREAM LIGHTING (Electric Only)**
Overview & Key Objectives	As noted in the description of the Initial Purchase and End of Useful Life core initiative description earlier in this Plan, the upstream delivery approach was initially designed to influence the purchase decision for replacement of standard efficiency fluorescent bulbs. Monitoring of the progress of that Initiative indicates that the upstream approach not only impacted market-driven equipment purchases, but the favorable economics of the improved equipment efficiency, coupled with an incentive, drove substantial purchases for retrofit purposes (*e.g.*, replacement of functioning, but less efficient lamps) as well.
Design and Delivery Mechanism	A special, and limited, set of circumstances are required for an upstream lighting approach to succeed. That is: (a) the premium equipment must be suited for one-for-one replacement for the less efficient product; (b) the equipment purchase decision must be driven by first cost, with no real amenity or reliability distinctions between the products; (c) the substitute premium efficiency equipment must be stocked and available at distributors at the time of the purchase decision; and (d) there must be no additional or unique installation requirements that distinguish it from the

	product for which it is substituted. That is, it must be "plug-and-play."
Marketing Overview	The upstream lighting incentive model leverages existing distributor networks and infrastructure to influence the thousands of equipment purchasing decisions that customers and contractors make every day. Under the upstream model, the PAs provide incentives directly to distributors rather than end users. The incentives are structured to entirely remove the price premium between conventional and premium products at the point of purchase, thereby placing premium product in direct competition with the conventional product on the basis of attributes of quality and efficiency alone – with the assumption that the purchaser will make the wise choice. For lighting products in a retrofit scenario the target markets are facility or maintenance managers and operators.
Three-Year Strategy/Roadmap	To date, the PAs have offered an upstream approach for select lighting products including premium efficiency linear fluorescent lamps, LED screw-ins, and an assortment of LED fixtures and downlights. As the lighting market evolves, particularly as LEDs become more cost-competitive and available for a wider range of end uses, the list of eligible products will expand.

H. <u>Pilots, Hard-to-Measure Efforts, and Creative New Approaches</u>

1. <u>Pilots</u>

The Program Administrators are not proposing any new pilot programs or initiatives for the 2016-2018 Plan term. The PAs will continue to explore new efforts to determine if a pilot would be a useful tool for studying a new effort. A key goal of any pilot is to ensure that data is collected to help determine if the approach explored in the pilot should be implemented on a larger, statewide scale, as a full program, or an element of a program. While the PAs are not proposing to conduct formal "pilots," there is a strong focus on conducting demonstration projects. These demonstration projects are regularly deployed to assess new technologies and strategies, with PAs using the resulting findings to improve upon their existing program offerings. The current approach of focusing on broad "umbrella" programs creates the opportunity to refine efforts quickly based on the lessons learned during the demonstration project. Below is a sample list of technologies studied by National Grid and Eversource through demonstration projects. These reports are included in Appendix K.

Research & Development and Demonstration Studies	
Report 1	Evaluation of 2013–2014 Smart Thermostat Pilots: Home Energy Monitoring, Automatic Temperature Control, Demand Response
Report 2	Heat Pump Clothes Dryer Technical Demonstration
Report 3	Technical Assistance Study - Vacuum Steam Heating
Report 4	Wi-Fi Thermostat Assessment

2. Hard-to-Measure Efforts

- *Statewide Marketing (Residential, C&I)*

The budget in the Statewide Marketing hard-to-measure effort is used to support statewide marketing efforts, as described in in Section III below.

- *Statewide Database (Residential, Low-Income, C&I)*

The PAs have allocated a statewide total of approximately $1.5 million to support database and data review and sharing efforts in 2016-2018, as described in Section III. Database efforts will affect all sectors, with funds budgeted for each sector.

- *DOER Assessment (Residential, Low-Income, C&I)*

The DOER Assessment represents an annual budget for DOER that is assessed per G.L. 25A §11H.

- *Council Consultants (Residential, C&I)*

The Council Consultants budget is collected by DOER and used to support the retention of expert consultants by the Council and reasonable administrative costs, in accordance with G.L. c. 25, § 22(c). The Council must annually submit to the Department a proposed budget for the "retention of expert consultants and reasonable administrative costs." G.L. c. 25, § 22(c). The cost for Council consultants allocated to the electric PAs is taken directly out of RGGI revenue that would have been distributed to PAs by DOER. As a result, the electric PAs do not collect this expenditure through the energy efficiency surcharge. The gas PAs, however, do recover these costs through their energy efficiency surcharges.

- *Sponsorships & Subscriptions (Residential, Low-Income, C&I)*

The budget for Sponsorships & Subscriptions is PA-specific and is made up of administrative costs such as membership fees to key associations within the industry (*i.e.*, ACEEE and the Association of Energy Service Professionals) and sponsorships at industry events. These sponsorships and subscriptions support information sharing with others involved in energy efficiency, education, and training.

- *Residential HEAT Loan (Residential)*

HEAT Loans are available to help customers finance the purchase and installation of qualified energy efficiency measures. The Residential HEAT Loan budget includes costs to buy down the interest due on the loan and the cost to administer the loans. Any savings or costs associated with installing energy efficiency measures due to availability of the HEAT Loan are included in the core initiative under which the measure was installed, for example, in HES - Measures.

- *Workforce Development (Residential, C&I)*

The PAs continue to monitor and contribute to trainings in order to:

- Educate new or promoted employees in topics such as marketing, building science, energy efficient new construction, heating and cooling technologies and techniques;
- Contribute to building a qualified workforce that will meet the demand for energy efficiency; and
- Promote cross training across different areas of expertise.

The PAs plan to look for collaborative ways to improve the delivery of trainings to address the demands of the market. This effort is ongoing within the respective management groups and best practices group, as exemplified by the Low-Income Best Practices Working Group chaired by LEAN, and the Contractor Best Practices Working Group, as well as through ongoing communication with key trade allies.

- *R&D and Demonstration (Residential, C&I)*

In the continued efforts to explore new technologies and measures through the MTAC, as well as proactive research and development into areas of interest, the PAs propose a consolidated research and development ("R&D") effort to (a) support the work of the MTAC, and (b) pursue technologies of interest in order to remain at the top of the "innovation curve." For residential innovations/enhancements within a planned initiative, please refer to the initiative enhancement sections within each program.

- *Education (Residential)*

The budget in the Education hard-to-measure effort is used to support public education efforts, as described in in Section III.J below.

- *Low-Income Energy Affordability Network (Low-Income)*

LEAN works with the Program Administrators to comprehensively serve low-income households. LEAN delivers low-income energy programs and represents low-income PA customers in legislative discussions and regulatory proceedings. The LEAN budget is used to pay for administrative and personnel costs.

3. Creative New Approaches

a. Demand Savings

Achievement of demand savings in 2016-2018 is a key goal shared by the PAs and the Council. In its March 31, 2015 Resolution on priorities, the fifth articulated priority of the Council is to "realize electric demand savings to significantly mitigate peak demand costs to the electric sector." In that same Resolution, Council Cross Cutting Recommendation #2 recommends that the PAs "support products and practices that reduce winter and summer peak." Demand savings have been a point of particular emphasis at the Council for ISO-NE and in the stakeholder workshops.

Issues relating to demand savings can be complex, and it is important to design efforts that take into account unintended negative consequences, such as increased energy usage (which, for example, can be an unintended result of subsidizing ice storage plants that reduce demand).

The PAs have formed an *ad hoc* group that is discussing these matters informally with the Council's consulting team. These discussions are expected to continue into the 2016-2018 term. The Term Sheet set forth at Appendix D provides for the continuation and expansion of this ad hoc group as follows:

> The PAs and the Council recognize the growing economic importance of achieving demand reduction goals and mitigating winter and summer peaks. The Term Sheet does not include targets for potential new statewide summer and winter demand peak reduction initiatives, and does not reflect costs, benefits or incentives associated with such initiatives. Subject to open meeting law requirements, PA representatives will work with a small Demand Savings Group that includes the DOER, the Attorney General's Office, the Low-Income Energy Affordability Network, interested expert and qualified stakeholders and the Council's consultants to explore approaches to cost-effective new demand reduction/peak reduction electric and gas initiatives. This Demand Savings Group will be addressing challenging and important matters, and all parties are committed to the successful development and actual implementation in-the-field during the 2016-2018 Plan term of new demand/peak reduction initiatives. To ensure that this in-the-field implementation goal is reached, the PAs will provide a report to the Council setting forth the specific scope, tasks, and detailed timelines for this group by the end of Q1 2016. This report will also provide an anticipated, high-level in-the-field deployment schedule for 2016-2018 based upon the then most current information. Deployment in-the-field will be subject to approval by the Department of Public Utilities and confirmation of cost-effectiveness. The PAs will also provide a report to the Council on the ongoing "super peak" avoided cost study on or before December 31, 2015 (if that study is delayed, this PA deliverable date will be appropriately adjusted).[100]

Demand savings opportunities can be divided into four categories with different strategies/approaches. The four categories are described below.

1. **Demand Savings from Traditional Energy Efficiency**. Excellent progress and results have been achieved in this essential category. The PAs' traditional energy efficiency efforts, historically and as proposed for 2016-2018, result in substantial demand savings. The 2016-2018 Plan projects electric demand savings of 592,375 kW (summer) and 620,992 kW (winter). In 2010-2014, the PAs achieved over 650,000 kW of summer

[100] CLC reserves its right to raise issues at any time with either the Demand Savings Group or the Council generally regarding its unique role as a municipal aggregator that may affect its ability to fully participate in the development and implementation of demand/peak reduction initiatives.

capacity savings. These substantial demand savings are a core element of the success of energy efficiency in Massachusetts and will continue to be important in 2016-2018. The PAs will continue to promote and prioritize energy efficiency measures that contribute both energy savings and demand savings, as well as explore adding technologies that have the potential for additional demand savings such as dimmable/"daylight dimming" LED lighting technologies (that, when installed in large enough scale, can be used for demand response efforts as well), tailored behavioral programs with a focus on achieving demand savings, and Wi-Fi thermostats and home automation technologies.

2. **Demand Response**. The Green Communities Act calls for PAs to "provide for the acquisition of all available energy efficiency and demand reduction resources that are cost effective or less expensive than supply." G.L. c. 25, §§ 19(a), 21(a), 21(b)(1), 21(b)(2). Demand savings through demand response (peak shaving and load shifting efforts) can contribute benefits such as reducing prices and price volatility for consumers, avoiding or deferring future generation, transmission and distribution investments, and reducing environmental impacts from electric generation. Demand response is a flexible, low-carbon resource that can also be used to help integrate renewable resources as they come onto the electric grid. Viable demand response strategies, combined with planned aggressive energy efficiency efforts, will contribute to the Commonwealth's economic and environmental sustainability goals.

   Keeping in mind the goals and objectives described above, PAs are seeking ways to understand both the costs and benefits of demand response in a way that will inform full scale deployment where benefits are expected to exceed costs. In order to contribute to this goal, individual PAs have developed or are working on developing individual or joint demonstration projects to gain a better understanding of costs and benefits of demand response in the context of the energy efficiency portfolio of programs. PAs will share the results of demonstration projects in order to gain insight, develop best practices, and utilize demand response strategies where appropriate going forward. Following the implementation of demonstration projects and related evaluation, PAs will use the results, along with related research and analysis, to guide the deployment of larger scale demand response initiatives in the latter years of this Three-Year Plan and beyond.

   Current avoided costs are not designed to assess cost-effectiveness for demand response initiatives. The PAs are working regionally to expand the scope of work completed by the avoided cost study contractor in order to derive the value of demand reductions from demand response efforts. These avoided cost values will be focused on the "super peak" period of highest demand, rather than the broader summer and winter peak periods that are currently considered when assessing demand savings from energy efficiency efforts.

   For PA-specific descriptions of demand response efforts, please see PA-specific materials at Appendix L.

3. **Load Shifting**. Similar to demand response, the PAs are examining the possible role of load shifting initiatives. Some efforts designed to shift load, such as time-of-use rates, are outside the scope of energy efficiency plans under the GCA. However, PAs are

reviewing storage technologies as a potentially appropriate focus in the energy efficiency Plan. In addition, behavioral programs and messaging may be used to drive load shifting. The PAs are continuing to review these possible strategies.

4. **Geo-Targeting**. The PAs are exploring whether the strategic investment of energy efficiency in specific geographic locations can yield additional benefits to customers and the energy network, particularly in regions that are subject to gas constraints, or as a strategy to help defer the need for infrastructure investments. The PAs are actively reviewing geo-targeting strategies and will deploy some geo-targeting demonstration projects in 2016-2018 to develop information, test strategies and drive demand savings.

   The hypothesis for implementing geo-targeting is that, if locations with projected high congestion and/or future planned infrastructure investments are targeted with incentives and/or concentrated marketing tactics, the resulting increase of energy efficiency and other demand reduction efforts in those areas may be able to alleviate the congestion or defer the need for infrastructure investments. Such results may have cost savings associated with them that are incremental to those counted in the current set of avoided costs.

   While increased energy efficiency alone will not solve capacity issues, it can be part of an overall plan to address capacity and gas deliverability, save energy, and provide benefits to customers. Berkshire and CMA are reviewing these matters at this time given capacity constraints in areas of their systems.

   As set forth in more detail in Appendix L containing National Grid specific materials, an example of geo-targeting for an electric PA is National Grid's ongoing Nantucket based initiative. National Grid is actively engaged in geo-targeting on Nantucket as one component of a comprehensive "non-wires alternative" ("NWA") project aimed at deferring the long term need for a third undersea cable to serve the island's electric load. In 2015, implementation began on an initial plan, primarily comprised of energy efficiency, to reduce almost 5 MW of load on the island by the end of 2019. The project's overall load reduction targets are approximately 18 MW over 17 years. If successful, the efforts could defer construction of the third cable for at least five years. The NWA project will combine geo-targeted energy efficiency with other technologies, such as renewables, energy storage, demand response, and potentially time varying rates to achieve the necessary load reduction during peak hours.

The PAs look forward to continuing to review potential demand savings approaches for 2016-2018.

b. Integration of Renewable Technologies

In its March 31, 2015 and July 21, 2015 Resolutions the recommended that the PAs proactively promote renewable thermal technologies and identify appropriate incentives for renewable thermal technologies. Exploring and deploying renewable thermal technologies was also a theme that was developed and discussed in the stakeholder workshops facilitated by Raab Associates, Ltd. More broadly, a point of interest for the PAs is exploring ways to leverage the powerful energy efficiency delivery infrastructure that the PAs have developed (working with many stakeholders, including the DOER and the program delivery contractor network) in order to provide increased benefits to customers and the Commonwealth.

The PAs have not fully developed strategies for addressing renewable thermal savings in 2016-2018, but are reviewing these matters, and seeking to ensure that they are addressed in the most appropriate forum. Core question to be addressed is exactly what technologies are contemplated by Councilors, what is their applicability in a three-year energy efficiency plan under the GCA and is implementation of some of these efforts perhaps more appropriately handled in other contexts or proceedings, *e.g.*, grid modernization. More specifically, some essential elements and questions in the PAs' review are:

- Are there cost-effective measures/strategies that are appropriately delivered as energy efficiency measures, as opposed to renewable supply side measures?
- What funding sources are potentially available to fund the measures/strategies, *e.g.*, energy efficiency funds under the GCA, Massachusetts Clean Energy Center ("MassCEC") grants, tax credits, HEAT Loan expansion (funding sources could vary by measure)?
- What energy savings and other quantifiable benefits can be claimed for incentivizing these measures, and can they be quantified and claimed under the TRC test as required for energy efficiency efforts under the GCA?
- What, if any, are the most promising potential technologies and, if applicable, how should deployment of these technologies be prioritized?

As with demand savings, issues related to renewables are complex, and it is important that any design efforts are carefully cost-justified and that appropriate funding sources are used. The PAs and Council do not have these issues resolved at this time, but efforts are continuing and the PAs will remain engaged with the Council on these matters.

c. Other Creative New Approaches

This Plan sets forth the highest goals ever established in the Commonwealth and, based upon the best information currently available to the PAs, in the United States. In order to achieve these high goals over time, the PAs will need to develop and incorporate creative new approaches to servicing customers and locating untapped or underserved opportunities. In its July Resolution, the Council has expressly supported the exploration in 2016-2018 of creative new approaches and testing new technologies and ideas. The PAs are relying on the Council's support of new approaches in adopting the bold goals set forth in this Plan.

The PAs need the flexibility to pursue these creative new approaches and untapped opportunities to continue to keep Massachusetts as a national leader in energy efficiency. The PAs will look to implement efforts targeting new, niche opportunities that must meet three core tests: (1) serving the opportunity must result in cost-effective savings using the Department's cost-effectiveness screening standards; (2) any resulting savings are not being funded and counted in the context of another mandated activity, for example, grid modernization, provided that the PAs have the ability to provide additional or incremental activities that are complementary or supplemental to these activities being taken pursuant to another mandated activity; and (3) the opportunity is not otherwise being addressed in other capital improvement projects funded through other rate mechanisms (*e.g.*, capital expenditures to reduce gas leaks), again with the understanding that the PAs will have the ability to provide additional or incremental activities that are complementary or supplemental to these capital improvement projects. A possible example of such an effort might be replacing inefficient lighting at a substation with new LED lights, or upgrading utility-owned streetlights.

Another niche opportunity the PAs seek to address in the term of this Plan would be providing services for a limited number of state or federal government agencies that are currently wholesale customers, in way that is consistent with Department directives and regulatory requirements. The PAs believe there may be some unique opportunities to address inefficient facilities within this sector, with benefits for all customers within the service area that are contributing to the payment of utility bills of such agencies through taxes or assessments. The PAs would only explore these opportunities for existing wholesale government customers and must be able to demonstrate the cost-effectiveness of the project and that the approach for a specific project was consistent with Department directives and applicable regulatory requirements.

Looking forward, and with no specific current proposals in this Plan, the PAs would like to explore creative ways in which they can engage new customer segments. For example, there may be opportunities to assist generators in becoming more efficient, enhancing their productivity and decreasing greenhouse gas emissions. Another opportunity that the PAs could explore is providing services to municipalities that do not currently offer energy efficiency services or do not offer the comprehensive suite of energy efficiency services offered by the PAs. As part of their R&D efforts, the PAs want to explore and examine these unique opportunities that, if properly implemented, could increase the efficiency of energy usage for new populations in the Commonwealth and materially assist the Commonwealth in greenhouse gas reduction efforts.

I. Marketing Plan and Activities

1. Introduction

The Program Administrators plan to continue to use public education and marketing as key tools to support a culture of sustainability in Massachusetts. By creating powerful, engaging and motivating education and marketing strategies, PAs can continue to increase awareness of the benefits of energy efficiency and drive increased participation in the available energy efficiency programs and services. Proposed public education and marketing strategies will take into account the unique motivational differences between residential and non-residential customers.

Support of the Mass Save® mark and statewide brand remains a key priority. The PAs commit to statewide marketing efforts that include the prominent integration and placement of the Mass Save® mark as the statewide brand. PAs will include the Mass Save® mark on statewide program, outreach, and marketing materials. In addition, PAs will include a link to the Mass Save® website on the portion of their company's website that is focused on energy efficiency services in Massachusetts.[101] PAs continuously review and evaluate the effectiveness of all joint statewide branding efforts, and engage in on-going refinements to ensure that such brands support clear, consistent, and recognizable messages that help promote program awareness.

Building on the success of digital and social marketing platforms will be a key focus of effort. The Mass Save® website has become a critical focal point in the comprehensive marketing program, providing a consolidated one stop shop for residents and businesses to learn about energy efficiency, program offerings and opportunities. The Mass Save® website and strategies that drive customers to the website will continue to be refined to ensure the highest quality customer experience. Marketing will continue to leverage the strong social media presence built over the 2013-2015 term. With over 110,000 Facebook fans (https://www.facebook.com/MassSavers) and nearly 15,000 Twitter followers (https://twitter.com/masssave), PA marketing and education is able to reach an ever broadening audience. The social media platforms support effective peer to peer marketing, allowing customers to become brand ambassadors.

Reaching out to customers who haven't participated in Mass Save® branded programs remains a fundamental commitment. Under this Plan the Mass Save® website will be translated into additional languages, starting with Spanish and Portuguese, to continue to expand access to diverse linguistic populations. The PAs will explore affinity marketing opportunities to expand the reach to new market segments while offering the added benefit of supporting the community beyond energy efficiency.

The refinements to current strategies and messages developed for statewide energy efficiency education, outreach, and marketing will augment the efforts already in use and will attempt to complement and leverage program-specific marketing and individual PA efforts across the Commonwealth.

2. Marketing Plan Overview

The ultimate goal of all educational, community outreach, and marketing efforts is to develop an effective system of communication with Massachusetts residents and businesses. This system is a critical tool to support customer awareness, understanding and participation in the PAs' comprehensive energy efficiency programs. Independent evaluation studies and a review of the marketing activities over the course of the first two plans (*i.e.*, 2010-2015) illustrate the extraordinary growth and success of the coordinated marketing efforts among the PAs and provide a path for PAs to better understand where improvements can be made.

For the 2016-2018 Plan, core objectives of the PAs' public education and promotion campaign include:

- Maximizing reach to ensure *all* residential and business customers are provided access to information and connection to resources.

[101] Except where expressly limited by internal corporate website policies.

- Providing compelling and accessible messages, which clearly describe the benefits of energy efficiency without excess jargon or overly technical language.
- Exploring and deploying targeted marketing to unique or specific communities throughout the state (including communities where English is not the primary language).
- Utilizing diverse media (*e.g.*, internet, bill inserts, radio, billboards, public transit, social media) to disseminate consistent and clear messages.
- Ensuring that the various strategies work together to ultimately achieve deeper and broader savings.

Through an extensive array of effective messages and an all-inclusive media strategy, the PAs commit to engaging with the broadest cross section of residential and business customers with tailored, targeted, and actionable information.

The careful balancing of breadth, depth, and understanding of customer motivation in the campaigns will drive value to customers and support obtaining the aggressive energy efficiency goals set forth in this Plan.

3. Mass Save®

In 2010, the PAs joined together to bring energy efficiency programs to the Commonwealth through a statewide PA brand. As sponsors of the Mass Save® word service mark, the intent of the PAs was to complement their individual PA brands when communicating with residential and C&I customers about energy efficiency programs.

The PAs are the owners of the Mass Save® word service mark. A trademark or service mark identifies goods and services as originating from a single source. Trademarks, in effect, represent the goodwill that a business has built up through its history of offering quality goods and services. A word mark is the most common form of trademark and simply consists of a word or group of words. The PAs have rights to the word mark Mass Save®, having obtained federal registration of it on August 29, 2006.

Under trademark law, the PAs must monitor and control the use of their marks in order to maintain them and to prevent inferior energy efficiency services from diminishing them. Throughout the past two plan periods, the PAs have overseen significant monitoring efforts with respect to the Mass Save® mark to identify unauthorized uses of the service mark. Legal measures have been successful to stop such unauthorized uses and thus the integrity of the mark has been protected.

4. Marketing for 2016-2018

During the term of the first Three-Year Plan (2010-2012), the PAs joined together to market energy efficiency services on a statewide basis through use of the Mass Save® service and design marks. In 2013-2015, a single website was created as a central repository to educate customers and provide access to energy efficiency program information and participation. The launch of this statewide website was a major and unprecedented undertaking satisfying a core Council priority. The existence and operation of this website demonstrates the commitment of the PAs to working together for the benefit of customers throughout the Commonwealth.

The PAs continued the Mass Save® Awareness Campaign during the 2013-2015 Plan term to increase awareness of energy efficiency and Mass Save® across the Commonwealth. The campaign continues to work across many forms of media, including radio, internet banner adds, social media, smartphone and tablet ads, and print ads. The Statewide Marketing team selected a new vendor for marketing and website services for the 2015 campaign. With the new vendor on board, the PAs completed a full audit of marketing materials used for outreach events and recruitment in Residential New Construction. As a result of this audit, a forward-looking plan for marketing materials was developed.

Additional notable highlights from 2013-2015 include: (1) a redesigned and refreshed the GasNetworks.com site; (2) customer-facing videos on the Mass Save® website that provide information on ductless mini split heat pump and heat pump water heater technologies; (3) successful leveraging of social media outlets, like Facebook and Twitter, to launch creative campaigns; and (4) the addition of Affinity marketing to the mix of promotional strategies.

The PAs also executed a pre-campaign awareness study and a post campaign study, now conducted annually, which allows the PAs to benchmark and evaluate the effectiveness of their messaging and media planning. The PAs will take into consideration the results of this study to develop their marketing campaign for the 2016-2018 Plan. Key findings from the study include: (1) awareness of Mass Save® has increased significantly since December 2013; (2) customer awareness of MassSave.com and self-reported website usage increased in 2014; (3) efforts to drive web traffic have been successful among those who are aware of the Mass Save® website; (4) campaign messaging was clear and resonated with residential and commercial customers; (5) self-reported exposure to Mass Save® messaging increased significantly among residential and commercial customers; and (6) depth of knowledge for program offerings is also increasing among residential and commercial customers.

In January 2015, the PAs began making several significant changes for the 2015 campaign and beyond. Specifically, the new marketing vendor, KSV, now manages the Mass Save® website in addition to serving as the campaign implementer. As part of this transition, KSV will develop new website content and seek to improve the website user experience. In addition to changes to the website, Mass Save® will use new campaign messaging in 2015 and beyond, focused on emphasizing how simple and easy it is for customers to save money on their energy bills.

MassSave.com will continue to be evaluated for content and usability and improvements made. The PAs' focus on total customer experience recognizes the entry of the customer through the website as a critical component of that experience. The website provides the PAs an opportunity to offer streamlined information, including assessment tools such as the online home energy assessment, and on line rebate processing which offer substantial customer experience benefits. The PAs will continue to feature all the PAs' brands in conjunction with the Mass

Save® marks per the findings from the Massachusetts Statewide Marketing Campaign Evaluation Report and consistent with their goal to convey who and what Mass Save® is.

The key themes for the Statewide Marketing efforts for the 2016-2018 planning cycle are as follows:

- Define who and what Mass Save® is and what it means to the customer.
- Increase the message that associates Mass Save® with "A way to lower your energy bills" to both residential and C&I customers.
- Message and graphically tie in the PA Brand Logos with the Mass Save® mark to create a strong association and clarity of message.
- Utilize the segmentation work identified by the RMC and C&IMC so PAs can better and more consistently target customers from a program and statewide awareness level.
- Create awareness and understanding of Mass Save® as a trusted statewide resource for all customers' energy efficiency needs.
- Educate customers about the opportunities to save energy and motivate them to take action.

During the 2016-2018 Plan term, the Statewide Marketing Committee will continue to meet monthly and update DOER, through informal discussions, on any new developments concerning the PAs' statewide marketing efforts. From a market research perspective, the PAs will continue to conduct pre/post campaign studies and track their campaign effectiveness in terms of driving customers to the website and refreshing content.

5. Maintenance of Complementary Individual Efforts

While working diligently on the statewide public education efforts, the PAs will also continue to maintain customer awareness, satisfaction, and participation goals and accordingly, the PAs will also continue outreach efforts utilizing customer representatives and account executives (who enjoy one-on-one/person-to-person relationships that are especially important in the C&I sector) and PA-specific efforts that complement and are consistent with statewide efforts and the findings of the 2014 Marketing Report.

J. **Public Education**

The key objective of the Residential Education initiative is to offer an array of K-12+ educational outreach programs and enhanced consumer education. Several Program Administrators collaborate with the National Energy Education Development ("NEED") Project, bringing energy efficiency curriculum and training to teachers in Massachusetts. An addition to teacher trainings in 2016-2018, some PAs will implement an energy-efficiency take-home initiative involving kits, which will contain instant-savings measures such as light bulbs, showerheads, and faucet aerators, as well as educational materials (budgeted through HES). After in-class lessons about energy-efficiency, students will bring the kits home and report back on which measures their families install. In this way, the PAs can capture additional savings and expand the reach of the education programs beyond teachers and students, to parents, as well.

The PAs' support of educators, students, and parents through program opportunities, curriculum, and materials on energy efficiency and conservation is a critical component in fostering an energy literate society.

Additional efforts directed at consumers focus on educating customers on the benefits of investing in energy efficiency products and services and the multitude of energy efficiency initiatives available to them. Collaborative efforts for consumer education in 2013-2015 included the Energy Savvy online energy assessment tool on the Mass Save® website (budgeted through HES) and kits containing "Kill A Watt" meters available through libraries. This outreach will be continued in 2016-2018.

Some PAs also conduct additional direct outreach and provide additional in-school programming to schools in their service territories. These programs will continue to evolve and expand to reach more students. Many of these programs have earned local and national awards for energy education programs.

The PAs plan to work with DOER, educational institutions, the statewide marketing working group, and PA education and/or marketing departments to develop educational and promotional strategies. Efforts for school-aged education will continue to focus on expanding the existing, in many cases award-winning, PA school programs. Educational outreach strategies for 2016-2018 may include:

- Sponsor energy efficiency related classroom presentations and activities to K-12+ schools.
- Direct educators and children to online educational resources to help educate children about energy safety and conservation.
- Sponsor science fairs, teacher training workshops, and other elementary and secondary educational opportunities in collaboration with DOER, Massachusetts Department of Education, and schools throughout the Commonwealth.
- Encourage schools and informal education programs to participate in the annual NEED Project's Youth Awards Program held in April of each year, with follow-up awards program and ceremony in June in Washington, D.C.
- Explore the program development for youth group summer camps promoting energy conservation and behavioral change.
- Partner with communities to educate and promote energy efficiency through energy fairs, sponsorships, and community-specific outreach.
- Participate in various energy-efficiency employee awareness events.
- Conduct school fundraisers promoting energy-efficient technologies (budgeted through Lighting).
- Offer prompt-based contests for students to showcase their energy and energy efficiency knowledge.

- Direct customers to online calculators and web tools to learn more about home energy usage and to offer energy saving recommendations, including information on available energy-efficiency incentives.

The PAs will work to develop energy efficiency marketing messages aimed at residential customers, educators, students, parent/teacher organizations, and community groups. Proposed collateral will highlight the many benefits of investing in energy efficiency, savings that can be generated by individual efficiency measure upgrades, behavioral changes, and testimonials from past program participants. The PAs will employ a variety of media sources for messaging, which may include bill inserts, bill messages, customer newsletters, www.masssave.com, direct mail, employee and business partnerships, newspapers, social media outlets, and educator workshops.

K. **Community Engagement**

Over the course of the prior Three-Year Plans, the Program Administrators have worked on a variety of community-based outreach and marketing initiatives throughout the Commonwealth. These efforts included collaboration with local community advocates and leaders from various communities, with PAs providing project management and technical support. The PAs continue to view community-based engagement activities as a component of overall marketing and outreach strategies. The PAs consider engagement with entire communities where appropriate, as well as engagement at a smaller scale based on the particular needs of a local municipality or neighborhood. The PAs appreciate the continuing efforts of their dedicated colleagues in community engagement initiatives and their desire to find the best ways to serve harder to reach constituencies.

Program Administrators recognize that the effective delivery of energy efficiency programs is highly dependent on building confidence among customers, as well as an extensive network of service providers. The programs and services offered by the PAs represent wise investments – investments that contribute positively to the well-being of homes, businesses and communities. In 2016-2018, the PAs plan to continue building on the successful relationships they have fostered with a diverse network of outside organizations in order to communicate the many benefits of saving energy.

In the residential programs, the PAs engage with local trade allies, municipalities, community organizations and other appropriate and highly visible outside organizations to deliver information about program opportunities, and to target specific customer segments. PAs establish these relationships, both on a statewide-level and as individual entities working within their communities, to ensure the visibility and success of their programs.

PAs partner with local trade allies such as the Building Performance Institute ("BPI"), Northeast HERS Alliance, Southern Middlesex Opportunity Council's ("SMOC") Green Jobs Academy, Plumbing – Heating – Cooling Contractors Association ("PHCC"), International Association of Plumbing and Mechanical Officials ("IAPMO") and Air Conditioning Contractors of America ("ACCA"). PAs communicate with these trade allies by hosting, attending, and presenting at trade ally conferences and events, through the distribution of direct emails and newsletters, by advertising in trade publications, and through direct conversations with PA program managers and/or service delivery vendors. For example, the PAs' annual GasNetworks® conference attracts hundreds of trade allies from the heating and cooling industry; the 2015 GasNetworks Conference was attended by nearly 400 contractors and industry representatives.

The PAs also actively collaborate with municipalities for geographic specific efforts such as Renew Boston, various municipal-specific Memoranda of Understanding and grant programs, the Nantucket Non-Wires Alternative effort, and partnerships with city and town planning boards and redevelopment authorities.

PAs collaborate with community organizations to ensure energy efficiency is being talked about where people gather in their daily lives. The community action agencies that administer the PAs' income-eligible energy efficiency programs work with multiple community organizations to create partnerships that ensure the success of programming for low-income families. The specific organizations vary from town-to-town; however, typical alliances include the local United Way, Goodwill, Salvation Army, veterans groups, school districts, fuel assistance providers, civic associations, food pantries, shelters, and community development corporations. Community action agencies, by design, engage local resources to increase awareness among qualifying members of their communities of the various program offerings, including the PAs' income eligible programs. Additionally, each year the PAs participate in statewide social service agency meetings, typically held in October, to present to several hundred social service providers to inform them of program offerings.

The residential education fundraisers held in dozens of Massachusetts public and private schools each year help schools raise funds while teaching students about energy efficiency and conservation. Schools receive free educational materials, hands on demonstrations, and support from fundraising coordinators. PAs also answer the needs of their local schools in additional ways, such as in-classroom educational opportunities that educate students on saving energy while promoting the programs to parents.

The PAs also attend and/or sponsor events relevant to their individual communities in an effort to educate people on the programs and energy efficiency in general. Examples include collaborations with local farmer's markets, community centers, civic associations, hospitals, fire-stations, Earth Day and sustainability celebrations, city and county fairs, seasonal festivals, home shows, real estate organizations, media outlets, colleges and universities, hazardous waste/appliance turn in events, and youth baseball teams.

In the commercial programs, the PAs have found that delivery is enhanced when they partner with a variety of organizations that serve, and are respected by, various business actors. For example, the PAs have partnered with the Massachusetts Lodging Association to promote LED room and common area lighting, and the Massachusetts Bankers Association to promote financing for efficiency programs. A listing of the organizations where the PAs have engaged members, either through training and education or joint promotions, in recent years includes BOMA/Boston, the Greater Boston Real Estate Board, the Boston Green Ribbon Commission, Boston Green Tourism, the International Facility Management Association ("IFMA"), Boston

Chapter, Massachusetts Restaurant Association, Municipal Solid-State Street Lighting Consortium (“MSSLC”), and the Northeast Sustainable Energy Association (“NESEA”).

In addition, PAs constantly engage in outreach to local community business groups – chambers of commerce, downtown business alliances, and local economic development and revitalization organizations – to advise them of programs and services available to their constituencies. For more information on C&I engagement strategies, please see the section titled “Education and Training for Customers, Trade Allies, and PA Staff and Contractors” in the C&I Retrofit program description in Section III of the Plan.

L. PA-Specific Programming

The PAs strive for consistency in program offerings with the goal that customers across the Commonwealth can take advantage of comprehensive energy efficiency services. In some instances, however, individual PAs may provide additional services or unique incentive structures that are specific to their territory. These offerings may be specifically related to the unique characteristics of a service area, or may be developed based on unique conditions in that territory, such as gas constraints or reduction in expense related to very large capital improvement projects. They may also be based on the governing structure of a PA, such as the Compact, which has a distinct role as a municipal aggregator. Finally, these efforts may be run as a test case by one PA, with the idea that the programming could be rolled out across PAs if proven successful and cost-effective. Please see Appendix L for information on PA-specific initiatives.

The PA-specific initiatives set forth in Appendix L represent proposals of only the Program Administrator making the proposal. They do not constitute proposals that have been reviewed and agreed to by all PAs, and PAs may have divergent views on the materials contained therein. All PAs reserve their right to comment on these proposals in the future, and the inclusion of these materials does not constitute the consent of any PA to any other PA’s specific initiatives or proposals.

IV. STATEWIDE BUDGETS, SAVINGS, AND BENEFITS

A. Development of Goals

1. Introduction

The PAs engage in a highly collaborative and detailed planning process for setting savings goals and budgets. Programmatic decisions that inform savings goals and budgets are made both at the individual PA level and at the statewide level, including work by the respective management committees, which facilitate ongoing stakeholder input, continuous sharing of best practices, and consistency of offerings among the Program Administrators. While ultimately the results associated with development of a PA's plan are PA-specific and the planning process for savings varies for each program and initiative, certain common processes apply to instruct the development and to facilitate regulatory review.

2. Electric Statewide Budget, Lifetime Savings, Annual Savings, and Benefits

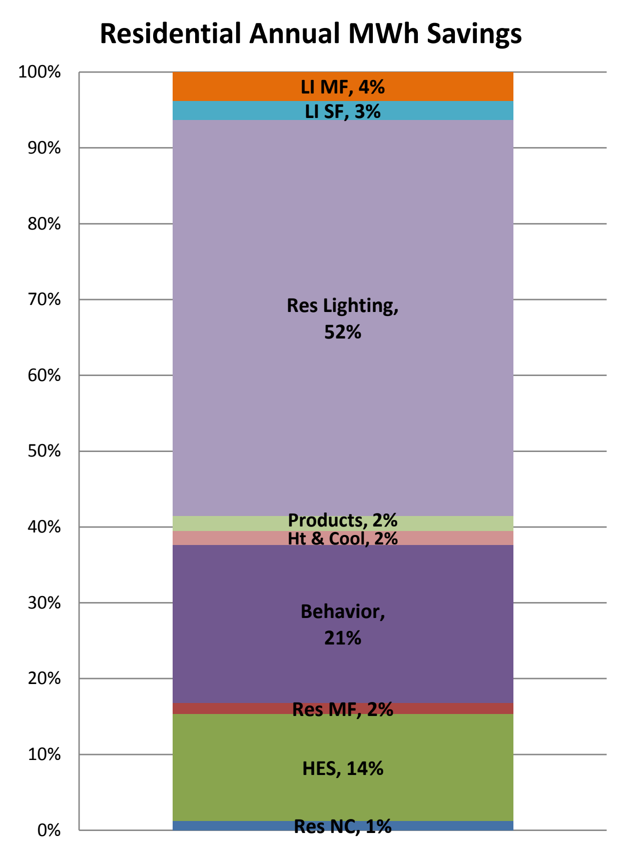
STATEWIDE ELECTRIC BUDGETS ($)	2016	2016-2017	2016-2018
Residential	$ 261,977,427	$ 532,392,444	$ 807,639,970
Low-Income	$ 67,526,840	$ 135,506,340	$ 203,237,116
Commercial & Industrial	$ 269,276,486	$ 552,122,527	$ 846,699,254
Total	$ 598,782,770	$ 1,220,021,310	$ 1,857,576,341

Annual Savings (MWh)	2016	2016-2017	2016-2018
Residential	627,236	1,211,113	1,739,994
Low-Income	40,615	79,837	118,051
Commercial & Industrial	703,733	1,453,127	2,259,494
Total	1,373,600	2,744,076	4,117,539

Lifetime Savings (MWh)	2016	2016-2017	2016-2018
Residential	4,691,711	9,166,815	13,319,806
Low-Income	354,457	695,416	1,040,323
Commercial & Industrial	7,766,005	16,343,042	26,023,915
Total	12,814,189	26,205,274	40,384,044

Benefits ($)	2016	2016-2017	2016-2018
Residential	$ 834,455,777	$ 1,646,070,369	$ 2,428,670,457
Low-Income	$ 114,662,979	$ 229,332,149	$ 344,859,874
Commercial & Industrial	$ 1,092,059,160	$ 2,230,507,497	$ 3,441,099,805
Total	$ 2,041,179,932	$ 4,105,910,016	$ 6,214,630,136

Statewide tables reflect aggregated proposals of the individual Program Administrators.


Residential Annual MWh Savings
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
LI MF, 4%
LI SF, 3%
Res Lighting, 52%
Products, 2%
Ht & Cool, 2%
Behavior, 21%
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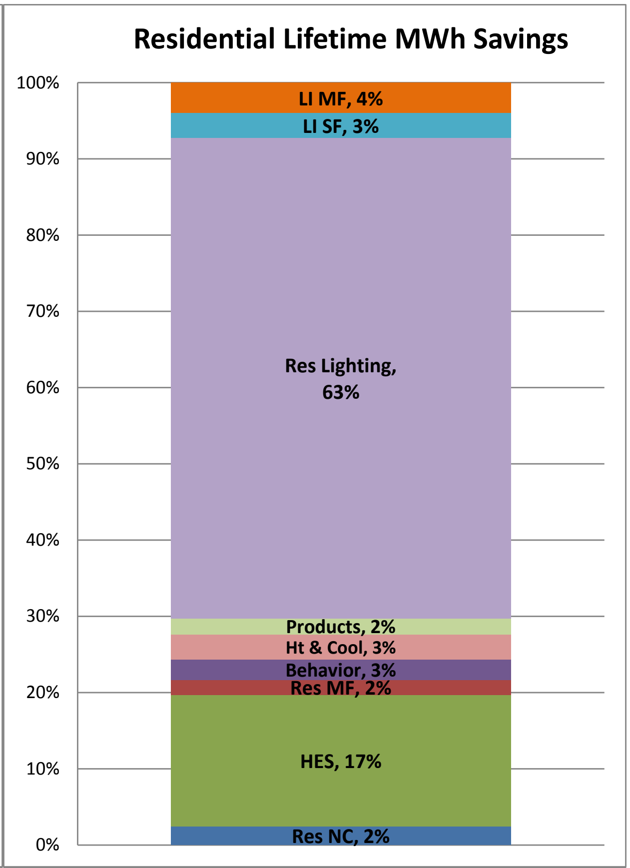
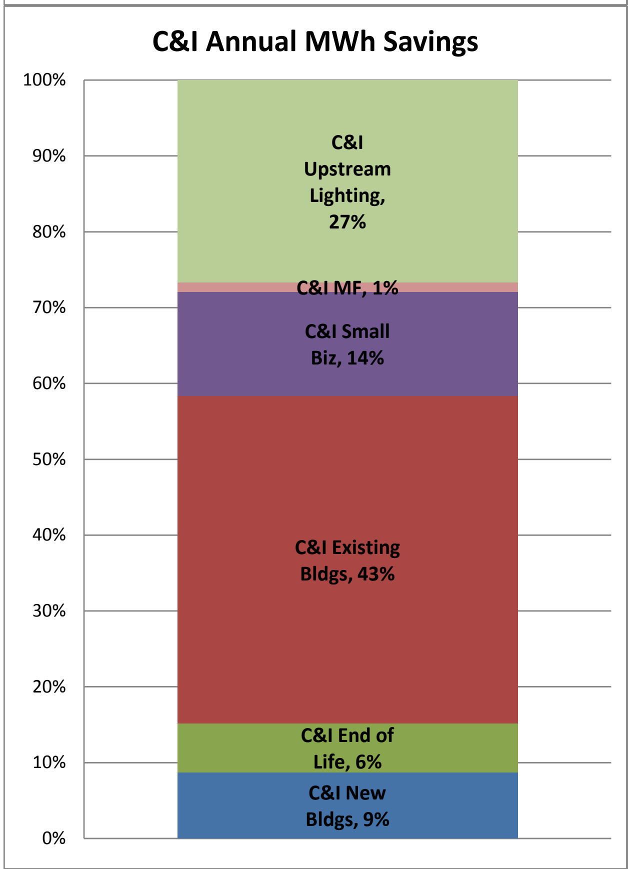
HES, 14%
Res NC, 1%


Residential Lifetime MWh Savings
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
LI MF, 4%
LI SF, 3%
Res Lighting, 63%
Products, 2%
Ht & Cool, 3%
Behavior, 3%
Res MF, 2%
HES, 17%
Res NC, 2%


C&I Annual MWh Savings
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
C&I Upstream Lighting, 27%
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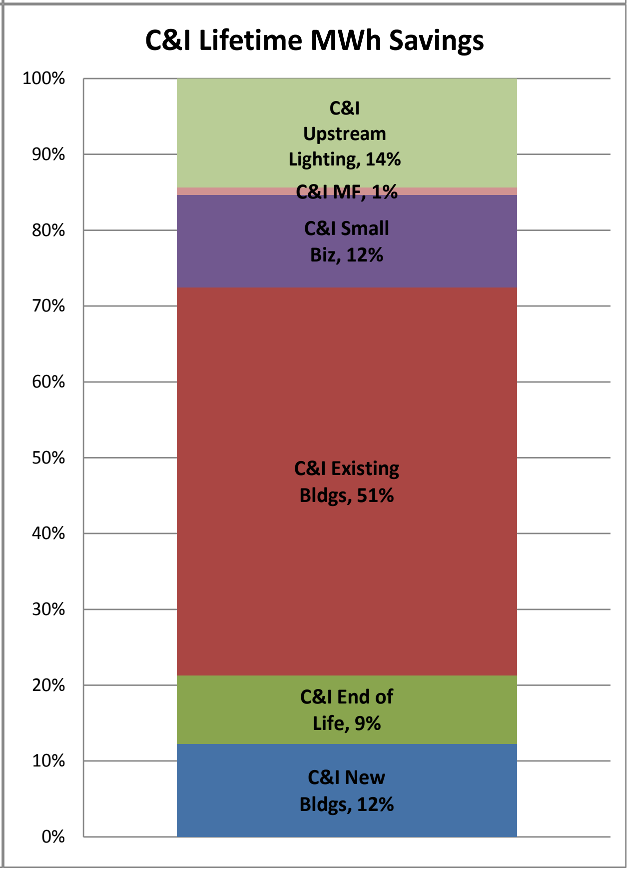
C&I End of Life, 6%
C&I New Bldgs, 9%


C&I Lifetime MWh Savings
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
C&I Upstream Lighting, 14%
C&I MF, 1%
C&I Small Biz, 12%
C&I Existing Bldgs, 51%
C&I End of Life, 9%
C&I New Bldgs, 12%

3. Gas Statewide Budget, Annual Savings, Lifetime Savings, and Benefits

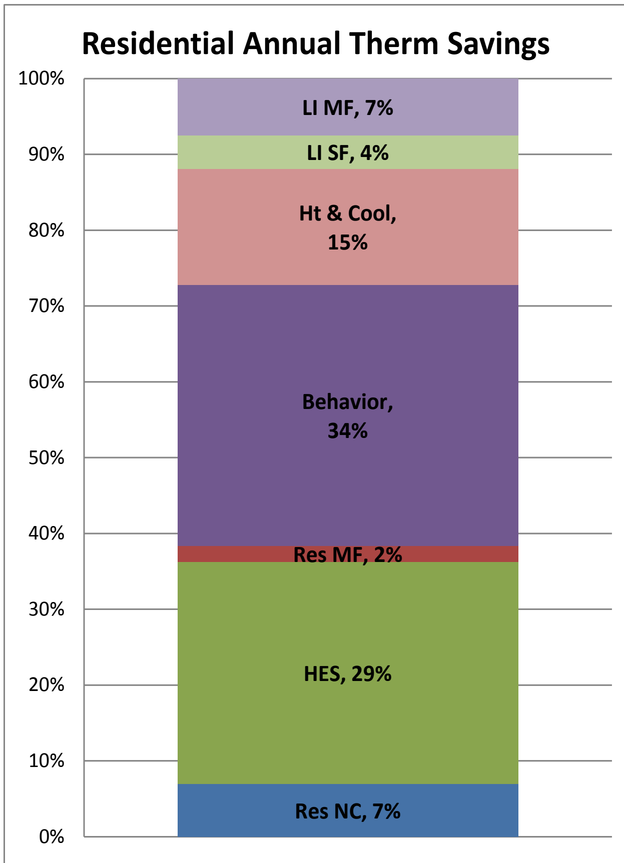
STATEWIDE GAS BUDGETS ($)	2016	2016-2017	2016-2018
Residential	$ 128,380,576	$ 259,637,085	$ 395,105,545
Low-Income	$ 44,552,694	$ 89,541,179	$ 135,176,393
Commercial & Industrial	$ 43,935,544	$ 88,828,956	$ 135,271,340
Total	$ 216,870,831	$ 438,007,220	$ 665,553,278

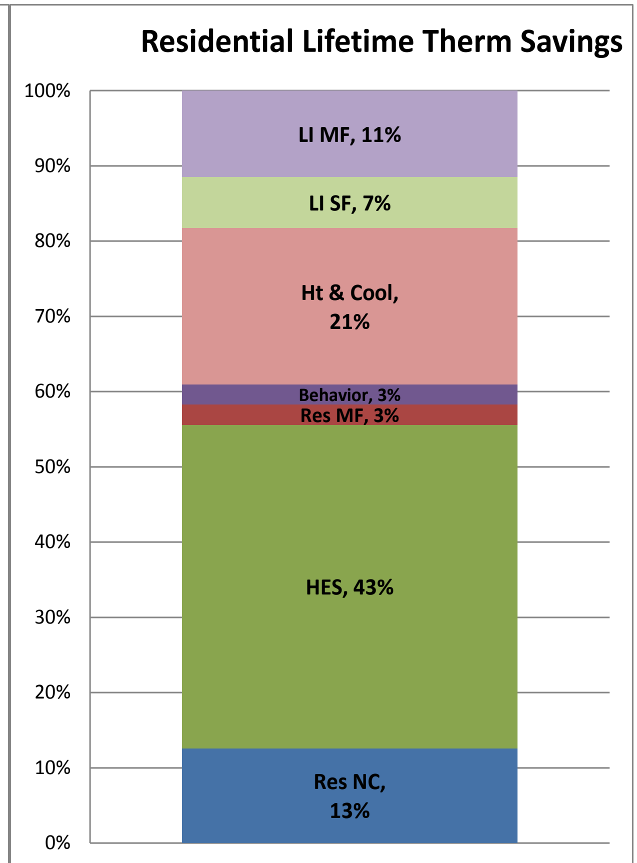
Annual Savings (therms)	2016	2016-2017	2016-2018
Residential	15,104,655	30,290,057	45,811,092
Low-Income	2,054,911	4,116,576	6,192,807
Commercial & Industrial	10,935,286	22,192,599	33,805,720
Total	28,096,868	56,599,232	85,809,618

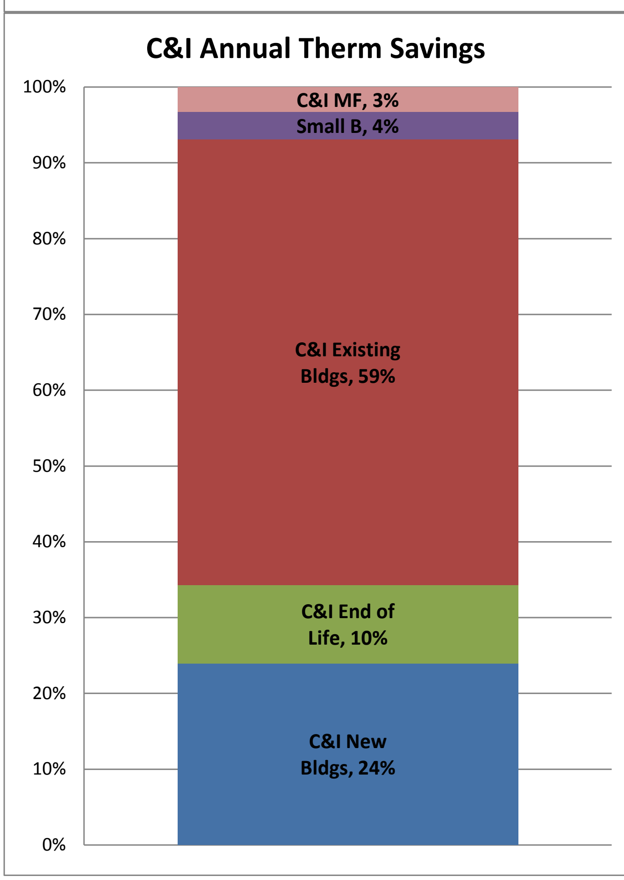
Lifetime Savings (therms)	2016	2016-2017	2016-2018
Residential	179,262,960	360,874,385	549,588,369
Low-Income	40,776,119	81,679,742	122,879,250
Commercial & Industrial	156,269,870	314,561,637	476,743,765
Total	376,310,966	757,115,763	1,149,211,383

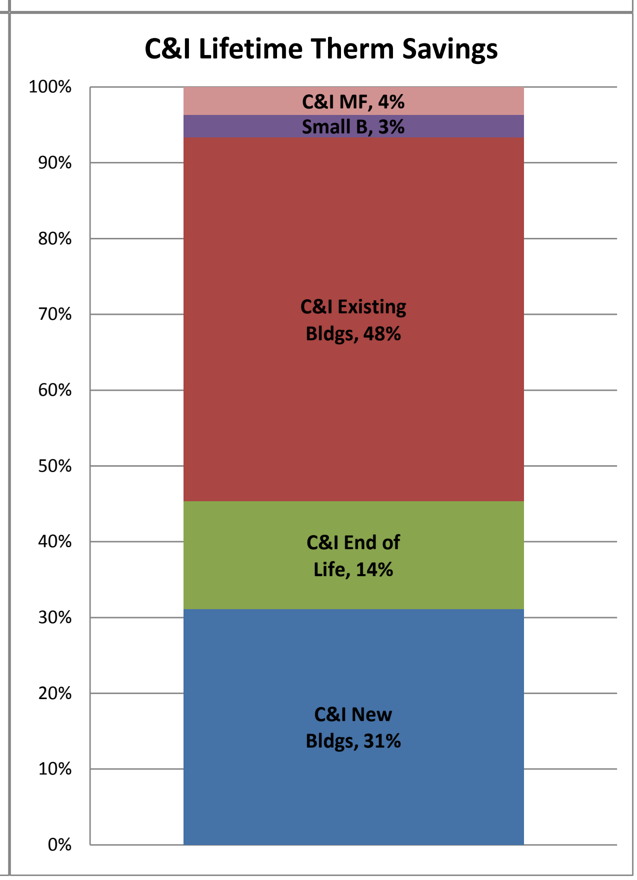
Benefits ($)	2016	2016-2017	2016-2018
Residential	$ 303,860,365	$ 607,629,997	$ 919,013,200
Low-Income	$ 78,097,881	$ 156,091,236	$ 234,635,623
Commercial & Industrial	$ 164,170,127	$ 327,545,874	$ 493,018,107
Total	$ 546,130,390	$ 1,091,267,106	$ 1,646,666,930

Statewide tables reflect aggregated proposals of the individual Program Administrators.


Residential Annual Therm Savings
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
LI MF, 7%
LI SF, 4%
Ht & Cool, 15%
Behavior, 34%
Res MF, 2%
HES, 29%
Res NC, 7%

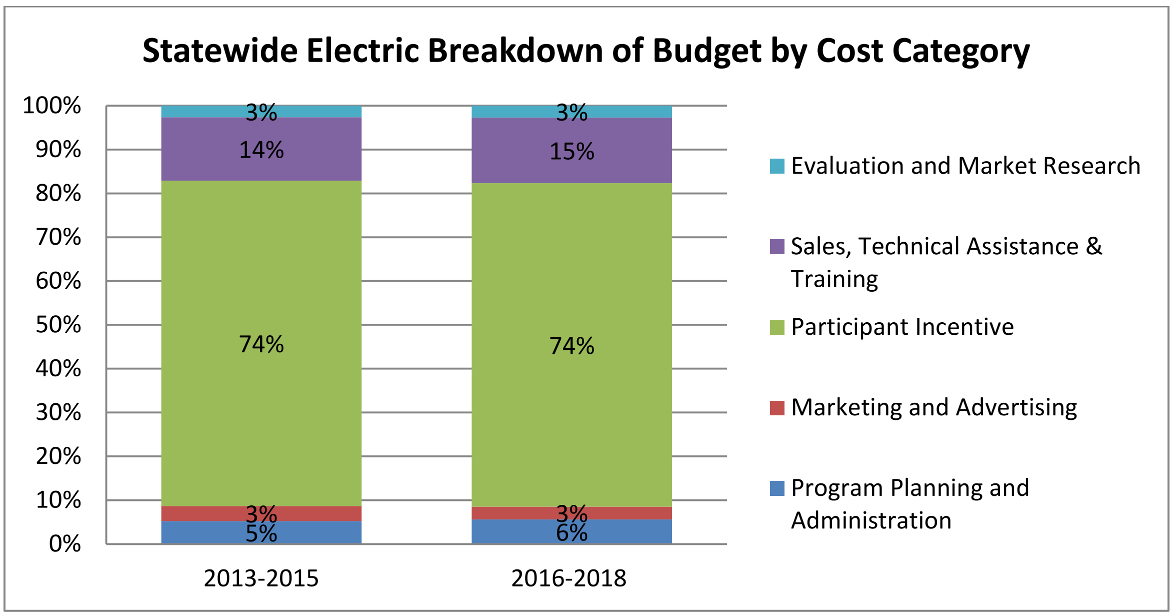

Residential Lifetime Therm Savings
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
LI MF, 11%
LI SF, 7%
Ht & Cool, 21%
Behavior, 3%
Res MF, 3%
HES, 43%
Res NC, 13%

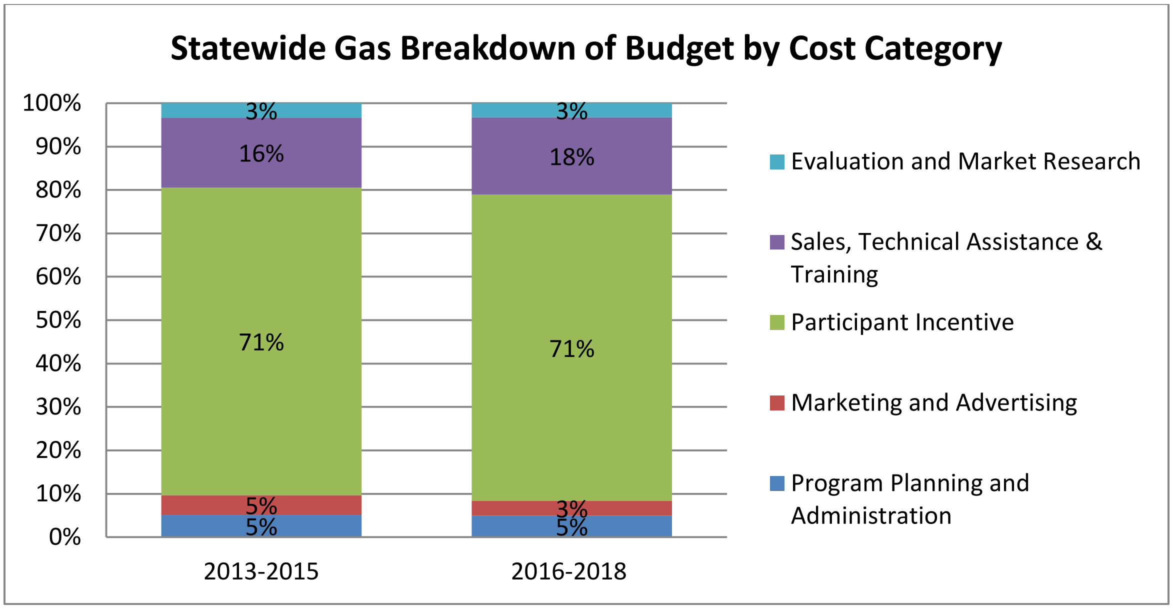

C&I Annual Therm Savings
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
C&I MF, 3%
Small B, 4%
C&I Existing Bldgs, 59%
C&I End of Life, 10%
C&I New Bldgs, 24%


C&I Lifetime Therm Savings
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
C&I MF, 4%
Small B, 3%
C&I Existing Bldgs, 48%
C&I End of Life, 14%
C&I New Bldgs, 31%

4. Breakdown of Budget by Cost Category

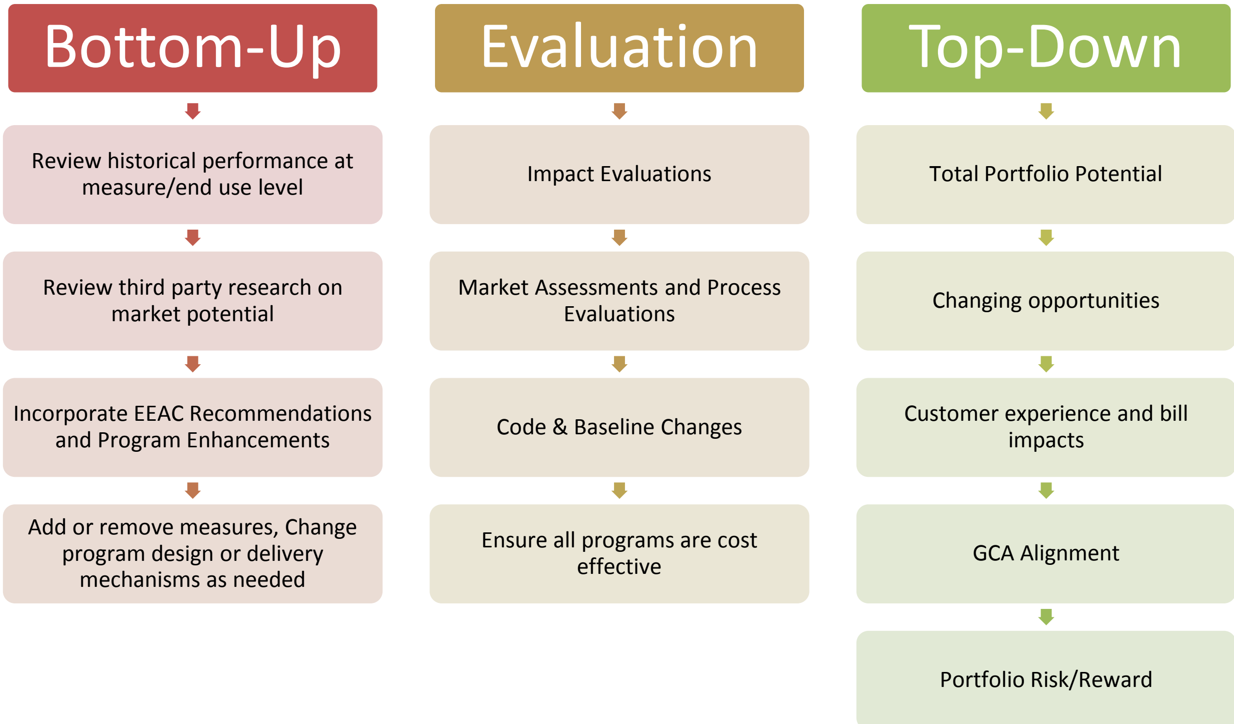
The majority of energy efficiency budgets are delivered directly to customers in the form of incentives that are intended to overcome the financial barrier to investment. In the 2016-2018 Plan, 74 percent of the electric and 71 percent of the gas budget is delivered directly to customers through use of participant incentives. These incentives drive customers to participate and are one of the underlying reasons the programs have been able to achieve historic savings levels. Approximately 15-18 percent of the PAs' costs are budgeted in the Sales, Technical Assistance & Training cost category, supporting the activities of vendors, contractors and other industry professionals. These investments are driving job creation and the evolution of a green economy in the Commonwealth. Approximately 3 percent of the statewide budget is dedicated to the rigorous Massachusetts Evaluation, Measurement and Verification process. Other administrative functions, like Program Planning and Administration and Marketing and Advertising, make up approximately 8-9 percent of the statewide budget. These percentages are in line with historical averages, demonstrating that the Program Administrators have been able to significantly grow their energy efficiency portfolios while keeping administrative costs low and maximizing the value of the programs for participating customers.





5. Process to Determine Goals

The development and determination of the proposed statewide and Program Administrator-specific savings goals takes into account an assessment of savings opportunities in individual PA service areas (bottom-up), consideration of evaluation study findings, and a collaborative consideration of statewide policy objectives that balances savings goals and the consideration of high level energy efficiency costs that are deemed acceptable (top-down). The bottom-up process involves determining savings by measure, including projected quantities and customer incentive amounts for every piece of equipment, type of technology or program service. The top-down process looks at the portfolio as a whole, evaluating the potential for achieving higher goals given markets in which the programs are operating, subject to overall cost. The impact of evaluation results are considered in both bottom-up and top-down planning and may drive other adjustments. The process to determine goals must be and is fluid, flexible and iterative, taking into account information that the PAs learn throughout the planning process related to program design, evaluation, costs and other factors.



The 2016-2018 Plan seeks to capture all available cost-effective energy efficiency for the three-year period beginning January 1, 2016, taking into account many competing considerations, including, but not limited to, bill impacts, cost-efficiency, integrated program delivery, economic and environmental benefits, efforts focused on innovation, and the need to establish as "integrated" effort that can be "sustained" over time, as laid out in the Green Communities Act. G.L. c. 25, § 22(b). Determining sustainability requires the PAs to examine the capability of vendors and contractors as well as that of the PAs themselves to respond to expanded programs, retain a capable workforce over time, and avoid large fluctuations in bill impacts.

The PAs also engaged in detailed discussions with stakeholders to help determine the appropriate budgets and goals for 2016-2018. Following the July 21st Resolution of the Council, the PAs collaborated with the Executive Office of Energy and Environmental Affairs ("EEA"), the DOER and the Attorney General, along with the Council's consultants, to further discuss goals, budgets, and key priorities. As a result of these discussions, the PAs, EEA, DOER, and the Attorney General were able to agree upon the Term Sheet. See Appendix D. The Term Sheet sets forth fundamental core goals for 2016-2018 that have served as a guide for the PAs in developing this Plan. The Term Sheet was developed and agreed to after extensive information sharing between these parties, and a general acknowledgement that there is no exact formula for determining all available cost-effective energy efficiency, that the Department must consider bill impacts, and that the GCA encourages consensus building among the PAs and the Council. Following feedback from the Council on the Term Sheet, the PAs revised electric annual savings to include an upward trajectory, taking into account the Council's desire to set a national example of continued commitment to energy efficiency in Massachusetts, while recognizing that overall results across the entire three-year period will be the measure of success.

The final statewide and PA-specific goals set forth in the Plan represent the effort of each PA over many months reviewing available measures and technologies, efficiency standards, avoided costs, past performance, evaluation studies, potential studies, cost drivers, and many other elements and considerations that go into planning, as well as extensive discussions and consensus-building with stakeholders and the Council to reach goals that represent all cost-effective energy efficiency, taking into account sustainability and bill impacts in accordance with the GCA.

a. Bottom-Up Planning

The planning process varies for each program and initiative. For example, the budgeting process for the core initiatives contained in the Residential Products program is measure-specific and driven by the number of rebates expected to be issued. Other initiatives take a whole-house approach with planning by projected audits, homes, or customer sites. Regardless of the approach, the PAs typically begin each planning process by examining historical data to gain insight into participation trends, savings achieved, and costs to achieve these savings. The PAs also examine any forward-looking data, such as new federal efficiency standards, third-party research on consumer adoption of new technology, and new avoided costs determined through a regional Avoided Energy Supply Cost study. See Appendix J. The PAs then collaborate to decide what changes, if any, need to be made to program offerings. For example, the PAs may decide to discontinue measures that have become standard efficiency practice, or to add new measures and services in response to improved technologies or identified consumer needs, subject to consideration of cost-effectiveness.

These types of overarching decisions are done at the statewide level at the respective management committees, ensuring input from all stakeholders and continuous sharing of best practices, and facilitating consistency of offerings among the Program Administrators. Each PA uses this information to develop a forecast of sustainable delivery in its unique service territory. PAs also consult their vendors to support or augment their forecasts based on field experience and what is in the vendor’s queue, as well as talk to manufacturers and contractors for insight into workforce and technology availability and limitations.

b. Top-Down Planning

While bottom-up planning focuses on what is reasonable for each individual measure, top-down looks at what is reasonable and achievable for the portfolio as a whole. This includes examining impacts to the overall markets that the programs are targeting as well as cost implications to customers.

One of the tools that Program Administrators use in top-down planning is potential studies, which help PAs to better understand the long-term availability of energy efficiency savings within their territory and give insight into three key pieces of information.

- *Technical Potential* is defined as the *complete* penetration of all measures that are feasible given current technology limitations without consideration of cost or likely consumer acceptance.

- *Economic Potential* refers to the subset of *technical potential* that is cost-effective when compared to supply-side alternatives.
- *Achievable Potential* refers to the amount of savings potential that is attainable given actual program infrastructure and societal and market limitations.[102]

The PAs use the results of potential studies to understand the achievable, cost-effective potential opportunity over a period of years. This information helps the PAs to set savings goals in the Plan that are sustainable in the long run, and take into account not only what is available and cost-effective, but also how willing and able customers are to adopt energy efficiency measures. Several PAs have performed new potential studies in advance of the 2016-2018 Plan. The results of those studies, and the lessons learned, have been shared among all PAs so that each PA can learn from these studies.

c. Evaluation Results

As noted above, PAs also look at EM&V results to inform proposed goals. As part of the statewide EM&V framework, the PAs collectively conduct many different types of evaluation studies. Each type of study serves a different purpose in the planning process, as outlined below.

- *Impact Evaluation* refers to the measurement of net or gross savings achieved within overall program populations. Results from these studies typically show impacts at a detailed measure or end-use level and assist the Program Administrators with their bottom-up approach to planning.
- *Market Evaluation* refers to the measurement of the effects that programs have on the structure and functioning of their target markets. This type of evaluation is useful in top-down planning and in consideration of projected net-to-gross ratios used to derive net savings.
- *Process Evaluation* refers to the systematic assessment of programs for the purpose of documenting their operations and developing recommendations to improve their effectiveness. This evaluation can be useful for both bottom-up and top-down planning.
- *Market Characterization or Assessment* refers to the systematic assessment of energy efficiency markets for the purpose of improving the effectiveness of programs targeting those markets. These types of evaluation studies are most often used to guide implementation strategy. For example, the results from a market evaluation study may help the PAs understand that the market for certain technologies is saturated and that the PAs need to plan to incentivize newer technologies to meet the needs of an evolving market. Again, this evaluation can be useful for both bottom-up and top-down planning.
- *Evaluation of Pilots* refers to EM&V activities intended to assess the effectiveness of pilot programs and demonstration projects, determine their potential for full-scale implementation, and develop recommendations for any changes in program approach.

[102] Potential definitions are based on ACEEE definitions available at http://aceee.org/topics/efficiency-potential-and-market-analysis.

In advance of the 2016-2018 Plan, the PAs completed 25 new studies, in addition to other studies that have been filed in previous Plan-Year Reports. These new studies include a wide range of evaluation topics in the residential, low-income, C&I, and cross-sector evaluation areas. A summary of each of these studies is included in the Plan at Appendix T, and the full set of studies is available at Appendix U.

d. Cost Drivers

A final step in goal setting is to assess the cost impact of the programs in support of "right sizing" proposed budgets. The Program Administrators' statewide energy efficiency programs have evolved significantly since the development of the first Three-Year Plan in 2009. In part as a result of their success, the Program Administrators are currently facing a new series of challenges – changes in projected program costs and the hurdles associated with achieving historically high savings levels on a sustained basis after having already had notable success in penetrating markets.

To address these challenges and deliver the most cost-effective energy efficiency programs to their gas and electric customers, the Program Administrators seek to develop a thorough understanding of current and future cost drivers and savings levels for their proposed energy efficiency programs. Each Program Administrator is affected differently by each cost driver, and variations in savings goals and the cost to achieve these goals are to be expected due to unique characteristics in service territories. Building demographics, income types, fuel type, economic conditions, and population demographics vary widely across each PA's service territory and influence how each PA plans to set and achieve its goals.

From 2009-2011, the cost to achieve savings for electric energy efficiency programs throughout the state was trending down.[103] During that same period, the cost to achieve savings for gas programs was trending upwards. From 2012-2014, the cost to achieve savings for electric and gas energy efficiency programs throughout the state has been relatively stable with a modest increase for gas programs. The PAs project the cost trend for 2016-2018 will be upwards.[104] This trend reflects continued market penetration and the expectation that savings per participant are expected to decline. That means that although the number of customers to be served in 2016-2018 is likely to be greater than the number served in 2013-2015, the average savings per participant will be lower in 2016-2018 when compared to 2013-2015. These trends are also influenced by increasing costs due to a shift to a more expensive measure mix (*e.g.*, moving from rebating inexpensive CFLs to more expensive LEDs), by decreasing levels of savings due to changes in codes and standards, and by impact evaluation findings that have

103 The PAs note that the costs and savings of large, one-time projects can skew the historical costs to achieve savings, often making the costs appear lower than the average. Because large projects are not typical or replicable, they should not be included in the planning process to estimate budgets or savings, or when calculating costs to achieve savings, without careful analysis and appropriate adjustments. For example, some PAs had large CHP projects in 2011, making the cost per kWh appear to decrease in 2011 compared to previous years. When excluded, however, costs were relatively flat.

104 "Cost to achieve" is typically discussed in terms of net savings. Net to gross factors are only updated at the beginning of a three-year term and their impact may therefore be more pronounced when looking at differences between two different Three-Year Plans.

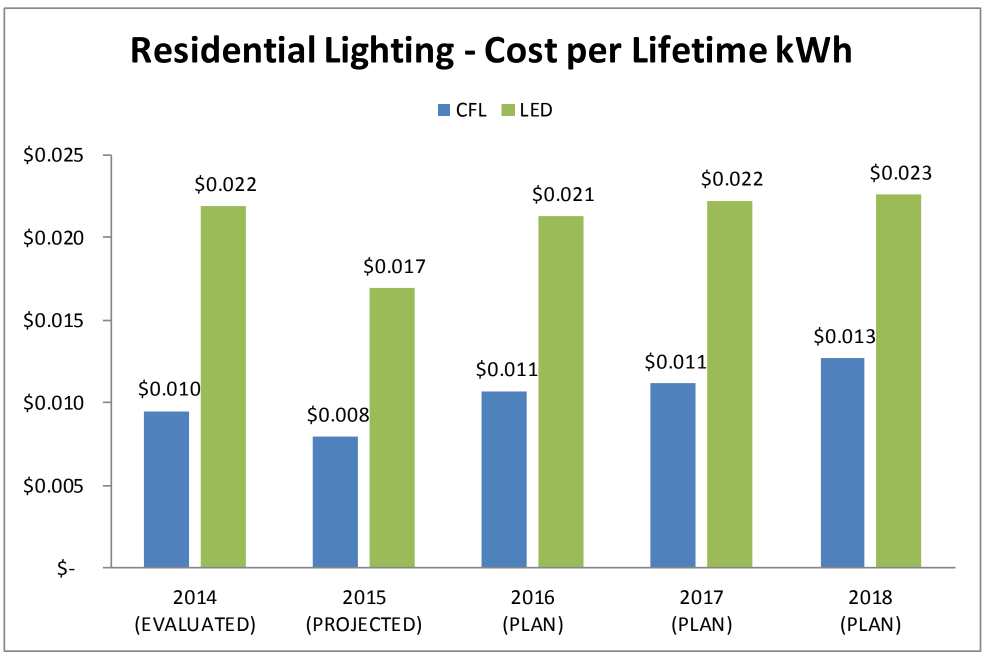
caused the PAs to temper their expectations about savings achievable in some initiatives. Additional details on key cost driver considerations include the following:

- **Codes and Standards –** As federal and state codes and standards become increasingly rigorous, the amount of incremental savings from installing energy efficiency measures decreases (unless the efficiency of the program measures rise as well). This decrease in savings results in a higher cost per unit of savings. Codes and standards that are posing a pronounced challenge to program savings include EISA lighting standards, federal water heater standards, a new 2015 User Defined Reference Home, adoption of the 2015 International Energy Conservation Code for new building construction and renovation, and federal heat pump standards, all of which raise baselines and reduce the savings the PAs can claim.
- **Going Deeper and Broader –** Another factor that is impacting the cost to achieve in this Plan is the need for new approaches to drive customer participation. As certain programs begin to saturate markets, PAs must find ways to encourage participation in more difficult, and often more expensive to reach, markets. New approaches for 2016-2018 include enhanced focus on encouraging renters to participate in the HES core initiatives, offering augmented incentives to consumers whose income is 61-80 percent of the statewide median, planning for weatherization jobs for oil-heated multi-family participants in the Residential Whole House program and the Low-Income Whole House program, which can lead to an increase in benefits for electric PAs (but do not increase electric savings).
- **Cost-Effectiveness Limitations –** The 2015 Avoided Cost Study found that with declining natural gas prices, the benefit of gas savings was reduced throughout the Commonwealth. Lower benefits can make it more challenging for measures to be cost-effective; as a result, some measures, and even entire initiatives, may have to be discontinued to retain program cost-effectiveness. The result is that PAs have fewer options available to them to attain savings, and this reduction in flexibility and program reach increases the cost to achieve savings.
- **Low-Income Funding –** Historically, the Program Administrators have partnered with the Community Action Agencies that receive funding from the federal Weatherization Assistance Program ("WAP") to deliver programs to income-eligible customers. Going forward, however, the availability of WAP funding will be sharply reduced due to national program cuts, and the Program Administrators will need to fund a greater portion of each project when providing services to this important sector.
- **Unique Service Area Drivers –** Despite consistent program offerings, some variations among PAs in savings goals and costs to achieve are appropriate due to the unique characteristics of each PA's service territory and the goal of fostering creativity among PAs. Each PA has a distinct mix of customers and sectors, which affects energy efficiency programs in different ways. Each PA has unique demographics, with different mixes of building types, income types, fuel types, fuel constraints, economic conditions, and population density. Reasonable variances among PAs are appropriate, consistent with sound regulatory policy, the GCA, and previous recognition of PA differences.

e. Cost to Achieve Example

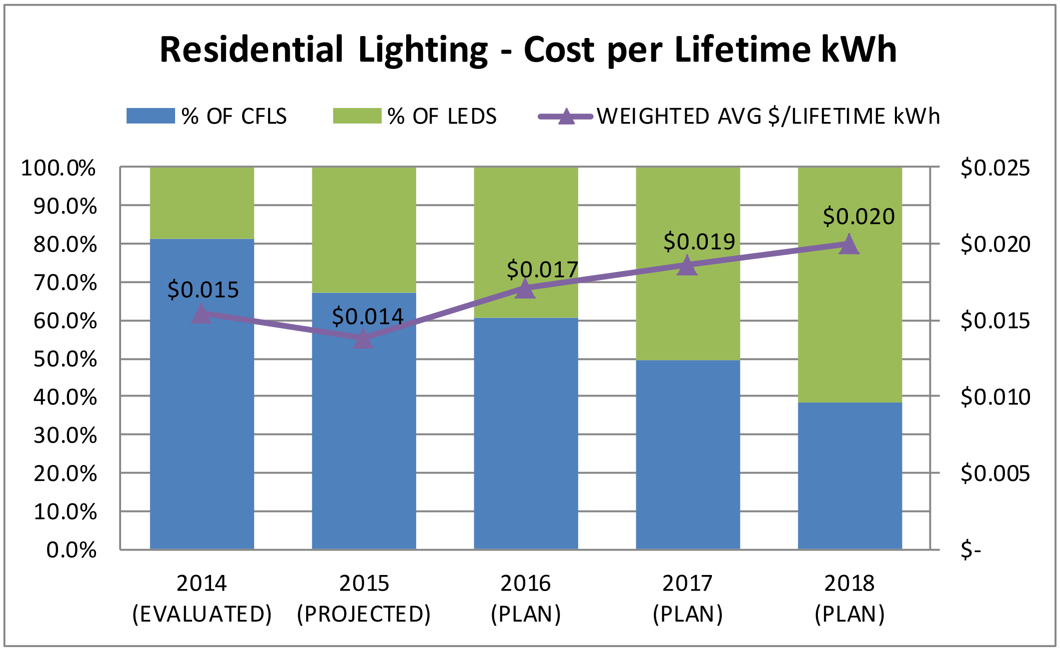
One initiative that is experiencing multiple simultaneous impact challenges is Residential Lighting. Historically, this initiative, an upstream buy-down delivery model, has been a relatively low-cost opportunity to achieve energy savings. However, a combination of factors, including continued implementation of federal EISA standards, a shift from rebating inexpensive compact fluorescent bulbs to more expensive LEDs, and an anticipated increase in free-ridership in each of the three plan years, has put significant upward pressure on the cost to achieve savings.

The first graph below shows the comparison in rebate cost per lifetime kWh saved between CFL lamps and LED lamps that are being impacted by code changes in the Residential Lighting initiative. While PAs have anticipated and planned for declining CFL and LED costs in each year, the net lifetime savings for each type of bulb are also decreasing in each year. LEDs remain nearly twice as expensive per lifetime kWh saved as CFLs.[105] The second graph below shows the statewide allocation between CFLs and LEDs, and the significant shift to LEDs in each year.[106] In 2014, LEDs made up approximately 19 percent of total lamps rebated in this initiative. By 2018, PAs anticipate that LEDs will make up over 60 percent of this total.



105 Note that the 2015 projections use the 2014 evaluation factors as an estimate for this example. The evaluation factors that will ultimately be applied to 2015 will differ from both the 2014 evaluation factors and the assumptions made for the 2016-2018 Plan.

106 The numbers in the graphs reflect the estimated amount of A-Line CFL and LED bulbs that are expected to be sold over the term.



- **Adoption of EISA Standards**: In 2014, the average lifetime of LEDs and CFLs was eleven and six years, respectively per the Massachusetts TRM. In the 2016-2018 Plan, the average lifetime of LEDs and CFLs drops to eight and four years, respectively. In the graph above, the impact is shown most clearly in the decrease in lifetime savings between 2014 and 2016.
- **Market Shift**: The market is shifting away from CFLs toward LEDs. However, as shown in the graph above, LEDs yield approximately twice the lifetime savings as CFLs but at worst (the constant scenario) cost over six times as much per lifetime kWh and at best (the decline scenario) cost nearly twice as much per lifetime kWh. Both scenarios show a marked increase over the 2014 cost of savings.
- **Net-to-Gross Ratios**: As residential LEDs transition from a specialty application into a commercialized product, the PAs expect that free ridership will grow. Those customers who would have purchased LEDs whether or not the PA programs offered an incentive must be subtracted from the calculation of savings PAs claim from the lighting program. The PAs planned for 2016-2018 with an assumption that free-ridership for LED purchases within the lighting program would be 10 percent in 2016 and increase 10 percent each year through 2018. In the graph above, the impact is shown in the decrease in lifetime savings from 2016 to 2018.
- **Combined Impact**: Considering all the factors listed above, by 2018, the PAs will need to rebate 2.7 times the number of LEDs and 1.25 times the CFLs just to equal the lifetime savings achieved in 2014.

This example shows the interplay of just two measures in a single initiative. While these are particularly sensitive measures, changes like this are becoming more common across dozens of measures within the PAs' portfolios. The PAs must continually refine cost and savings assumptions throughout the planning process, working to balance innovation and deeper savings with cost increases.

f. Unique Service Area Drivers

The Program Administrators have successfully worked together to provide comprehensive, statewide programs that are available for all customers across service territories. Despite these consistent program offerings, some variations among PAs in savings goals and costs to achieve are appropriate due to the unique characteristics of each PA's service territory.

Each PA has a distinct mix of customers and sectors, which affects energy efficiency programs in different ways. Each PA has unique demographics, with different mixes of building types, income types, fuel types, fuel constraints and population density. For example, the service territory of one PA may have a smaller percentage of commercial customers than the statewide average, and thus may not be able to benefit from the higher savings opportunities that tend to correspond with that customer segment. Similarly, a PA may serve a lower-income population, which is more expensive to serve. In setting their goals, each PA has used their knowledge of their unique service territory to design programs that best meet the needs of their customers, and all PAs are committed to achieving all available cost-effective energy efficiency in accordance with the GCA. The Council and the Department should continue to support reasonable variances among PAs, consistent with sound regulatory policy, the GCA, and previous recognition of PA differences.

Several PAs have conducted potential studies to look at the unique characteristics of their territories and customers. Those studies have confirmed the existence of real and reasonable variances among PAs, and are attached at Appendix M. Maps reflecting the service territories of each PA are attached at Appendix N.

In this Plan, Berkshire, Liberty, Unitil and Cape Light Compact are proposing aggressive savings goals that are tailored to the conditions within, and the characteristics of, their service areas in compliance with the GCA's mandate to acquire all cost-effective and sustainable energy efficiency. Some PAs have included presentations outlining the unique challenge in their specific service territories that justify variations from statewide targets in Appendix O. The Term Sheet recognizes the need for PAs with unique service territory characteristics to have flexibility from statewide targets and have determined their goals are appropriate. Reasonable variances in savings and goals that reflect the unique strengths and challenges among service areas are entirely appropriate.

g. Conclusion

The development of the proposed statewide and Program Administrator-specific savings goals involved a detailed review of energy efficiency opportunities and costs from all angles. This analysis included a bottom-up approach to assess savings opportunities by measure, a top-down look at savings potential and costs, consideration of evaluation study findings and other market changes, and statewide policy objectives. Additionally, development of goals for 2016-2018 was influenced by collaborative discussions with EEA, the DOER, the Attorney General, and the Council's consultants to better understand key savings and costs drivers across the Commonwealth, taking into account sustainability of delivery efforts and bill impacts. Using all of these methods, the Program Administrators were able to develop and determine savings goals to achieve all available cost-effective energy efficiency that have ultimately received the approval and support of the Council.

6. Common Assumptions

a. Overview

By reviewing all assumptions included in the development of this Plan and harmonizing them to the greatest extent practicable, the PAs have been able to reduce variances among themselves. This review has allowed the PAs to collectively provide the best available data in the most consistent manner.

The Program Administrators have common program designs, and continuously work together to develop assumptions and apply those assumptions in the RMC, C&IMC, low-income best practices, Evaluation Management Committee, common assumptions working group, and other PA working groups and discussions. Additionally, PAs have worked to harmonize assumptions related to the calculation of savings and benefits. They have developed a set of definition guidelines that guide each PA's participant calculation in order to be able to review participants in a consistent manner.

The PAs have confirmed common approaches to various cost and savings data and have determined collectively the manner by which evaluation results are applied, including non-energy impacts. Specific program assumptions have been accounted for uniformly, and algorithms will be applied in the same manner across PAs, with such assumptions set forth in the TRM. The PAs have also reviewed the 2015 AESC study in order to ensure that all avoided costs are applied in the same manner. Transmission and distribution costs have been updated and inflated consistently.

Additionally, PA cost categories are now consistent as described in more detail in Section III.B.

b. Participant Definitions

Participant definitions are common for all electric and gas PAs. These definitions are designed to more accurately reflect unique participants in each program and core initiative, and continue to be refined over time. The definitions that the PAs have used for participants in this Plan are set forth in Appendix P. Using these common definitions, the PAs have worked together to determine how best to apply them to estimate the number of participants for this Plan in a consistent manner. In some instances, variances in participant numbers or table columns such as costs per participant may not reflect true differences. This is because the definitions of participants require some assumptions, which may have been chosen for a particular reason, but may not make as much sense for another purpose. For instance, in HES - Measures, the definition is "Unique Account Number for a customer with at least one major measure installed." At this point in time, "major measure" only includes air sealing and insulation for most PAs. This definition was chosen to help approximate HES closure rates. However, many other measures, such as upgraded heating systems, early replacements of boilers, duct sealing, and Wi-Fi thermostats have material savings and costs and thus may be considered to be "major." Without these included, at first glance it appears that the cost per major measure is high, but the reality is that many other measures are installed for additional customers.

The category of participants reflects an approximation of customers who participate in individual core initiatives. If an individual customer participates in more than one program or core initiative, that customer will be counted as a participant in each core initiative. Therefore, the number of participants does not correspond directly to the number of unique customers participating in any program for a particular PA or across PAs. This is complicated by overlap between PA territories and by program delivery models, such as upstream, which do not get delivered to a customer, but rather work through manufacturers and distributors. The PAs are using Customer Profile Studies to better understand customers participating in energy efficiency programs across core initiatives, fuels, and PAs. See Appendix T, Appendix U, and Appendix X for more information on Customer Profile Studies.

7. Updates to Tables

In preparation for the filing of the first Three-Year Plan, the Department convened a working group in D.P.U. 08-50 to review, among other things, draft data tables to be filed with the Three-Year Plan. The content and format of the tables were developed collaboratively through the course of many productive sessions convened by the D.P.U. 08-50 Working Group. The working group intended for the tables to serve as a quantitative anchor for the review of the ambitious programs set forth in the Three-Year Plan. The D.P.U. 08-50 tables have continued to provide useful data to the Department, Council, and stakeholders. In preparation for the 2016-2018 Plan, the PAs have reviewed these tables, along with the comments and suggestions made by stakeholders over the years, and have made revisions to the tables. The data tables prepared by each PA and attached hereto as statewide roll-ups at Appendix C reflect the updates and revisions that improve upon the D.P.U. 08-50 comprehensive tables. These updates clarify certain data points, and are presented in pivot table format to allow stakeholders to create various outputs using the data. Made in the spirit of the original D.P.U. 08-50 Working Group mandate, the changes take into account lessons learned since 2009. Specific changes to the tables include:

- Added a Master Data tab
    - This tab allows the PAs to input their data for use in the pivot tables.
    - Includes data for 2010-2014 (evaluated), and 2015-2018 (planned). Includes all gas and electric PAs.
    - Includes lifetime savings for other fuels, as well as gross savings for some types of savings.
- Added a Master Sector tab
    - This tab is similar to the Master Data tab, but only includes sector-level data that is needed for sales, outsourced costs, and historical comparisons.

- Added an Additional Sources tab
    - This tab serves as an introduction to the tables, and directs reviewers to where they can find additional information as well as information that is no longer included in the plan tables.
- Funding Tables
    - Removed the Other Funding table and added that information to the Additional Sources tab because the electric PAs assume no other funding sources for 2016-2018.
    - SBC: Removed columns indicating how SBC collections were allocated to each sector because, consistent with the EE Guidelines, SBC collections are allocated to each customer sector consistent with how the funds are collected from each customer sector. Therefore, the removed columns were redundant.
    - FCM: Edited the annual tables to be more flexible and therefore more accurate for each PA, because each PA adopts different FCM bidding strategies. Further, the previous version of the FCM table did not clearly indicate the kW bid and the clearing prices associated with each auction, so the edited version of the table is more transparent in this regard.
    - RGGI: Edited to be better reflect: (a) the allowances and prices associated with auctions in each year, (b) the actual expected proceeds available for energy efficiency after accounting for other costs, and (c) the PA's annual receipt of RGGI proceeds from each auction.
    - Carryover: Edited to be the three years in total, rather than just 2015, to be consistent with streamlining efforts to view the plan in the three-year term construct.
    - EERF: Removed columns indicating how the low-income costs are subsidized by residential and C&I because each PA applies a different approach consistent with their PA-specific rate cases.
- Avoided Costs
    - Removed the Avoided Cost table and added that information to the Additional Sources tab because the PA-specific Benefit-Cost Screening Models better provide this information.
- Low-Income Allocation
    - Removed the columns that provided a comparison to the SBC, to better focus the reviewer on the GCA's requirement for low-income spending, which is unrelated to SBC collections.
- Competitive Procurement
    - This data is now presented for the total budget at the sector level, instead of by program and budget category. This done to better review the PA's procurement processes at a higher level.

- GHG
    - Added a table for greenhouse gas reductions, consistent with the 2013-2015 Term-Report Template.
- Master Sum
    - Removed the DRIPE column. Broke out Gas separately from other Resources. Removed lifetime capacity savings. Added propane, oil, and water savings instead of one sum of the three. Only shows annual savings.
- Other, Unused Savings/Benefits
    - Deleted columns for No. 4 Oil, Kerosene, and Wood, as well as lifetime kW and the summer and winter peak/off peak energy breakouts in the tables that they appeared in, because the PAs determined that these columns were either consistently unused or were no longer useful.
- Cost-Effectiveness
    - Combined the TRC Cost Summary table and the Cost-Effectiveness table into one table to streamline the data, because the two previous tables were providing similar information.
- Historical Comparison
    - Historical comparisons are reformatted based on how Pivot Tables can present data. The information included in the tables is consistent with previous table formats.
    - Revamped the historical benefits tables to match the edits in the benefits table and to streamline the reviewer's analysis of historical benefits.
    - Competitive procurement data is now presented for the total budget at the sector level, instead of by program and budget category. This done to better review the PA's procurement processes at a higher level.
- General Formatting
    - The table numbering (*e.g.*, IV.B.1) has been maintained from previous table formats even though some tables have been removed. This is to better allow comparisons to historical tables.
- Additional Filing Requirements
    - This tab includes the additional information requested in Question 2 of the Hearing Officer Memorandum regarding Additional Filing Requirements (10-2-2015). <u>See</u> Appendix X.

B. <u>**Budget Cost Categories**</u>

1. <u>Overview</u>

Since the establishment of the GCA, the PAs have worked to develop common assumptions and definitions with respect to implementation of their energy efficiency programs.

Historically, due to their varying sizes and business models, the PAs have managed their programs in different ways. In the 2013-2015 Order, the Department directed the PAs to develop consistent definitions and methods of assigning costs across all five program implementation cost categories. 2013-2015 Order at 74. With respect to salaries, the Department directed PAs to report all non-administrative employee costs in the cost category that applies to the employee's job description. Id. With respect to vendor costs, the Department directed the PAs to develop uniform practices to the extent possible (noting tracking system differences), and, where limitations exist, to adopt reasonable alternative allocation methods based on cost-causation principles (actual factors underlying the incurrence of costs). Id. In accordance with the 2013-2015 Order, the PAs submitted a report on their progress towards meeting these requirements on July 31, 2014. In that report, the PAs noted that changes would be made for the 2016-2018 Plan.

2. Budget Category Definitions

PAs have refined the budget category definitions developed over the last several years in order to clarify certain details and to include additional details within the definitions. The statewide definitions used by all Program Administrators in this Plan are as follows.

Program Planning and Administration ("PP&A") - includes costs associated with developing program plans, including market transformation plans, R&D (excluding R&D assigned to Evaluation and Market Research), day-to-day program administration, including labor, benefits, expenses, materials, supplies, overhead costs, any regulatory costs associated with energy efficiency activities, database/data repository development and maintenance, sponsorships and subscriptions, and energy efficiency services contracted to non-affiliated companies, *e.g.*, outside consultants used to prepare plans, screen programs, improve databases and perform legal services. This category also includes internal salaries for administrative employees/ tasks, including program managers who do not have direct sales and technical assistance contact with customers.

Marketing and Advertising - includes costs for the development and implementation of marketing strategies and costs to advertise – through television, radio, billboards, brochures, telemarketing, web-sites and mailings – regarding the existence and availability of energy efficiency programs or technologies, and to induce customers or trade allies to participate in energy efficiency programs. These costs include internal salaries for employee functions related to marketing and advertising.

Participant Incentives - includes funds paid by the reporting Program Administrator to or on behalf of customers or trade allies as rebates or in other forms. Participant incentives includes costs that directly benefit customers, including permit fees, pre-weatherization expenses, repairs, and interest buy-down.

Sales, Technical Assistance & Training ("STAT") - includes administration, sales technical assistance and training costs to motivate: (1) customers to install energy efficiency products and services; (2) retailers to stock energy efficiency products; (3) trade professionals to offer energy efficiency services; (4) manufactures to make energy efficiency products; and (5) use of vendor services and suppliers that demonstrate benefits of energy efficiency. This category also includes costs not directly tied to savings, including residential assessments, technical assistance studies, contractor fees and performance bonuses, vendor cost of money; lead vendor fees and internal salaries for employees with direct customer sales and technical assistance contact.

Evaluation and Market Research - includes costs associated with evaluation activities: costs related to cost-effectiveness evaluation, market research (*e.g.*, baseline studies, market assessments and surveys), impact and process evaluation reports, tracking and reporting program inputs and outputs, funding studies, and other costs clearly associated with evaluating the program. This category also includes internal salaries for employee functions related to evaluating the programs.

Costs are assigned to the relevant category within the relevant program, core initiative, or hard-to-measure program. For example, HES assessments are assigned to STAT in the HES-RCS core initiative in the Whole House program; similarly, all training is assigned to STAT in Workforce Development. Costs that cannot be assigned directly to a program are allocated among relevant programs on an appropriate basis and tracked accordingly.

3. Salaries

For the 2013-2015 Plan, Berkshire, CMA, Liberty, and NSTAR Gas assigned all salaries to PP&A, while National Grid Electric, National Grid Gas, NSTAR Electric, Western Massachusetts Electric Company, Unitil, and Compact reported all non-administrative employee costs in the cost category that applied to the employee's job description. In accordance with the 2013-2015 Order, all PAs have developed allocation methods based upon cost causation principles to assign expenses to the appropriate non-administrative budget category.

For PA staff performing multiple functions, which is a common practice for smaller PAs, employee salaries have been allocated across the appropriate budget categories based on the percentage of employee time spent on various functions within energy efficiency. Beginning with the 2016-2018 Plan, all PAs will treat salaries as follows: (1) assign salaries of staff performing a single function to the appropriate cost category in the appropriate program/sector (*e.g.*, the salary of an employee specializing solely in residential evaluation will be assigned to the Evaluation and Market Research category in all residential programs); and (2) assign salaries of staff performing multiple functions to multiple cost categories in multiple programs/sectors, as appropriate, based on an allocation for each employee in accordance with assigned job tasks.

One specific area in which PAs were not previously consistent was allocation of salaries for program managers. PAs have reviewed these differences and have determined that salaries of program managers with direct sales and technical assistance customer contact are appropriately allocated to STAT, while salaries of program managers without direct contact are more appropriately allocated to PP&A. For example, the salary of a C&I program manager who works directly with customers will be allocated to STAT, while the salary of a residential program manager who does not deal directly with customers due to the lead vendor model will be allocated to PP&A.

4. Vendor-Related Costs

The PAs have performed a detailed review of vendor costs and related cost categories to determine changes that need to be made in order to achieve consistency. PAs have developed a chart, attached at Appendix Q, showing vendor cost types and the related cost category to support consistency and serve as a guide going forward.

5. Identification of Any Costs That are Difficult to Assign to One of the Five Cost Categories

At this time, the PAs have not encountered any costs that are difficult to assign to one of the five cost categories. All costs have been assigned based on type and function. The PAs will continue to review current and new costs as they come into the programs and assign appropriate cost categories.

6. Continuous Improvement

The PAs recognize that there may be instances in which differences in cost categorization are discovered in the future, but are committed to consistency and continued improvement. The PAs have established consistent budget cost category definitions, determined methods for allocating salaries across cost categories, and harmonized vendor cost categorization, and are committed to continuing to review new costs and to seek and maintain consistency across PAs throughout the Plan term.

C. **Performance Incentives**

On January 28, 2010, the Department issued the 2010-2012 Electric Order and 2010-2012 Gas Order ("2010-2012 Orders") on the first Three-Year Plans. The 2010-2012 Orders approved most aspects of the performance incentive mechanism proposed by the Program Administrators in their 2010-2012 Plans.[107] However, for certain aspects of the proposal regarding the allocation method of the statewide pool and performance metrics, the Department ordered the Program Administrators to work further with the Council and re-file these components with the Department for its review and approval. For 2011, the Program Administrators worked closely with the Council in order to update the allocation method in compliance with the 2010-2012 Orders, as well as to propose updated performance metrics. As a result of this effort, a comprehensive settlement was achieved on this and other matters, which was filed on April 15, 2011. Similarly, for 2012, the Program Administrators used the extensively reviewed 2011 method and performance incentive model as a basis for 2012 performance incentive allocations and updated performance metrics. Performance incentive proposals applicable to 2012 efforts were filed with the Department on October 28, 2011. The

[107] See 2010-2012 Electric Order at 93-125, 165, and 168-169; 2010-2012 Gas Order at 79-115, 168-169, and 172-173.

Department approved the 2011 and 2012 proposals on November 26, 2014, including the proposed method of allocating statewide incentives to each Program Administrator and all but one of the proposed performance metrics, the 2012 Cost Efficiency Metric. See 2011 Mid-Term Modification for Energy Efficiency Programs, D.P.U. 10-140 through D.P.U. 10-150 (2014); 2012 Mid-Term Modification for Energy Efficiency Programs, D.P.U. 11-106 through D.P.U. 11-116 (2014). For the 2013-2015 Plan, the Program Administrators retained the performance incentive model that included the Savings Mechanism, the Value Mechanism, and Performance Metrics. 2013-2015 Performance Metrics, D.P.U. 13-67 (2014). In its review of that proposal, the Department determined that Performance Metrics were no longer needed and directed the Program Administrators to reallocate the funds that had been allocated to that component of the incentive mechanism to the Savings and Value Mechanisms. Id.

For the 2016-2018 Plan, the Program Administrators have retained the focus on benefits through the Savings Mechanism and on net benefits through the Value Mechanism. In this discussion, the Program Administrators summarize the 2016-2018 performance incentive amounts in the following manners: statewide, by component, and by Program Administrator. Performance incentive models are attached at Appendix R.

I. Summary of the Orders on Performance Incentives in the 2010-2012 Plan.

In the 2010-2012 Orders, the Department noted its support of the following elements of the proposed incentive design:

1. The proposed statewide incentive pool.
    a. The electric statewide incentive pool goals equal $22 million in 2011 and $25.5 million in 2012, assuming that goals on a statewide basis are equal to the goals established by the Council. 2010-2012 Electric Order at 93. The actual incentive pool can be adjusted up or down according to actual goals. Id. at 111. The Department approved the statewide goals. Id. at 112.
    b. The gas statewide incentive pool goals equal $4.5 million in 2011 and $5.5 million in 2012, assuming that goals on a statewide basis are equal to the goals established by the Council. The actual incentive pool can be adjusted up or down according to actual goals. 2010-2012 Gas Order at 100. The Department approved the statewide goals. Id. at 101.
2. The structure of the proposed incentive mechanism includes three components: the Savings Mechanism (focusing on the dollar value of benefits); the Value Mechanism (focusing on the dollar value of net benefits); and Other Performance Metrics.
    a. The three-pronged structure of the incentive mechanism was approved in the 2010-2012 Electric Order at 113, 124 and the 2010-2012 Gas Order at 101-102, 114. The Department noted that similar mechanisms have been approved in the past.
3. Common payout amounts under both the Savings and Value Mechanisms.
    a. The approval for common payout rates in the 2010-2012 Electric Order is found on pages 113-114 with reference to Table D at 96.

   b. The approval for common payout rates in the 2010-2012 Gas Order is found on pages 102-103 with reference to Table C at 83.

4. The proposed allocation of the statewide incentive pool to each Program Administrator for 2010 but not for 2011 or 2012.

   a. The allocation of the statewide electric incentive pool to each Program Administrator was based on that Program Administrator's contribution to the statewide savings goals as expressed in MWh. However, the allocation for each of the three components was not consistent among the Program Administrators; the savings component amount was allocated on the basis of the dollar value of savings, the value component amount was allocated on the basis of the dollar value of net benefits, and the performance metrics component was derived to total the overall allocation method based on savings goals. Although the Department approved the allocation of the components for 2010, the Program Administrators were directed to revise the allocation method for 2011 and 2012 so that, to the extent possible, the revised allocation method would result in (1) uniform statewide payout rates for the savings and value components, and (2) an allocation of incentive dollars across the three components for each Program Administrator that, on a percentage basis, approximates the statewide allocation across the three components, as endorsed by the Council and approved by the Department. See 2010-2012 Electric Order at 114-116.

   b. The allocation of the statewide gas incentive pool to each Program Administrator was based on a similar methodology. This methodology produced some anomalous results for certain Program Administrators that required special adjustments. Similar to the electric side, the Department approved the gas Program Administrators' component allocation for 2010, but the Program Administrators were ordered to revise the allocation methodology in 2011 and 2012. See 2010-2012 Gas Order at 103-105.

   c. A revised allocation methodology was proposed in the 2011 Mid-Term Modifications settlement proposal. The revised methodology was created following extensive discussions with the Council, and addressed the concerns of the Department, as noted in the Orders.

5. Specific limitations on how EM&V results would be used to determine performance for both the electric and gas Program Administrators. 2010-2012 Electric Order at 124; 2010-2012 Gas Order at 114.

However, the Department did not accept: (1) the proposed allocation method for 2011 and 2012 as mentioned above; or (2) the proposed performance metrics for 2010. The Department stated that it did not accept an EM&V "Omnibus Metric," and directed the Program Administrators to include a financing and funding metric.[108] The Department further ordered that a cap on the earned incentive mechanism apply both in total and by component. The cap by

[108] In response to the 2010-2012 Orders, the Program Administrators filed a revised performance metric proposal on March 12, 2010. The Department subsequently approved the revised performance metrics on August 10, 2010 with the exception of the Deeper Savings metric. On September 14, 2010 the Program Administrators filed a compliance filing in regard to changing the baseline year of that metric.

component and overall has been set at 125 percent of design level performance.[109]

II. Summary of the Orders on Performance Incentives in the 2013-2015 Plan.

In the 2013-2015 Order, the Department approved the 2013-2015 Plan statewide incentive pool structure of the PI mechanism, as revised, for the savings and value components (metrics were reviewed separately), calculation of the savings and value payout rates, and adjusted threshold levels (the slightly different mechanism for PAs with goals that exceed Council targets). The Department directed the PAs to recalculate the threshold levels to be consistent over the three years and provided the calculation method in the appendix to the Order.

The Department reviewed the performance incentives in light of the D.P.U. 11-120-A, Phase II Order, which among other things, creates a true three-year PI structure. The D.P.U. 11-120-A, Phase II Order requires PAs to calculate design-level incentive payments based on projections of performance for the entire three-year term, not based on annual projections, and directs both electric and gas PAs to collect performance incentives in the EES at the design level during the three-year term. The Department will review PI at the end of the three-year term.

Citing previous approvals of PI pools that were a greater percent of budget than proposed in the 2013-2015 Plan, the Department approved the PI pool. Additionally, the Department approved the full increase to the statewide PI pool, as set forth in the updated tables, noting the link between the statewide incentive pool and projected savings. The Department found that the PAs had kept performance incentive funds as low as possible consistent with the Guidelines.

The Department had previously approved the PI mechanism and its components, and the Council had endorsed the components and allocation of incentive dollars to each component. For these reasons, the Department found the savings and value components to be reasonable and consistent with the GCA and precedent and approved the PI mechanism, with the exception of the metrics which were reviewed in a separate docket.

The Department found that the application of uniform statewide payout rates for the savings and value components was consistent with the goals of the GCA and Department precedent, and, because the rates do not vary by year, found that the payout rates were consistent with the D.P.U. 11-120-A, Phase II Order. The Department approved the method used to calculate the statewide savings and value components payout rates. The Department approved the PAs' adjusted threshold levels for the savings and value components of the PI mechanism for those PAs with savings targets in excess of the Council's goals.

The Department found that the PI mechanism must be revised to be consistent with the D.P.U. 11-120-A, Phase II Order. Mid-term or annual adjustments that result in payout rates that vary over the three-year term are inconsistent with the D.P.U. 11-120-A, Phase II Order. The Department addressed the issue of updates to the Avoided Energy Supply Costs and stated that they will be reviewed in the context of streamlining working groups. The Department reviewed

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[109] The Program Administrator proposals had thresholds for the savings and value incentive mechanisms of 75 percent of design or target level performance.

the one-year nature of metrics in a separate proceeding on metrics. With respect to the threshold levels proposed by the PAs, because they varied in the third year, the Department noted that they are inconsistent with the D.P.U. 11-120-A, Phase II Order, and directed the PAs to recalculate the threshold as described in the appendix and as shown for each PA in the Order. The Department directed the PAs to implement a revised PI model with one combined threshold level for the entire three-year term. On or before February 21, 2013, each PA filed a compliance filing with a revised PI model, including all tables, using the revised thresholds.

In D.P.U. 13-67, the Department concluded that performance metrics are no longer a necessary component of the PAs' performance incentive mechanism and, therefore, did not approve the metrics for 2013. As noted in this Order and the 2013-2015 Order, the portion of the statewide incentive pool allocated to performance metrics will be reallocated to the savings and value components of the performance incentive mechanism. Therefore, the PI pool will remain intact and PAs retain the ability to earn the total amount of PI allocated to them.

In D.P.U. 13-67, the Department stated that metrics were originally intended to incentivize specific activities, but now that the GCA requires all available cost-effective energy efficiency, metrics would only seek to incentivize activities that are already required. The Department also stated that the PAs do not need the guidance traditionally provided by metrics, noting that the "Program Administrators, in conjunction with the Council and other stakeholders, have developed a comprehensive infrastructure to promote statewide energy efficiency program integration and continuous improvement in program delivery." D.P.U. 13-67, at 11. The Department specifically noted that the Management Committees and low-income best practices address program implementation barriers and foster communication with the Council and other stakeholders. The Department also found that "[n]egotiating, satisfying, and documenting performance metrics is costly and time consuming." Id. at 13, n.25. The Department found that such an investment of time and resources solely for the purpose of verifying metric performance is out of proportion with the potential benefit of metrics. Further, verifying performance of these metrics would divert PA and stakeholders focus from the successful implementation of the Three-Year Plans and is inconsistent with the Department's obligation to fulfill its oversight responsibilities in an administratively efficient and effective manner.

III. Allocation Proposal for 2016 – 2018

Based upon the well-developed principles and precedent described above, the Program Administrators propose an incentive mechanism for 2016-2018 that is comprised of a Savings Mechanism and a Value Mechanism with common payout rates in each component applicable to the electric and gas Program Administrators, respectively with performance assessed at the portfolio level using cumulative three-year results. In 2016-2018, the statewide incentives for the savings component of the incentive pool are allocated on the basis of the dollar value of benefits using common payout rates as approved by the Department. The statewide incentives for the value component of the incentive pool are allocated on the basis of the dollar value of net benefits using common payout rates as approved by the Department. The total incentive is the sum of the two components. This methodology was followed for allocating the incentive dollars among Program Administrators, as well as to each sector and to each program.

This proposed allocation model results in a similar distribution of each Program Administrator's incentives among the two components. The proposed payout rates for 2016-2018 remain constant for all Program Administrators and for each year in the Plan, consistent with the focus on the comprehensive three-year effort as a single Plan.

Distribution of Performance Incentive for Electric Program Administrators in 2016-2018:

Percent of Total Incentive

State	Residential	Low Income	C&I	Total
Savings	23.5%	3.3%	34.8%	61.5%
Value	14.3%	1.3%	22.9%	38.5%
Total	37.7%	4.6%	57.7%	100.0%
National Grid	Residential	Low Income	C&I	Total
Savings	27.2%	3.9%	31.4%	62.5%
Value	16.2%	1.7%	19.6%	37.5%
Total	43.4%	5.6%	51.0%	100.0%
Eversource	Residential	Low Income	C&I	Total
Savings	20.3%	2.7%	37.7%	60.8%
Value	12.6%	1.0%	25.6%	39.2%
Total	32.9%	3.7%	63.3%	100.0%
Unitil	Residential	Low Income	C&I	Total
Savings	17.0%	4.0%	35.5%	56.4%
Value	12.9%	2.2%	28.4%	43.6%
Total	29.9%	6.2%	63.9%	100.0%

Distribution of Performance Incentive for Gas Program Administrators in 2016-2018:

Percent of Total Incentive

State	Residential	Low Income	C&I	Total
Savings	34.3%	8.8%	18.4%	61.5%
Value	18.6%	4.8%	15.1%	38.5%
Total	52.9%	13.6%	33.5%	100.0%
National Grid	Residential	Low Income	C&I	Total
Savings	37.9%	10.5%	16.7%	65.1%
Value	16.2%	6.0%	12.7%	34.9%
Total	54.1%	16.5%	29.4%	100.0%
Eversource	Residential	Low Income	C&I	Total
Savings	28.4%	8.4%	24.5%	61.4%
Value	13.6%	4.8%	20.2%	38.6%
Total	42.0%	13.2%	44.7%	100.0%
Columbia	Residential	Low Income	C&I	Total
Savings	33.4%	5.5%	14.8%	53.7%
Value	29.8%	2.5%	14.1%	46.3%
Total	63.2%	7.9%	28.9%	100.0%
Unitil	Residential	Low Income	C&I	Total
Savings	24.2%	8.3%	23.2%	55.7%
Value	17.5%	4.7%	22.1%	44.3%
Total	41.7%	13.0%	45.4%	100.0%
Berkshire	Residential	Low Income	C&I	Total
Savings	28.8%	7.9%	27.3%	64.0%
Value	10.8%	3.7%	21.5%	36.0%
Total	39.6%	11.5%	48.8%	100.0%
Liberty	Residential	Low Income	C&I	Total
Savings	34.8%	9.5%	19.6%	63.8%
Value	19.4%	3.7%	13.1%	36.2%
Total	54.2%	13.1%	32.7%	100.0%

IV. Statewide Incentive Pool for 2016-2018

Statewide, the design level incentive is set at $100 million for electric efforts and $18 million for gas efforts. These amounts reflect the challenge of continuing to adopt aggressive savings goals in 2016-2018 in light of achievements to date, the remaining savings opportunities identified in each service territory, and the success the Program Administrators are cultivating as markets are transformed. In addition, these electric and gas incentive pools are consistent with the Term Sheet that has been supported by DOER, the AG, and the PAs, attached hereto at

Appendix D. The statewide incentive pool will not change as a result of changes to avoided costs that may occur during the term of this Plan.[110]

V. Summary of 2016-2018 Incentives

The models set forth as Appendix R – Part 1 (Electric) and Appendix R – Part 2 (Gas) provide calculations of the 2016-2018 incentives based on the Three-Year Plan proposals of each of the Program Administrators for electric and gas, respectively. For the electric Program Administrators this is a 19 page exhibit and for the gas Program Administrators this is a 25 page exhibit. The calculations are described below. Additionally, a summary of the 2016-2018 incentives is provided below.

A. Calculation Exhibits

Appendix R – Part 1 (Electric) provides the derivation of the 2016-2018 electric incentives at the design level of performance. Similarly, Appendix R – Part 2 (Gas) provides the derivation of the 2016-2018 gas incentives at the design level of performance.

Pages 1 and 2 of both Appendix R - Part 1 (Electric) and Part 2 (Gas) are input pages that summarize each Program Administrator's 2016-2018 goals, benefits and costs (excluding performance incentives and demand reduction-related costs).

Page 3 in both Appendix R - Part 1 (Electric) and Part 2 (Gas) derives the common payout rates used to calculate projected design level incentives under the Savings and Value Mechanisms given the electric and gas statewide incentive pools. The Program Administrators note that if avoided costs change compared to what has been used here, either as a result of orders issued by the Department in D.P.U. 11-120 or due to a study where avoided costs are updated, the common payout rates applicable under the savings and value components will need to be updated. However, these changes would not impact the size of the incentive pool or PA-specific design-level incentives. At a statewide level for both electric and gas, 61.5 percent of the incentive has been allocated to the Savings Mechanism and 38.5 percent to the Value Mechanism. To determine the payout rate under the Savings Mechanism, the electric or gas statewide incentive pool is multiplied by 61.5 percent, the portion of the statewide performance incentives allocated to the savings component, and the resulting amount is divided by the projected dollar value of benefits statewide from proposed electric or gas efforts. Similarly, to determine the payout rate under the Value Mechanism, the electric or gas statewide incentive pool is multiplied by 38.5 percent, the portion of the statewide performance incentives allocated to the value component, and the resulting amount is then divided by the projected dollar value of net benefits statewide from proposed electric or gas efforts.

Pages 4-11 of Appendix R – Part 1 (Electric) and pages 4-17 of Appendix R – Part 2 (Gas) provide the calculation of potential design level incentives under the savings mechanism and the value mechanism on a statewide basis and for each individual Program Administrator. Lines 1 through 3 determine the savings amount by multiplying the dollar value of benefits by

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110 The PAs do not currently anticipate updating avoided costs applicable to 2016-2018 efforts at this time.

the savings mechanism payout rate. Lines 4 through 6 determine potential design level incentives under the value mechanism by multiplying the dollar value of net benefits by the value mechanism payout rate. Line 7 provides the total performance incentive.

Pages 12 - 15 of Appendix R – Part 1 (Electric) and pages 18 - 21 of Appendix R – Part 2 (Gas) provide summary information about performance incentives by sector and by component of the incentive mechanism in real dollars ($2016). Pages 16-19 of Appendix R – Part 1 (Electric) and pages 22 – 25 of Appendix R – Part 2 (Gas) provide the same information in current year (nominal) dollars.

Appendix R – Part 1 (Electric) and Appendix R – Part 2 (Gas) do not show how the performance incentives are further allocated to specific programs for benefit/cost screening purposes. Rather, the program allocation assumptions are summarized below:

- The savings component amount is allocated to programs on the basis of program dollar of benefits.
- The value component amount is allocated to programs on the basis of program dollar of net benefits.
- Any programs with negative allocations (efforts with projected costs without identified projected savings) are reallocated to other programs within the sector.

B. Summary

A summary of the threshold, design, and exemplary performance incentive amounts by component of the proposed incentive mechanism for 2016-2018 is provided for each electric and gas Program Administrator, below. The threshold level is set at 75 percent of the design level incentive while the exemplary level is set at 125 percent of the design level incentive.

Electric:

Summary of 2016 - 2018 Performance Incentives by Program Administrator ($2016)

		Threshold	Design	Exemplary
National Grid		Threshold	Design	Exemplary
	Savings	$21,499,886	$28,666,515	$35,833,144
	Value	$12,917,889	$17,223,852	$21,529,815
	Total	$34,417,775	$45,890,367	$57,362,958
Eversource		Threshold	Design	Exemplary
	Savings	$24,183,684	$32,244,913	$40,306,141
	Value	$15,616,431	$20,821,908	$26,027,385
	Total	$39,800,116	$53,066,821	$66,333,526
Unitil		Threshold	Design	Exemplary
	Savings	$441,429	$588,573	$735,716
	Value	$340,680	$454,240	$567,800
	Total	$782,109	$1,042,812	$1,303,516

Gas:

Summary of 2016 - 2018 Performance Incentives by Program Administrator ($2016)

		Threshold	Design	Exemplary
National Grid				
	Savings	$4,368,695	$5,824,927	$7,281,159
	Value	$2,346,539	$3,128,719	$3,910,898
	Total	$6,715,234	$8,953,646	$11,192,057
Eversource		Threshold	Design	Exemplary
	Savings	$1,908,900	$2,545,200	$3,181,500
	Value	$1,201,365	$1,601,820	$2,002,274
	Total	$3,110,265	$4,147,020	$5,183,775
Columbia		Threshold	Design	Exemplary
	Savings	$1,627,631	$2,170,174	$2,712,718
	Value	$1,405,513	$1,874,018	$2,342,522
	Total	$3,033,144	$4,044,192	$5,055,240
Unitil		Threshold	Design	Exemplary
	Savings	$86,646	$115,528	$144,411
	Value	$68,827	$91,769	$114,712
	Total	$155,473	$207,298	$259,122
Berkshire		Threshold	Design	Exemplary
	Savings	$181,043	$241,390	$301,738
	Value	$101,725	$135,633	$169,541
	Total	$282,767	$377,023	$471,279
Liberty		Threshold	Design	Exemplary
	Savings	$129,585	$172,780	$215,974
	Value	$73,531	$98,041	$122,552
	Total	$203,116	$270,821	$338,526

D. <u>Bill Impacts</u>

Consistent with directives of the GCA and the goal of the 2016-2018 Plan to provide for the acquisition of all available energy efficiency and demand reduction resources that are cost effective or less expensive than supply, the Program Administrators sought to develop a statewide energy efficiency plan that acquires these resources with the lowest reasonable customer contribution. G.L. c. 25, § 21(b). Additionally, the Program Administrators worked collaboratively to review and analyze the rate and bill impacts associated with the implementation of the 2016-2018 Plan in order to ensure compliance with the requirements of the GCA, the Department's Orders in D.P.U. 08-50-A and D.P.U. 11-120-A, Phase II and with the Department's ratemaking precedent. The PAs have sought to balance the value of the long-term benefits expected from proposed energy efficiency efforts with short-term customer bill impacts. Proposed budgets reflect these considerations along with a focus on the equitable distribution of costs and benefits for customers.

The Department convened a technical session on August 16, 2012, at which the Department reviewed the history of bill impacts, implementation of D.P.U. 08-50, the GCA requirements, the Department's goals with respect to rate continuity, and different aspects of the traditional bill impact models as well as the Department-developed D.P.U. 08-50 bill impact models. Ultimately, the Department explained that the short-term information provided in traditional bill impact models satisfies the GCA requirement that the Department consider the effect of any rate increases on residential and commercial customer bills before approving ratepayer funding of energy efficiency programs. See G.L. c. 25, § 19(a).

On October 19, 2012, the Department issued its order acknowledging the efforts of the Bill Impact Working Group, but declining to adopt the bill impact models under discussion. D.P.U. 08-50-D; see also Section III.L, supra. Instead, the Department directed the PAs to submit traditional bill impacts for non-participants under the following scenarios:

1. the current (*e.g.*, 2012) energy efficiency surcharge ("EES") to the proposed EES for the first year of the three-year plan (*e.g.*, 2013);
2. the EES from the first year of the three-year plan (*e.g.*, 2013) to the proposed EES for the second year of the three-year plan (*e.g.*, 2014);
3. the EES from the second year of the three-year plan (*e.g.*, 2014) to the proposed EES for the third year of the three-year plan (*e.g.*, 2015);
4. the current EES (*e.g.*, 2012) to the proposed EES for the third year of the three-year plan (*e.g.*, 2015).

D.P.U. 08-50-D at 12. The Department also directed the PAs to submit bill impacts for participants, "where consumption is reduced for three levels of savings -- low, medium, and high -- and [to] provide a description of how these savings levels were determined." Id. The Department later clarified the bill impact requirements for non-participants by providing a spreadsheet to the PAs, directing them to use average monthly usage levels under the first and fourth scenarios listed above.

Accordingly, to calculate bill impacts for participants, the PAs will populate the Department's spreadsheet (with peak and off-peak rates on separate sheets), using the average monthly kWh and/or therm usage for non-participants for each rate class, and the percentages set forth in the table below. To best approximate low, medium and high annual savings consistent with the Department's directive in D.P.U. 08-50-D, the PAs collaborated on appropriate assumptions for residential, low-income and C&I programs to develop statewide percentages that best approximate savings for those types of participants. The PAs determined that the percentages in the table below will provide directional information on the bill impacts that a residential, low-income or C&I participant may experience.

The PAs determined that there is no low, medium and high savings scenario for low-income participants. These participants typically receive a comprehensive "whole house" energy efficiency approach, meaning potential measures are installed in most cases (the work that can be done is done). Similarly, the PAs determined that there is no low, medium and high savings scenario for residential and low-income gas non-heating participants and street lighting. Accordingly, the PAs determined that the percentages in the table below best approximate savings for those types of participants.

	Low	Medium	High
Residential- Electric:	2%	10%	30%
Residential- Gas:	2%	15%	30%
Residential Gas Non-Heating:		2%	
Low-Income Gas Non-Heating:		2%	
Low-Income:		25%	
Street Lighting:		10%	
C&I- Electric:	1%	10%	20%
C&I- Gas:	1%	10%	20%

Each PA has provided traditional bill impacts for all rate classes in each individual PA's filing.

E. Evaluation, Measurement & Verification

1. EM&V Framework

Consistent with past Three-Year Plans and the Council's September 8, 2009 EM&V Resolution, the PAs propose to continue the evaluation framework that has successfully allowed the PAs to engage in high quality third-party EM&V efforts. The Council and the PAs find that it is critical that the programs be evaluated, measured, and verified in a way that provides confidence to the public at large that the savings are real and in a way that enables the Program Administrators to report those savings to the Department with full confidence. Additionally, the Council stated that there is a need to ensure both the reality and the perception of the independence and objectivity of EM&V activities, as well as the need to help ensure consistency, timeliness, and credibility of the results. Accordingly, the Council will continue to have an oversight role over the EM&V activities of the Program Administrators to ensure the objectivity and independence of those activities, and the perception of such, and to help ensure consistency, timeliness, and credibility. The Council's oversight role will be accomplished through the Council's EM&V consultant ("EM&V Consultant"), a third-party expert consultant who has primary responsibility for working with the PAs to plan and implement high-quality EM&V in Massachusetts.

While PAs and the EM&V Consultant will continue to work diligently to reach a consensus on evaluation issues, where there are areas of difference that may arise that cannot be resolved through consensus during the on-going interactive process between the EM&V Consultant and the PA evaluation staff, authority for decision-making will reside with the EM&V Consultant and the Council.

To enable the Program Administrators to fulfill their responsibility to report program savings to the Department with full confidence, an appeals process has been established, through which the PAs may bring decisions made by the EM&V Consultant or the Council for review and resolution. This process will be implemented through the formation of an evaluation appeals committee ("Appeals Committee") of the Council, whose responsibility in this area will be to hear the matter under dispute and rule so that the study may proceed in a timely way. In general, it is expected that this review process will be completed within 72 hours once an issue is elevated to the Appeals Committee. This Appeals Committee will consist of three voting members of the Council, including DOER. Consistent with general Council proceedings, the Appeals Committee will include and consult with, in both deliberations and decision-making, a representative of both the PAs and the Council's consultant team, neither of whom shall have a vote in the standing committee. The Appeals Committee will review the issues related to the disputed matter, hear from the PA evaluation staff and EM&V Consultant, and make a determination on the outcome of the matter. The decision will be recorded, along with a description of the applicable issues. The participants in the appeal will sign the record of the decision, indicating their acceptance of, the representation of the issues and of the decision. In exceptional cases, where the PAs perceive there to be significant risk to their ability to manage the energy efficiency programs in the near term, the PAs will note their disagreement with the decision of the Appeals Committee on the record of the decision and reserve the right to immediately petition the Department on the Appeal's Committee's decision. The PAs shall be able to submit any such documents to the Department in conjunction with the filing of the Three-Year Plans, mid-term modifications, and term reports. The Department will be able to review the record of this decision in its review of Three-Year Plans, mid-term modifications, plan-year reports, and term reports.

To date, the EM&V Consultant and PA Evaluation staff have been able to resolve all areas of differences without proceeding to the Appeals Committee (as defined in this Section IV.E.1.). This is a testament to the hard work and collaborative engagement of the PAs and the EM&V Consultant.

The PAs will maintain a statewide focus to the maximum extent possible, will review EM&V budgets with the EM&V Consultant, and will integrate electric and gas evaluation efforts to the maximum extent possible. The Program Administrators will be the main mechanism for contracting with the independent evaluation contractors, and will work with evaluation contractors to maintain privacy of customer data.

2. Evaluation Management Committee

The PAs and the EM&V Consultant established the EMC to be similar to other management committees. The EMC serves as a steering committee for statewide evaluation issues, providing guidance and direction to each of the evaluation research areas. The EMC works to plan, prioritize and delineate the research studies to be undertaken over the Three-Year Plan term.

The Program Administrators and the EM&V consultant have worked to consistently improve the EM&V process over time. As issues arise, the EMC has established working groups to review and address new topics, areas of concern, or disagreement. In 2014, the PAs and the EM&V Consultant determined that the current research into baselines associated with energy efficiency measures was not clearly defined. Due to the lack of definition, disagreements arose surrounding the way to apply evaluation results to baseline parameters. In response to those issues, the EMC formed a Baseline Working Group, and established guidelines to handle such concerns in the future. The EMC will continue to establish appropriate working groups to address issues as they arise and keep the EM&V process running transparently, efficiently, and effectively.

3. Descriptions of Research Areas

Consistent with the experience since the establishment of the GCA, the EMC worked collaboratively to develop and refine three market research areas. These research areas are organized primarily by target markets, which design is intended to help maximize the statewide effectiveness of EM&V, while presenting minimal overlap among areas. The research areas identified are as follows:

a) **Residential**

Originally, this research area consisted of three separate categories: Residential Retrofit and Low-Income, Residential Retail Products, and Residential New Construction. Residential still includes these categories, but as a single overarching research area. As currently defined, the residential research area will include all residential and low-income core initiatives.

b) **Commercial & Industrial**

This research area previously consisted of two separate categories: Non-Residential Large Retrofit and New Construction and Non-Residential Small Retrofit. C&I still includes these categories, but as a single overarching research area. As currently defined, the C&I research area will include all C&I core initiatives.

c) **Special and Cross-Sector Studies**

This research area reflects the fact that not all studies will fall into the two market categories above, and some studies may be cross-sector in nature. Some types of studies in this research area can include: cross-sector free ridership and spillover studies, non-energy impacts, behavioral programs, community-based pilots, and marketing, public education, and outreach activities.

The research areas were consolidated to improve administrative efficiency and cross-sector coordination. Cross-sector coordination has been an area that the EMC has been working to consistently improve in order to leverage data and research done by the various research teams to improve depth and quality of research, while lowering cost. More details regarding these research areas and specific research topics can be found in the Strategic Evaluation Plan, which is attached at Appendix S.

4. Evaluation Budgets

The EM&V budget available to the research areas for the 2016-2018 Plan is projected to be in line with historical program budget levels. Twenty percent of each sector's available evaluation budget is allocated to the Cross-Cutting research area. The remaining evaluation budget in the residential and low-income sector is allocated to the Residential research area; the remaining evaluation budget in the C&I sector is allocated to the Non-Residential research area. Total evaluation budgets for the 2016-2018 Plan term are expected to be $18.7 million for gas programs and $41.3 million for electric programs.[111]

5. Types of Evaluation Functions

EM&V refers to the systematic collection and analysis of information to document the impacts of energy efficiency programs and improve the effectiveness of these programs. EM&V includes the following types of studies:

- *Impact Evaluation* refers to the measurement of net or gross savings achieved within overall program populations.
- *Market Effects Evaluation* refers to the measurement of the effects that programs have on the structure and functioning of their target markets.
- *Process Evaluation* refers to the systematic assessment of programs for the purpose of documenting their operations and developing recommendations to improve their effectiveness.
- *Market Characterization or Assessment* refers to the systematic assessment of energy efficiency markets for the purpose of improving the effectiveness of programs targeting those markets.
- *Evaluation of Pilots* refers to EM&V activities intended to assess the effectiveness of pilot programs, determine their potential for full-scale implementation, and develop recommendations for any changes in program approach.

6. Evaluation Planning and Strategic Evaluation Plan

The EMC has sought to establish a long-term strategic view of EM&V for the 2016-2018 Plan, including developing evaluation strategy and determining priorities that the EMC expects to research during the three-year term. These priorities were developed based on the findings of current research, a three-day Strategic Evaluation Planning Summit in February 2015, and discussions in the EMC and with Councilors and other stakeholders. The Strategic Evaluation Plan expands upon and prioritizes the important research topics that were discussed and established at the summit and during EMC and other discussions. These details and priorities are attached at Appendix S.

111 It is noted that since evaluation activities typically occur after program implementation activities, evaluation costs can lag up to several years.

7. Evaluation Studies Completed in Advance of the 2016-2018 Plan

Twenty-five studies were completed in advance of the 2016-2018 Plan that were not previously filed with the Department as follows:

STUDY NAME	STUDY LOCATION AND NUMBER	FUEL
Residential Program Studies		
Massachusetts Residential Lighting Cross-Sector Sales Research	App. U, Study 1	Electric
Multistage Lighting Net-to-Gross Assessment: Overall Report	App. U, Study 2	Electric
Lighting Market Assessment and Saturation Stagnation Overall Report	App. U, Study 3	Electric
Baseline Sensitivity Analysis 2016 - 2018	App. U, Study 4	Electric/Gas
Lighting Interactive Effects Study Preliminary Results	App. U, Study 5	Electric/Gas
Program Assessment Tube TV Recycling	App. U, Study 6	Electric
Cool Smart Incremental Cost Study	App. U, Study 7	Electric
Home Energy Services Initiative and HEAT Loan Delivery Assessment	App. U, Study 8	Electric/Gas
Residential Customer Profile Study	App. U, Study 9	Electric/Gas
Multifamily Impact Findings Memo	App. U, Study 10	Electric/Gas
Ductless Mini-Split Heat Pump (DMSHP) Final Heating Season Results	App. U, Study 11	Electric
Ductless Mini-Split Heat Pump (DMSHP) Baseline Determination	App. U, Study 12	Electric
Low-Income		
Massachusetts Low-Income Multifamily Initiative Impact Evaluation	App. U, Study 13	Electric/Gas
Special & Cross Sector Studies		
Comprehensive Review of Non-Residential Training and Education Programs, with a Focus on Building Operator Certification	App. U, Study 14	Electric/Gas
Comprehensive Review of Behavior and Education Programs	App. U, Study 15	Electric/Gas
Massachusetts Behavioral Programs Process Evaluation	App. U, Study 16	Electric/Gas
2014-2015 Commercial and Industrial Natural Gas Programs Free-ridership and Spillover Study	App. U, Study 17	Gas
Efficient Neighborhoods + Incremental Cost Assessment	App. U, Study 18	Electric/Gas
Commercial & Industrial Program Studies		
Prescriptive Gas Impact Evaluation - Steam Trap Evaluation Phase 1	App. U, Study 19	Gas
Prescriptive Programmable Thermostats	App. U, Study 20	Gas
Impact Evaluation of PY2013 Custom Gas Installations	App. U, Study 21	Gas
Massachusetts Commercial New Construction Energy Code Compliance Follow-Up Study	App. U, Study 22	Electric/Gas
Massachusetts LED Spillover Analysis	App. U, Study 23	Electric
Impact Evaluation of Prescriptive Chiller and Compressed Air Installations	App. U, Study 24	Electric
Impact Evaluation of 2012 Custom HVAC Installations	App. U, Study 25	Electric

Summaries of these evaluations are attached at Appendix T and full copies are available at Appendix U. Additionally, all currently completed studies are available on the Council's website at: http://ma-eeac.org/studies/.

F. Technical Reference Manual/Library

The TRM documents how the energy efficiency Program Administrators consistently, reliably, and transparently calculate savings resulting from the installation of prescriptive energy efficiency measures. The TRM provides methods, formulas, and default assumptions for estimating energy, peak demand, and other resource impacts from energy efficiency measures. The TRM, which did not exist until the PAs developed their initial Three-Year Plan, is an excellent example of how the PAs work together, share data and best practices and work to develop common assumptions that reflect state-of the-art EM&V results. The complete TRM is available at Appendix V.

In 2014, the PAs also began developing an electronic version of their TRM, which documents impact factors and input assumptions, with sources and references. This electronic version is still under development and will be available during the term of the Plan, but was not complete in time for this filing. In recent years, the PAs have developed and provide a paper copy of the TRM for each Three-Year Plan and annual performance report filed with the Department. The PAs provided a paper copy of the TRM in Appendix V of this Plan, and will supplement it with the electronic version, when it is complete and usable.

The electronic product associated with the development of the TRM will be known as the Technical Reference Library ("TRL"), and will allow the public to access information from a central website. The development of this product is a collaborative effort of the PAs. The TRL will reflect the efforts of the PAs to align common measure naming across all PAs, where appropriate. The PAs have been working diligently on developing the TRL, but development has been more complex than anticipated; the PAs expect that the TRL will be complete in 2016.

G. Core Benefits and Cost-Effectiveness

1. Energy and Demand Savings

The savings goals and program budgets set forth in this Plan are presented on an aggregate, statewide basis by program. In the Energy Efficiency Data tables, each Program Administrator provides its individual recommended savings and budget levels for the three-year term commencing January 1, 2016, consistent with the overall goals and budgets developed in the statewide Plan review process, which are included as supplemental enclosures with this Plan. The statewide Plan review process is a phased process that first requires the filing of a joint statewide plan by all Program Administrators in April, followed in October by individual PA-specific plans, after the conclusion of the review process of the statewide plan at the Council. G.L. c. 25, §§ 21(b)-21(d).

In developing the proposed statewide goals and budgets in this Plan, the Program Administrators first submit an initial Plan on April 30, 2015, and file a final Plan with the Department by October 30, 2015. In advance of these filings, the Program Administrators engage in intensive internal and statewide discussions regarding savings goals, budgets, benefits, and incentives. The PAs also participate in Council meetings and workshops related to 2016-2018 planning and engage in discussion with the Council consultants, individual Councilors and other interested stakeholders. The savings goals and budgets presented on a statewide basis by the Program Administrators in this Plan represent the results of that collaborative process.

Following historic aggregate three-year savings levels, this Plan reflects the current market after years of energy efficiency in Massachusetts, the unique characteristics of each Program Administrator's service area, and the specific needs of its customers as appropriate for 2016-2018. The Program Administrators developed PA-specific filings that are consistent with, and flow out of, the overall goals developed in the statewide Plan review process.[112] Please see Section IV.A for the annual savings goals proposed by the Program Administrators in this Plan, on a per sector basis, by year and in total. Please also see Appendix C for statewide Energy Efficiency Data Tables for budgets, savings, benefits, and cost-effectiveness.

2. Environmental Benefits

The reduction in the amount of electricity and natural gas required to run the Commonwealth's economy through energy efficiency program development brings significant environmental benefits to Massachusetts and the region. Benefits include reduced air pollution, improved air quality and additional resource benefits, such as oil and water savings. Decreasing energy consumption results in less demand for energy from fossil fuel power plants and natural gas pipelines. Reduced plant operating time can lessen air pollutants and greenhouse gas emissions.

Generating electricity or heat from non-renewable fossil fuels (*e.g.*, coal, oil, or natural gas) produces nitrogen and sulfur oxides - two of the six "criteria pollutants" defined by the Clean Air Act and identified as air quality indicators by the U.S. Environmental Protection Agency. Nitrogen oxides are precursors to ozone, a primary component of summer smog and exacerbate public health problems, such as asthma, and contribute to acid rain. Reducing the amount of fossil fuel needed to operate our homes and businesses through the adoption of energy efficiency improvements reduces these impacts both in Massachusetts and in neighboring states. One particularly impactful measure is the conversion of customers from old, often oil-fired, heating equipment to new, high-efficiency units, which can significantly reduce local pollution levels.

Water resources also benefit from energy efficiency. With fewer pollutants in the air and acid rain abatement, fresh water resources have less opportunity for particulate contamination or potential acidification. Additionally, some energy efficiency measures offer the co-benefit of providing water savings. For example, aerators reduce the volume of water flowing from a faucet, thus lessening the energy needed to heat the smaller volume of water. Reducing water

112 Program Administrators are not required to make all changes or revisions recommended by the Council in their October filing to the Department. G.L. c. 25, § 21(c)-(d)(1). Each Program Administrator supports the statewide Plan and their PA-specific filings are built upon and consistent with the statewide Plan and the best interests of their customers.

usage limits stress on reservoirs and water treatment facilities. The 2016-2018 Plan projects saving over 470 million gallons of water annually and approximately 4 billion gallons over the lifetime of installed measures.

In addition to providing cleaner air and water for Massachusetts, the 2016-2018 Plan's programs provide climate benefits in the form of reduced emissions of nitrogen oxide, sulfur dioxide and carbon dioxide. Information on the reductions in these emissions from energy efficiency is available on the GHG Reductions tab of Mass Save Data, the PAs' energy efficiency database. This tab can be accessed at http://www.masssavedata.com/Public/GreenHouseGases.aspx. The GHG Reductions tab allows for conversions between metric and short tons and displays conversion factors and sources.

Collectively, the programs contained in the 2016-2018 Plan are expected to provide three-year adjusted gross electric annual savings of 4,512,325 MWh, and three-year adjusted gross gas annual savings of 61,280,092 therms. Over the three years of this Plan, these savings equate to the following:

2016-2018 Annual Savings	
	**410,162**
Number of cars removed from the road through electric and gas savings	
	**601,643**
Number of homes powered through electric savings	
	**64,710**
Number of homes heated through gas savings	

Information from the table above will be available on Mass Save Data for 2016-2018. This information is currently available for 2010-2015.

For reference, as of 2010, there were 272,481 homes in Boston and 2,802,254 homes in Massachusetts. Using the combined number of homes powered through electric and gas savings, the 2016-2018 Plan allows the state to power 24 percent of its homes through energy savings.

Investment in energy efficiency is recognized as the most effective cost-containment and climate protection tool of the Commonwealth under climate cap and trade programs such as RGGI, other climate regulation such as the Clean Power Plan proposed by the Environmental Protection Agency, and the Commonwealth's climate change initiatives under the GWSA. Energy efficiency lowers energy consumption, which reduces GHG emissions and the demand for allowances. The result is a lower price for carbon allowances and lower overall cost of the cap and trade program.

3. Net Benefits and Cost-Effectiveness

a. Introduction

The Program Administrators have projected the expected benefits and costs associated with this statewide 2016-2018 Plan consistent with the requirements of the Guidelines and D.P.U. 08-50-A, in which the Department reaffirmed that "the Total Resource Cost test is the appropriate test for evaluation of the cost-effectiveness of ratepayer-funded energy efficiency programs." D.P.U. 08-50-A at 14. To conduct the TRC test, the Program Administrators routinely update their benefit/cost screening models to reflect new assumptions relating to program costs and benefits, the discount rate, the general rate of inflation, and avoided costs. In general, the benefit categories in the TRC test include the value of energy savings, gas and electric system benefits, and other measurable benefits (*e.g.*, participant resource benefits, participant non-resource benefits and benefits due to measurable market effects).

Costs included in the TRC test include all PA costs and program participant costs. PA costs include program implementation expenses, evaluation costs, proposed performance incentives, and tax liability for performance incentives. Program-participant costs include initial costs incurred by customers as a result of their participation in the program.

The benefit/cost screening model uses this data to calculate the present value of the program benefits and costs, and then calculates ratios of these values to produce BCRs for the TRC test. The present value of costs and benefits is calculated over the expected duration of the useful life of the measures installed in the program.

The tables below summarize the expected benefits, costs, and BCRs at the sector level for the portfolio of programs the Program Administrators propose to implement over the three-year term.

STATEWIDE ELECTRIC BENEFIT RATIOS	2016	2017	2018	2016-2018
Residential	2.37	2.33	2.30	2.34
Low-Income	1.65	1.68	1.73	1.68
Commercial & Industrial	2.58	2.59	2.63	2.60
Total	2.42	2.41	2.43	2.42

STATEWIDE GAS BENEFIT RATIOS	2016	2017	2018	2016-2018
Residential	1.63	1.62	1.63	1.63
Low-Income	1.71	1.74	1.77	1.74
Commercial & Industrial	2.61	2.58	2.56	2.58
Total	1.85	1.84	1.85	1.85

b. Avoided Energy Supply Cost Study

To develop avoided supply costs, the PAs participate in the AESC study process, which is a well-established regional and collaborative process.[113] The AESC study determines projections of marginal energy supply costs that will be avoided due to reductions in the use of electricity, natural gas, and other fuels resulting from energy efficiency programs. The AESC study is prepared for the AESC study group, which is comprised of the PAs, as well as utilities throughout New England and other interested non-utility parties. Historically, the AESC study has been developed every two years, but beginning with the 2015 AESC, will move to a three-year cycle.

In order to inform the initial draft of the 2016-2018 Plan, which must be filed with the Council by April 30, 2015, the 2015 AESC study was completed on March 27, 2015, as revised on April 3, 2015. Unlike previous studies, the 2015 AESC study is designed to be updated in synch with the three-year planning cycle of energy efficiency plans required by the GCA. A three-year cycle for the AESC study is consistent with the Department's focus on the three-year planning and performance construct envisioned by the GCA. D.P.U. 11-120-A, Phase II at 2.

The AESC study provides projections of avoided costs of energy in each New England state for a hypothetical future, the "Base Case," in which no new energy efficiency programs are implemented in New England. The 2015 AESC study provides an updated assessment of avoided electricity and natural gas costs using a model that simulates the operation of the New England wholesale energy and capacity markets in an iterative, integrated manner. In the 2015 AESC, there were several factors that changed significantly from the previous study. One significant difference from the 2013 AESC is an increase in the quantity of shale gas production at correspondingly low production costs, resulting in lower avoided gas supply and electric

113 While the PAs are aware of, and have participated at some varying levels in, the ongoing avoided cost of carbon proceeding currently before the Department in D.P.U. 14-86, no final determinations were made in that docket in time to instruct the development of the 2015 AESC study for this Plan.

energy costs. Estimates of electricity costs, natural gas costs, and cross-fuel Demand Reduction Induced Price Effects ("DRIPE") are all lower than estimated in the 2013 Study as well. However, the avoided costs for electric capacity are higher than in the 2013 Study due to changes in generation retirements and costs of new capacity additions. The reduced avoided costs in the 2015 AESC tend to decrease benefits and cost-effectiveness relative to the previous Plan term, making goals harder to achieve. The 2015 AESC is available at Appendix J.

c. *Net Savings*

i. Non-Energy Impacts

A Non-Energy Impact ("NEI") is an additional benefit (positive or negative) for participants in energy efficiency beyond the energy savings gained from installing energy efficient measures. NEIs include benefits such as reduced costs for operation and maintenance associated with efficient equipment or practices, or reduced environmental and safety costs. In the 2010-2012 Orders, the Department instructed the PAs to undertake studies that evaluate NEIs to ensure that updated and reliable values would be developed in time for inclusion in the cost-effectiveness analyses in their subsequent Three-Year Plans. See 2010-2012 Electric Order at 130-131 (called non electric benefits); 2010-2012 Gas Order at 121 (and 48-51) (called non-resource benefits). In the 2013-2015 Order, the Department stated that NEIs are "a well established component of the program cost-effectiveness analyses conducted by the Program Administrators" and noted that many of the NEIs included in the 2013-2015 Plan were the result of studies that the Program Administrators took to comply with this directive. 2013-2015 Order at 61. Finding that the benefits of the NEIs are quantifiable and flow to Massachusetts ratepayers, subject to a few exceptions, the Department approved the NEIs as proposed in the Three-Year Plan. In addition to Department Orders, the Guidelines also specifically state that non-resource benefits should be included in cost-effectiveness. Guidelines at §3.4.4.1, §3.4.4.2.

In accordance with prior Orders and the Guidelines, the PAs have included NEIs in this Plan that are supported by evaluation studies. The PAs have included the benefits established in these studies in the benefit cost testing that determined program cost-effectiveness.

ii. Market Effects

The PAs have sought to study both direct and indirect effects of the energy efficiency programs. Market effects studies look at whether the energy efficiency programs have successfully reduced market barriers and transformed markets. Market effects capture a moment in time. To quantify program impacts that have translated to market effects, first a baseline must be established, and then changes from the assumed baseline can be determined to be program induced. Only then can the market effects be counted in net savings. In this Plan, the PAs have specifically studied market effects related to the Residential New Construction Program and Commercial LED impacts. The PAs note that the methods used to study market effects and claim benefits do not imply that those values can be counted in perpetuity. Current values from market effects may change due to non-program induced shifts in the market, which may be applicable to additional market effects that are determined in the future.

4. Additional Benefits

a. Reduction in Peak Load

Energy efficiency efforts often provide capacity savings in addition to energy savings. These capacity savings and benefits are reflected under the cost-effectiveness screening efforts described in Section III.G.

b. Economic Development and Job Growth/Retention

Another positive effect of the energy efficiency programs in Massachusetts has been job growth. The Massachusetts Clean Energy Center ("MassCEC") has tracked the growth of the Commonwealth's clean energy economy on an annual basis. The 2014 Clean Energy Industry Report looks at Massachusetts-wide employment of people in a broad category of energy efficiency.[114] MassCEC's most recent report from 2014 provides the following information on full time employees ("FTE") in energy efficiency related fields.

Energy Efficiency Technology	**FTE Estimate**
HVAC and Building Controls	17,764
Lighting	10,937
Energy Efficient Appliances	10,318
Energy Efficient Processes and Machinery	5,799
Weatherization Services	5,762
Energy Efficient Building Materials	5,656
Other	3,115
Smart Grid	1,868
Water and Wastewater Technologies	1,535
Demand Response Services	1,256
Energy Storage	1,173

114 http://www.masscec.com/content/2014-clean-energy-industry-report

MassCEC developed these employment numbers through an in-depth survey effort based on the following methodology:

- The primary data included in this study are derived from a comprehensive survey of business establishments in Massachusetts.
- Surveys were administered online and by telephone to a list of known employers as well as to a representative, clustered sample of companies from the North American Industry Classification System ("NAICS") identified by the Bureau of Labor Statistics ("BLS") and BW Research Partnership.
- The research team placed 36,782 telephone calls and sent 3,793 emails to employers.
- The survey effort, with a combined margin of error of approximately +/-2.23 percent at a 95 percent confidence interval, yielded 1,891 survey responses.
- Survey respondents were asked to select the technology to which their firm's work is most closely associated, from a list including renewable energy, energy efficiency, alternative transportation, or greenhouse gas emissions accounting and sequestration.

In addition to the MassCEC, the Northeast Energy Efficiency Council ("NEEC") issued a report on the impact of the GCA on the energy efficiency industry in Massachusetts. The report states:

> Since the passage of the [GCA], Massachusetts has achieved nation-leading energy efficiency success. . . [E]ach year of program activity produce lifetime savings of more than 13 million MWh of electricity and 300 million therms of natural gas. . . The engine behind this achievement has been the state's energy efficiency industry: small, medium, and large companies that deliver, or support the delivery of, energy efficiency-related products and services. Since 2008, this industry has evolved from a small circle of specialty firms to an open, market-driven ecosystem of companies that compete with each other for a piece of the action. . . While program funding increased 335% from 2008-2014, the number of companies participating in the programs increased by even more. We identified more than 7,000 companies participating in the Massachusetts energy efficiency industry today. What's more, the majority of those companies are not energy efficiency-focused companies, but rather are companies that have added energy efficiency to an existing line of business.[115]

115 *An Industry Transformed: The Impact of the Green Communities Act of 2008 on the Energy Efficiency Industry in Massachusetts*, Northeast Energy Efficiency Council (October 2015), available at: http://www.neec.org/wp-content/uploads/2015/10/NEEC_IndustryReport_102715.pdf

c. Supporting the Global Warming Solutions Act ("GWSA")

i. Energy Efficiency Under the GCA Supports the Goals of GWSA

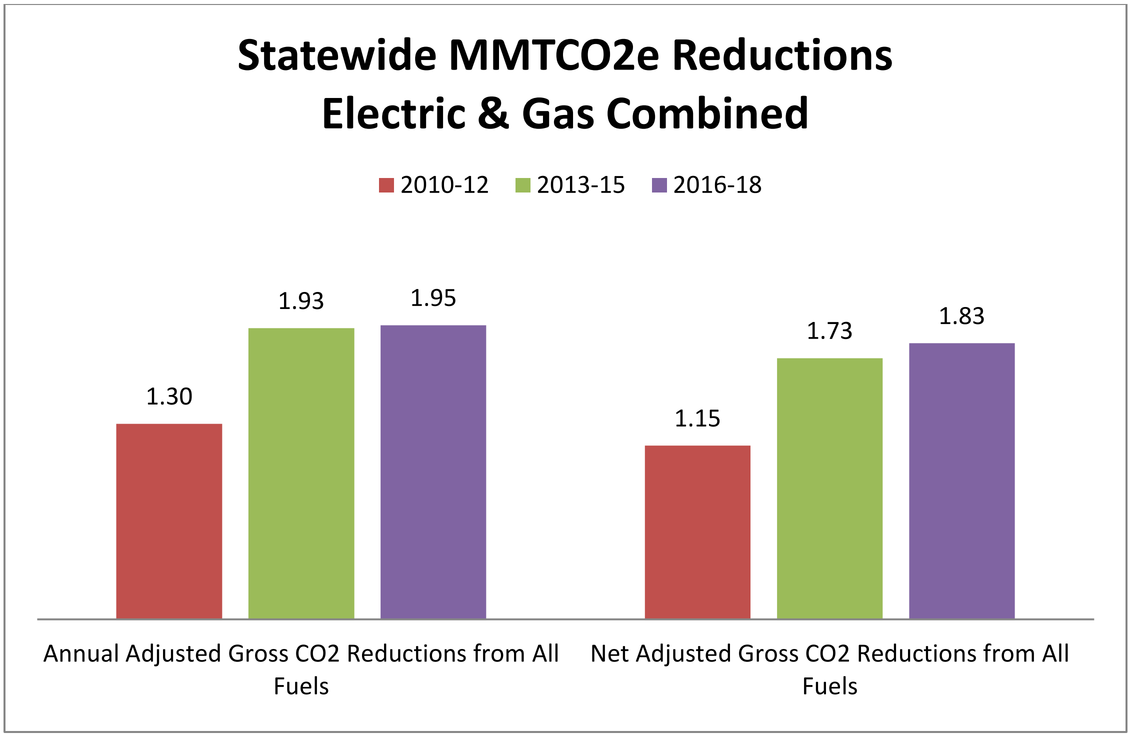
One purpose of the Global Warming Solutions Act ("GWSA") is to reduce Greenhouse Gas ("GHG") emissions within Massachusetts 25 percent below 1990 levels by 2020.[116] Energy efficiency programs implemented pursuant to the Green Communities Act ("GCA") support the goals of the GSWA because reduction of GHG emissions is an important result of the programs. As discussed further below, by delivering on the goals in their Three-Year Plans, the PAs are materially contributing to GHG emissions reductions in the Commonwealth, and each Three-Year Plan to date has reduced more GHG emissions than the one before it. Although the GWSA does not govern the PAs,[117] the PAs remain committed to achieving reductions in GHG emissions through implementation of their Three-Year Plans.

ii. More GHG Reductions Than Prior Plans

The PAs are substantially contributing to GHG emissions reductions in the Commonwealth. In fact, as demonstrated in the graph below, the 2016-2018 Plan will deliver more reductions in GHG emissions than prior plans.

116 The GWSA, which was enacted in 2008, identifies broad statewide GHG reduction goals for the Commonwealth to achieve. G.L. c. 21N. The GWSA requires DEP to "monitor and regulate emissions of greenhouse gases *with the goal of reducing those emissions*." G.L. c. 21N, § 2(a) (emphasis added). The GWSA seeks to encourage early action to reduce GHG emissions. See G.L. c. 21N, § 3(b) (requiring EEA to develop plans to meet limits; § 5(i) (requiring EEA to report on reduction measures, their benefits and whether they encourage early action).

117 The GCA governs the PAs' energy efficiency efforts and requires them to seek to acquire all available cost-effective energy efficiency and demand management resources. The specified purpose of energy efficiency under the GCA is to encourage the efficient use of energy. St. 2008, c. 169 § 11; G. L. c. 164, § 1. The GWSA does not supersede or abrogate the Department's regulatory authority or the Council's role with respect to Three-Year Plans under the GCA. For a more detailed discussion of these issues, please refer to the initial and reply briefs filed by PAs in Method for Calculating Avoided Costs of Complying with Global Warming Solutions Act, D.P.U. 14-86, which is pending before the Department.



*MMTCO$_2$e = million metric tons of carbon dioxide equivalents

To further demonstrate the contribution of energy efficiency to the Commonwealth's GWSA goals over time, the PAs provide a table below that is based upon adjusted gross annual savings. This table is provided to depict how energy efficiency contributes to reductions in GHG emissions in a snapshot annual view. Please note that the GHG emissions calculations for the electric PAs take into account non-electric savings, such as gas and oil savings in addition to electric savings. Similarly, the GHG emissions calculations for the gas PAs take into account non-gas savings such as electric savings that are not claimed by the electric PAs.

Adjusted gross savings are the actual savings achieved due to the installation of energy efficiency measures, as adjusted by impact factors but without factors related to program attribution. Attribution factors determine whether savings are attributable to the efforts of the PA programs pursuant to their Three-Year Plans and in compliance with their GCA mandate to reduce energy use. Attribution looks at free-ridership (*i.e.*, someone would have implemented energy efficiency measures without the program) and spillover factors (i.e., savings resulting from program existence outside of program efforts). While these factors are appropriate for use with the GCA, which seeks to determine which savings resulted from PA program efforts (net savings), the GWSA seeks to quantify all energy efficiency GHG reductions without regard to PA program attribution. Consequently, calculating GHG reductions based upon net savings would undervalue the contribution of energy efficiency to GHG emission reductions.[118]

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118 Adjusted gross savings represent reliable energy efficiency savings that are used for other reporting purposes but not for the GCA. For example, ISO-NE relies on adjusted gross savings for all capacity and reliability purposes related to competitive wholesale energy markets.

Finally, the PAs used the most current emission factors provided by DEP to convert savings to GHG emission reductions. These factors are available on the GHG Reductions tab of Mass Save Data, the PAs' energy efficiency database. To access the factors, go to http://www.masssavedata.com/Public/GreenHouseGases.aspx and look for "Click here to view Emissions Factors used" in the table labeled "Total CO2 Reductions from All Fuels." The PAs used 2014 factors to estimate the reductions for years 2015-2018. The PAs recognize that these are backward-looking factors and that there is ongoing work related to emissions factors. When more accurate forward-looking factors become available, the PAs will apply them for reporting and on Mass Save Data.

Adjusted Gross Annual Savings and CO2 Reductions (2010 - 2018)				
Year	**Electric Energy Savings (MWh)**	**Gas Savings (Therms)**	**Oil Savings (MMBTU)**	**Annual CO2 Reductions (Short Tons)**
2010	631,568	11,162,323	208,500	363,613
2011	891,117	10,407,225	335,727	461,667
2012	1,226,549	29,562,657	396,068	679,035
2013	1,300,824	26,301,689	433,180	699,358
2014	1,490,550	28,277,668	454,099	787,068
2015	1,450,312	21,225,598	370,033	723,237
2016	1,484,266	22,021,736	42,636	714,802
2017	1,502,951	20,571,227	70,735	715,917
2018	1,525,109	18,687,129	111,489	716,880
Total (2010 - 2018)	**11,503,246**	**188,217,252**	**2,422,467**	**5,861,578**

To place these reductions in context, the PAs have converted their reductions in GHG emissions from 2010-2018 into the equivalent number of (1) cars removed from the road through electric and gas savings; (2) homes powered through electric savings; and (3) homes heated through gas savings.

2010-2018 Annual Savings	
	**1,119,481**
Number of cars removed from the road through electric and gas savings	
	**1,533,766**
Number of homes powered through electric savings	
	**198,751**
Number of homes heated through gas savings	

In making these calculations, the PAs used recent GHG conversion factors from the Energy Information Administration and/or the federal Environmental Protection Agency's Greenhouse Gas Equivalencies. Please note that the information contained in the tables and the conversions to cars and homes is available for 2010-2015 on Mass Save Data at http://www.masssavedata.com/Public/GreenHouseGases.aspx. Data for 2016-2018 will be available after the October 30 filing with the Department. The GHG Reductions tab allows for conversions between metric and short tons and displays both the emissions and conversion factors.

iii. EM&V Study to Fully Quantify Energy Impacts that Result in Reductions in GHG Emissions and Environmental Benefits

As discussed above, energy efficiency under the GCA supports the goals of the GWSA. The plain language of the GWSA makes it clear that all GHG emissions reductions that "are real, permanent, quantifiable, verifiable and enforceable" should be counted.[119] The PAs can, to a large extent, reliably quantify how energy efficiency savings as reported under the GCA contribute to GHG reductions. They are concerned, however, that their quantification does not account for all verifiable GHG reductions resulting from program activity. For example, while the PAs quantify the incremental savings that result from incenting a natural gas customer to purchase a new high-efficiency furnace rather than a new standard-efficiency furnace, the PAs do not quantify the energy savings or emissions reductions related to that customer transitioning from their old furnace to a new furnace. And in the case where the old furnace was oil fired

119 G.L. c. 21N, § 5(ix); see also G.L. c. 21N, § 2(a)(6) (ensure rigorous and consistent accounting of emissions); G.L. c. 21N, § 4(d) (use "the best available economic models, emissions estimation techniques and other scientific methods").

rather than gas, the emissions savings are even higher and are not counted. Quantifying environmental benefits is a specific goal of the GCA and an important goal of the Commonwealth. Accordingly, the PAs will explore efforts through EM&V activities, with the support of the Council's independent EM&V experts and planning consultants, as well as DEP and DOER, to better quantify both the energy impacts used to determine climate and air quality benefits, and the estimates of other environmental benefits.

The implication for PA research differs depending on the scale at which EE impacts would be analyzed. For example, a gross savings analysis may look at the Gas Heating and Cooling program. While the PAs quantify the incremental savings that result from incenting a natural gas customer to purchase a new high-efficiency furnace rather than a new standard-efficiency furnace, the PAs do not quantify the emissions reductions related to that customer transitioning from their old oil furnace to a new gas furnace. While those savings may or may not be attributable to energy efficiency efforts, the savings are not being counted in other areas and estimating the savings can help better quantify the impact of the Massachusetts energy efficiency efforts on reduction of GHG emissions.

If a larger scale view is preferred, other research, such as investigating impacts from a top-down[120] approach, may be needed. In addition to the question of scale, research may need to extend beyond the traditional bounds of the utility system. Quantifying environmental benefits is a specific goal of the GCA and an important goal of the Commonwealth. This study could allow the Commonwealth to reassess the accounting of the GHG emission reductions attributable to energy efficiency. The PAs propose to complete this study before the filing of their 2019-2021 Plan.

iv. Conclusion

In sum, the PAs are proud to be material actors in helping the Commonwealth achieve its GHG emission reduction goals, and to be proposing savings goal for the 2016-2018 Plan that will support the Commonwealth's obligations under the GWSA. To better understand the GHG benefits that result from energy efficiency, the PAs propose to quantify the full suite of GHG reductions and benefits through an EM&V study to be completed before the next three-year plan. The PAs expect that this study will identify additional GHG emissions reductions that result from energy efficiency. In the meantime, the PAs have developed and launched a GHG Reductions tab on Mass Save Data, which provides transparency into the PAs' current calculations as to the effect of energy efficiency on GHG emissions reductions in Massachusetts.

[120] Top-Down methods employ aggregate consumption and macro-economic data to measure reductions in energy use resulting from energy efficiency efforts.

V. GREEN COMMUNITIES ACT REQUIREMENTS AND GOALS

A. <u>**All Cost-Effective or Less Expensive than Supply Resources**</u>

1. <u>Introduction</u>

Pursuant to G.L. c. 25, § 21 (b)(1), the 2016-2018 Plan seeks to capture all available cost-effective energy efficiency for the three-year term beginning January 1, 2016, taking into account many requisite competing considerations, including, but not limited to, bill impacts, cost efficiency, integrated program delivery, economic and environmental benefits, and the need for sustainability. The GCA does not define "all available" cost-effective energy efficiency, and thus developing related values requires a reasonable level of judgment. There is no single study or planning tool that can reliably set forth such a value. Rather, a multifaceted approach is necessarily employed and multiple reference points are considered. As discussed in Section II.D.1, the Department requires the PAs to consider and strike an appropriate balance among six factors in order to determine a reasonable pace for the sustained acquisition of all cost-effective energy efficiency.

In determining the level of savings for 2016-2018 necessary to satisfy the GCA's mandate and the Department's directives, the Program Administrators considered and weighed multiple factors, including: (1) the plain language of the GCA; (2) the input and recommendations of the Council and other stakeholders; (3) the Department's energy efficiency Orders, including those (a) approving previous Three-Year Plans, Mid-Term Modifications ("MTMs") and Annual Reports; (b) in D.P.U. 08-50-A and D.P.U. 08-50-D (bill impact considerations); (c) in D.P.U. 11-120-A Phase I (net savings and application of evaluation results) and D.P.U. 11-120-A, Phase II (revised Guidelines); and (d) in D.P.U. 13-67 (performance metrics); (4) assessments of all available cost-effective energy efficiency; (5) multiple studies and reports, including extensive EM&V results; and (6) the PAs' experience in implementing nationally-recognized energy efficiency programs for over three decades. The Program Administrators met collaboratively on a frequent basis to determine the appropriate savings goals and budgets to propose in this Plan. The Program Administrators also participated in the Council's planning activities and engaged in numerous discussions with Councilors, their Consultants, and other stakeholders.

2. <u>Experience in the Field</u>

First and foremost, the Plan has been developed based on the in-depth experience of the Program Administrators in designing and implementing energy efficiency programs over more than 30 years, and, more specifically, in the course of implementing the Three-Year Plans for the periods 2010-2012 and 2013-2015. This experience includes (1) understanding of the customers' circumstances and the cost of implementing aggressive programs over a sustained period and (2) knowledge that the PAs can successfully deliver impressive savings levels in the field. This experience also informs the PAs that as energy efficiency efforts yielding high savings become more difficult to identify and achieve, and as market penetration increases, there will be challenges in achieving additional savings. Importantly, the Program Administrators are factoring in upward pressures on the cost to achieve energy efficiency savings, especially as EM&V results, the level of CHP projects currently foreseen, and increased efficiency codes and standards make the achievement of incremental efficiencies through PA-sponsored programs more difficult. In short, the PAs' experience in the field provides valuable lessons that inform this planning process in a unique and important way.

3. Review of EM&V Results

Working together and with the Council, the Program Administrators have undertaken extensive EM&V efforts designed to ensure accuracy and accountability in program planning and implementation and to guide the PAs as they focus on improving energy efficiency program efforts. Section III.E of the 2016-2018 Plan includes information regarding the comprehensive EM&V efforts that have been undertaken to date and which have informed program design and savings goals for 2016-2018. EM&V efforts will continue throughout the term of the 2016-2018 Plan, pursuant to the EM&V strategic plan. EM&V results have been used by the Program Administrators to more accurately forecast the actual savings resulting from their energy efficiency activities, in particular, net savings resulting from these activities. EM&V results indicate that strong savings are occurring as a result of the Program Administrators' efforts, but that savings, in particular for several gas programs, are not as high as originally forecasted. This is an important factor in looking to establish goals for 2016 -2018.

4. Potential Studies

a. Introduction

In the Department's Order in the 2013-2015 Plan proceeding, the Department directed "[t]he Program Administrators with an aggregate three-year savings goal of greater than 20 percent below the statewide three-year aggregate goal [to] conduct a study, either jointly or individually, during the upcoming three-year term to document the penetration of energy efficiency within its service territory and the remaining cost-effective energy efficiency opportunities available." 2013-2015 Energy Efficiency Plans, D.P.U. 12-100 through D.P.U. 12-111 at 18-19, 40 (2013). In compliance with this directive from the Department, The Berkshire Gas Company, Liberty Utilities, Unitil, and the Cape Light Compact each completed an assessment of the penetration of energy efficiency in their respective service territories and then used the results of that analysis to inform proposed savings goals and budgets in 2016-2018. In addition, although not directed by the Department to complete a potential study, National Grid completed an assessment of the remaining achievable electric and gas savings that could be secured in the C&I sector to help it to propose appropriate goals in that sector.

b. The Berkshire Gas Company, Liberty Utilities and Unitil

In 2014, Berkshire, Liberty, and Unitil (individually, "Company," collectively "Companies") each retained GDS Associates, Inc., to prepare Remaining Potential Assessments ("Assessments") in accordance with the 2013-2015 Order at 18-19, 40 (2013). The Department directed "[t]he Program Administrators with an aggregate three-year savings goal of greater than 20 percent below the statewide three-year aggregate goal [to] conduct a study, either jointly or individually, during the upcoming three-year term to document the penetration of energy efficiency within its service territory and the remaining cost-effective energy efficiency opportunities available." Id. at 18-19. The Companies also worked with the Council's consultants on the scope of these Assessments. GDS was tasked with performing a program-specific assessment focused on what each Company's current energy efficiency programs had achieved (penetration and savings to date) and what remaining opportunities could likely be achieved within each Company's programs over the 2016-2018 term. The Assessments are available at Appendix M.

In early February 2015, GDS delivered these Assessments to the Companies. The Assessments encompass the demographics, market conditions, and customer attitudes in each Company's service territory. The Assessments also provided Company-specific information regarding savings potential that each Company has used in conjunction with other planning tools to build ambitious and achievable cost-effective energy efficiency goals for the 2016-2018 timeframe. The Assessments were conducted over approximately six months and relied on primary research in the Companies' territories as well as a review of historical data (2013 data was the most recent data available at the time GDS performed its studies). The Assessments estimated remaining potential based on actual in-service territory baseline data collection (phone surveys and site visits) and review of participant and non-participant customer feedback, which revealed a broader assessment of potential that is not solely based on any single year's performance.

The Assessments looked at past performance to set minimum levels of participation that could be achieved over the 2016-2018 term. The high-case potential scenario does not include budget constraints on the part of either customers or the Companies, nor does it take into consideration any territory-specific economic conditions, customer behaviors (as measured by the telephone and in-person surveys), or any physical barriers to measure installation. In determining goals for 2016-2018, the Companies considered these penetration constraining elements as well as the bill impacts that are likely to occur given the funding needed to reach the proposed level of savings.

While the Companies considered 2014 performance in developing goals for 2016-2018, they do not view 2014 performance as the only predictor of future potential. The tendency on the part of the Companies to experience swings in performance from one year to the next has been acknowledged in multiple evaluations, and should be taken into account when making projections for the 2016-2018 cycle. Using results from any given year in isolation, including the associated single-year payback, or cost to achieve savings, cannot in isolation produce a reliable projection of future potential; it is not possible to draw a line estimating any trajectory with a single data point. While considering two or more data points in relation to each other mathematically allows one to estimate a trend, the actual variance in performance is influenced by far too many non-linear variables to produce a reliable forecast of future performance.

c. Cape Light Compact

Consistent with the Department's directive on potential studies, the Compact retained Opinion Dynamics Corporation and Dunsky Energy Consulting to prepare the 2014 Cape Light Compact Penetration, Potential, and Program Opportunity Study (the "Study"). See 2013-2015 Order at 18-19. Prior to finalizing the scope of the Study, the Compact requested that the Council's consultants provide feedback on the proposed scope.

The goal of the Study was to determine the remaining achievable potential from electric measures among residential, low-income, and C&I customers for the six-year period 2016-2021 and to inform Compact's program planning efforts. The results of the Study are based on extensive primary and secondary data collection. The primary data collection activities for the residential and low-income sectors included a mail survey with 2,785 customers, in-home visits at 169 homes, and a telephone survey with 144 customers. The primary data collection activities for the commercial & industrial sector included a telephone survey with 448 customers and on-site visits at 150 facilities. In-depth interviews with a small number of local contractors to inform assumptions for the potential model were also conducted.

The Study identifies the average achievable energy savings representing 1.98 percent of Compact annual sales for the six-year Study period. To achieve the Study savings, it would cost the Compact $220 million (incentive and non-incentive program costs), an average of $37 million per year. The total cost (including the participants' net cost) amounts to $246 million for the six-year period. Total cost to achieve increases over the 2013-2015 planning period, however, all of the 2016-2021 proposed investments are cost-effective, with a Total Resource Cost ratio of 3.6 and a Program Administrator Cost ratio of 2.8. For the 2016-2018 Plan, the Compact Governing Board is considering a higher goal than the 1.98 percent of sales because it is considering the adoption of several new measures that were not addressed as part of the Study.

The Study also affirms the unique service territory of the Compact relative to serving seasonal residential and seasonal commercial customers. Serving seasonal residential and commercial customers is challenging and may require the Compact to consider exploring adjustments to the statewide benefits and savings assumptions.

The Study is available at Appendix M.

d. National Grid

In advance of the 2016-2018 Plan, National Grid engaged DNV GL to assess the potential for electric and natural gas energy and electric demand savings from company-sponsored commercial and industrial demand side management (DSM) programs. The method used for estimating potential is a "bottom-up" approach, in which energy efficiency costs and savings are assessed at the customer segment and energy efficiency measure level. For cost-effective measures (based on the Total Resource Cost (TRC) test), achievable savings potential is estimated as a function of measure economics, rebate levels, and program marketing and education efforts. The modeling approach was implemented using a National Grid specific Excel model which allows for efficient integration of large quantities of measure, building, and economic data to determine energy efficiency potential. The Company focused explicitly on the C&I sector because the Company had greater uncertainty about remaining potential in this sector due to the maturity of the Company's programs.

In order to conduct its assessment of technical potential, DNV GL used National Grid specific data as inputs to its model. The model was populated with data collected from National Grid customers through Wave 1 and a portion of Wave 2 of the Massachusetts Existing Building Market Characterization C&I Customer On-site Assessments (study to be completed in 2016), previous state-wide and National Grid specific evaluation efforts, the Massachusetts Technical

Reference Manual, National Grid's internal documents and tracking data and other secondary sources.

In this study, DNV GL looked at the potential available under three scenarios - a business-as-usual (BAU) scenario where overall incentives levels paid in 2015 are used going forward as well as two additional funding scenarios: 25 percent increase over those BAU levels (25 Percent Plus scenario) and a 75 percent increase (75 Percent Plus scenario). DNV GL first provided preliminary results in May 2015. DNV GL revised these estimates in August 2015, taking into account information from completing additional site visits, revisions to the model to more closely represent the Company's programs, and updates to the savings and costs assumptions. DNV GL provided its final report to the Company on October 26, 2015. While the point estimates of achievable potential changed slightly between the drafts, two key factors that impacted the results of DNV GL's assessment of C&I technical potential emerged.

1. The maturity of National Grid's energy efficiency programs causes awareness among the participant population to be already quite high. Put more simply, much of the "low hanging fruit" is gone in National Grid's territory, while simultaneously there is not an anticipated disruptive change (either in new technology or program design) during the 2016-2018 time frame.[121]

2. The saturation of retrofit upgrades during earlier years of the model result in a noted decline over time in the annual energy savings. Put another way, as retrofits are completed, there are fewer opportunities going forward.[122]

The study identified the average achievable energy savings representing cumulative savings of six to seven percent of National Grid's 2018 C&I electric annual sales (averaging between 2 and 2.3 percent each year) and cumulative savings of two to three percent of National Grid's 2018 C&I gas annual sales (averaging between 0.7 and 1 percent in each year) for the 2016-2018 Plan term.

The Company used the results of this potential analysis as one of many pieces to help inform National Grid's proposed savings goals. The Company used additional information as well, including, but not limited to, reviewing historical performance, intelligence from field personnel, savings attributable to measures not included in the scope of this study (*i.e.*, CHP), and expectations for new technologies to become available and to be cost-effective. Taking these additional factors into account, the Company has proposed savings goals higher than the average results from the potential study, at 2.35 percent of annual sales and 0.90 percent of annual sales for its C&I electric and gas sectors, respectively.

The potential assessed by DNV GL is consistent with other technical potential studies in areas with mature energy efficiency programs, as shown in the table below.

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121 *National Grid Massachusetts Energy Efficiency Potential Study***,** DNV GL, October 2015, p.14

122 *National Grid Massachusetts Energy Efficiency Potential Study***,** DNV GL, October 2015, p.14

10-Year Achievable Scenarios (percent of base) from other recent Potential Studies

Study	BAU	Low-Case	High-Case
Electric Results			
National Grid 2015 Potential Study	13%	14%	16%
CPUC 2015 Potential Study[123]	9%	NA	NA
Vermont Public Service 2013 Potential Study[124]	NA	NA	19%
Xcel Energy 2012 Potential Study[125]	9%	10%	11%
Idaho Power 2012 Potential Study (Comm'l)[126]	9%	NA	NA
Idaho Power 2012 Potential Study (Ind'l)[127]	9%	NA	NA
Natural Gas Results			
National Grid 2015 Potential Study	5%	6%	7%
CPUC 2015 Potential Study[128]	3%	NA	NA
Xcel Colorado DSM Market Potential (Gas results)[129]	NA	3%	7%

For the complete report provided by DNV GL, please see Appendix M.

5. Council Coordination

The Program Administrators have also considered presentations at Council meetings by the Councilors, their consultants, industry stakeholders and the general public. The level of interest and commitment evidenced by these presentations affirms that opportunities for energy efficiency remain in Massachusetts because its citizens embrace a culture of energy efficiency

123 *Energy Efficiency Potential and Goals Study for 2015 and Beyond, Stage 1 Public Draft Report.* Navigant Consulting May 2015. http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Energy+Efficiency+Goals+and+Potential+Studies.htm

124 *2013 Vermont Energy Efficiency Potential Study Update, Final Report.* GDS Associates, Inc., March 2014. http://publicservice.vermont.gov/sites/psd/files/Topics/Energy_Efficiency/2013%20VT%20Energy%20Efficiency%20Potential%20Study%20Update_FINAL_03-28-2014.pdf

125 *Xcel Energy Minnesota DSM Market Potential Assessment, Final Report.* KEMA, Inc., April 2012. http://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/MN-DSM/MN-DSM-Market-Potential-Assessment-Vol-1.pdf

126 *Idaho Power Energy Efficiency Potential Study,* EnerNOC, February 2012. https://www.idahopower.com/pdfs/EnergyEfficiency/Reports/2012PotentialStudyReport.pdf

127 Ibid.

128 *Energy Efficiency Potential and Goals Study for 2015 and Beyond, Stage 1 Public Draft Report.* Navigant Consulting May 2015. http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Energy+Efficiency+Goals+and+Potential+Studies.htm

129 *Colorado DSM Market Potential Assessment.* Kema Consulting March 2010. http://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/CODSM-Report.pdf

and sustainability. Presentations and comments at Council meetings have suggested, among other things, program design enhancements to target and achieve new savings in 2016-2018.

As discussed in Section II.D.2, the PAs were active and engaged participants in the Council planning process and have worked collaboratively with the Council and its consultants in the development of the 2016-2018 Plan. The Council conducted a number of sector-related workshops, facilitated by Raab Associates, Ltd., to assist in the development of the 2016-2018 Plan. The PAs were active and engaged partners in the development of meeting materials and in the workshops. In February and March 2015, there were three C&I workshops, three residential workshops and one multi-family/low-income workshop. In June 2015, there was one residential/low-income workshop and one C&I workshop.

As discussed in Section II.D.2, the PAs have carefully reviewed the Council's priorities and resolutions that relate to the development of the 2016-2018 Plan. The PAs appreciate the Council's thoughtful feedback on the April plan and their participation in the workshops and planning process. Together with the Council's input,[130] the PAs have developed comprehensive and innovative program designs that they believe will continue to set the standard for the rest of the nation. For ease of reference please refer to the following matrices responding to the Council's recommendations: Appendix F (matrix dated May 25, 2015 responsive to the 150 recommendations contained in the Council's March 31, 2015 Resolution); Appendix H (matrix dated September 23, 2015 responsive to the over 100 recommendations in the Council's July 21, 2015 Resolution). The PAs appreciate working with the Council in a collaborative and productive manner to develop energy efficiency programs for customers that will continue to deliver historic and nation leading savings and benefits.

6. Stakeholder Engagement

The PAs interact with a broad range of stakeholders on a regular basis in order to capture all good ideas and optimize program development and delivery. The breadth of stakeholders with whom the PAs interact on a regular basis spans the entire supply chain, including manufacturers, equipment distributors, contractors and service providers, trade associations, policy makers, community advocates, civic leaders, and customers. Each of these groups, individually and collectively, has an interest in, and is affected by, the energy efficiency plans designed and implemented by the PAs. The legislature recognized this significant scope of interested parties when it created the Council, the formal entity responsible for stakeholder input. The PAs recognize that both formal and informal interactions can yield program benefits, and therefore participate in and lead a multitude of activities and forums to foster this interaction, including: Council meetings, subcommittees, and the workshops facilitated by Raab Associates, Ltd.; MTAC; establishing the Process for Managing Proposals by Stakeholders and Interested Parties; open house meetings for trade allies and vendors; PA speakers for trade associations and meetings; providing collateral materials for customer events; and various ad hoc discussions with Councilors, government agencies, trade groups, and stakeholders. Additionally, the PAs seek

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[130] The PAs have incorporated many but not all of the Council's recommendations for the 2016-2018 Plan. Each Resolution clearly stated they contained "recommendations," consistent with the Council's advisory role under the GCA, but they were not a consensus view of the Council. See Section I.F.2 and related footnotes.

and benefit from long term, close relationships with their customers, allowing for continual feedback and program refinement.

7. Consultant Assessment

In developing the 2016-2018 Plan, the Program Administrators reviewed analyses of the Council's consultants and worked collaboratively with them to narrow differences of opinion on the assessment of potential for 2016-2018. The PAs appreciate both the efforts of the consultants in analyzing the assessment of potential for 2016-2018 and their willingness to engage in collaborative and productive discussions to refine that assessment. As discussed above and in Section V.A, there are many factors to consider in determining goals, including: potential, costs, bill impacts, AESC study results, EM&V results, changing costs and baselines, new technologies, and performance incentives. These factors interrelate and should be considered together in iterative discussions and through a progressive refinement process.

The PAs specifically considered the following reports from the Council's consultants: (a) report dated March 5, 2015 and entitled "Preliminary Assessment of Potential for 2016-2018," which was presented at the March 10, 2015 Council meeting ("Preliminary Assessment"); (b) report dated April 30, 2015 and entitled "Draft 2016-2018 Energy Efficiency Plan," which was presented at the April 23, 2015 Council meeting ("Draft Plan Goals"); (c) report dated May 12, 2015 and entitled "Comparison of PA 2016-2018 Plan with Consultant Team Goal Framework Analysis, which was presented at the May 19, 2015 Council meeting ("Comparison"); and (d) report dated July 14, 2015 and entitled "2016-2018 Planning Assumptions for Key Driver Update – DRAFT," which was presented at the July 14, 2015 Council meeting ("Key Driver Update"). Having reviewed the consultants' analyses, the PAs provided comments on the written reports of the consultants.

Over the course of the summer and into early fall 2015, the PAs and the consulting team engaged in continued and extensive collaborative discussions, with all parties looking to understand positions better, review data, and narrow gaps in respective analyses of key drivers of costs and savings. In large part, these collaborative efforts helped the PAs, EEA, DOER, and the Attorney General come to common understandings that resulted in the Term Sheet described in this Plan and set forth in Appendix D.

B. **Key Challenges and Market Barriers**

As with the 2010-2012 Plan and the 2013-2015 Plan, the 2016-2018 Plan seeks to acquire all available cost-effective energy efficiency in a sustainable manner. In assessing the level of energy efficiency savings that is possible and sustainable for 2016-2018, the PAs took into account a number of factors. These factors include: (1) quality of program implementation; (2) customer economic conditions; (3) market conditions/seasonality for various measures; (4) lower gas costs relative to recent history; (5) landlord/tenant barriers; (6) other market barriers; (7) equity concerns; (8) the need to avoid "stops/starts" that send negative messages to the contractor community; (9) the need to provide consistency over time to be able to capture time-dependent opportunities such as renovations and new construction; and (10) the need to accommodate new technologies over time. The PAs describe below the key market and policy issues they considered and their approach to assessing the sustainable acquisition of all available energy efficiency resources for 2016-2018.

1. Market Barriers

As in past plans, the 2016-2018 Plan is designed to address significant market barriers. To deliver energy efficiency successfully, the programs must bridge the five major market barriers of awareness, availability, accessibility, affordability, and aversion to risk. These barriers affect customers' adoption of energy efficiency measures and the ability of PAs to achieve savings. This Plan outlines the initiatives that PAs believe are critical in bridging the five major market barriers.

a) **Awareness** is a barrier that historically was not confronted on a large scale, given capped budgets, marketing, and outreach. The 2016-2018 Plan recognizes that continued strong public education, marketing, and outreach, including community-based efforts, are needed to achieve deeper and broader penetration. Deeper penetration refers to the promotion of additional cost-effective technologies and strategies to capture comprehensive, whole-building savings among the traditional base of expected program participants. Deeper penetration requires raising participant awareness and understanding of the value of investing in additional measures that create increased savings. Broader penetration can include outreach to traditionally hard-to-reach customer groups, including economically marginalized communities and groups where English is not the first language.

b) **Availability** is a barrier when manufacturers either do not produce or do not effectively market sufficient quantities of energy efficient products and services. Availability may also be constrained by limited workforce or delivery mechanisms. The challenge for manufacturers in the energy efficiency sector is to respond not only to the Commonwealth's demand for more efficient products, but also to demands on a national or even global scale. This challenge is compounded by economic pressures which reduce the willingness of manufacturers to make additional investments. From a workforce perspective, PAs recognize that continued workforce training and deployment is required to effectively deliver the programs. This is not an insignificant barrier.

c) **Accessibility** is a barrier that refers to customer access to the product. To mitigate this barrier, PAs must continue to connect with mid-stream market actors, such as distributors, to ensure that products are displayed and stocked in sufficient quantity. The program descriptions set forth in this Plan provide for continued work with key market actors, and include campaigns for training and marketing, as well as proposed community mobilization outreach strategies.

d) **Affordability** is a major market barrier resulting from the initial cost of energy efficiency solutions. PAs are concerned that affordability is more difficult to predict as customer buying patterns have changed dramatically with the advent of limited credit. The Plan attempts to mitigate this barrier through the use of incentives, new delivery models for economically challenged neighborhoods, and broadly accessible financing. In some cases, particularly with respect to gas energy efficiency efforts, the PAs propose to increase incentives for measures so that the low commodity cost of natural gas does not impede investments in cost-effective gas energy efficiency measures and services.

e) **Aversion to Risk** is a market barrier that describes customers who are unwilling to take a chance on technologies that they perceive to be unproven. To address this barrier, the PAs seek to provide detailed, clear information to customers about the direct benefits of energy efficiency measures. In some cases, this information will be provided to customers in the form of a case study highlighting the performance of proposed measures, which will help reduce the perceived risk associated with energy efficient measures and practices.

2. Policy Issues

As in past plans, the 2016-2018 Plan also takes into account policy issues, including economic, sustainability, and regulatory issues.

a) **Economic** obstacles continue to be relevant in today's environment. The PAs recognize the 2016-2018 Plan's tremendous value, but must also consider the impact of short-term rate increases related to the ramp-up of these programs. The 2016-2018 Plan discusses the associated preliminary expected bill impacts of program implementation. As noted above, traditional incremental bill impact analyses, as well as participant analyses will be provided for each PA in the PA-specific filings later this year. The detailed bill impact analyses for each PA using traditional bill impact models that will be provided with each PA's Plan will contain the information required by the Department's Orders in D.P.U. 08-50-D.

b) **Sustainability** of the programs is an important consideration for the Three-Year Plan and an expressly repeated priority of the Council. Many advocates, including the Program Administrators and the Attorney General, stress that in achieving all available energy efficiency, the annual efforts must also strive to be sustainable for the long term. This sustainability is vital to support the health of the economy, and the growth of the workforce and infrastructure needed to ensure the long-term benefits of these efforts.

c) **Regulatory Guidance** includes the support of strong regulatory frameworks that complement the Program Administrators' ramp-up of programs. These frameworks create a healthy regulatory infrastructure by which PAs can confidently advance programs knowing that there is clarity in the regulatory rules and process and the opportunity to align shareholder objectives with public policy objectives. The Department's investigation in D.P.U. 11-120 is an example of the strong commitment to regulatory guidance in Massachusetts, which has streamlined energy efficiency regulatory filings and clarified the three-year nature of energy efficiency plans under the GCA.

3. Assessing

As discussed in Section V, the Program Administrators used multiple resources to build a robust understanding of the potential for all available cost-effective energy efficiency and demand reduction resources. These efforts are grounded in the definition of "Technical Potential" as the complete penetration of all measures analyzed in applications where they are deemed technically feasible from an engineering perspective. Technical Potential does not necessarily take into account cost-effectiveness, budget constraints, or whether homeowners or businesses are willing to undertake energy saving actions or investments

"Economically achievable energy efficiency potential" is defined as that portion of the technical potential that is cost-effective. Like past plans, the 2016-2018 Plan aggressively targets all available cost-effective energy-efficiency resources, while taking into account market and policy barriers that can constrain program implementation. In addressing these barriers, the 2016-2018 Plan seeks to allow for sustained energy efficiency efforts that do not create insupportable bill impacts, consistent with the GCA, Department precedent and the PAs' public service obligation to their customers.

Assessing potential takes into account impediments to program implementation, including financial, political, and regulatory barriers that are likely to limit the amount of savings that might be achieved through energy efficiency and demand response programs. This assessment, therefore, recognizes both the market and policy barriers. After more than three decades of successfully implementing energy efficiency programs, the PAs understand these barriers and are able to integrate this knowledge of both market and policy concerns to inform this Plan. The program incentive design, delivery models, and support infrastructure developed by the PAs and discussed throughout this Plan are informed by a careful review of different types of potential.

C. Allocation of Funds for Low-Income Programs and Education

Energy efficiency funds shall be allocated to customer classes in proportion to their contributions to those funds, and, "at least 10 percent of the amount expended for electric energy efficiency programs and at least 20 percent of the amount expended for gas energy efficiency programs shall be spent on comprehensive low-income residential demand side management and education programs." G.L. c. 25, § 19(c). Based on the budget figures set forth in this Plan, for electric Program Administrators, 10.9 percent of the total budget will be allocated to the electric low-income residential sector for 2016-2018. Based on the budget figures set forth in this Plan, for gas Program Administrators, approximately 20.3 percent of the total budget will be allocated to the gas low-income residential sector for 2016-2018.

D. Minimizing Administrative Cost

In accordance with the GCA, the PAs seek to minimize administrative costs to the fullest extent practicable. Administrative costs, also commonly referred to as PP&A costs, include costs associated with:

- Developing program plans, including market transformation plans, research and development ("R&D") activities (excluding R&D assigned to Evaluation and Market Research).
- Day-to-day program administration, including labor, benefits, expenses, materials, supplies, and overhead costs.
- Any regulatory costs associated with energy efficiency activities.
- Costs for energy efficiency services contracted to non-affiliated companies such as outside consultants used to prepare plans, screen programs, improve databases, and perform legal services.
- Internal salaries for administrative employees/tasks, including program managers that do not have direct sales and technical assistance contact with customers.

For the 2016-2018 Plan, approximately 15-18 percent of the PAs' costs are budgeted in the Sales, Technical Assistance & Training cost category, supporting the activities of vendors, contractors and other industry professionals. Approximately 3 percent of the statewide budget is dedicated to the rigorous Massachusetts Evaluation, Measurement and Verification process. Other administrative functions, like Program Planning and Administration and Marketing and Advertising, make up approximately 5 percent of the statewide budget. Importantly, the majority of energy efficiency budgets are returned to customers in the form of incentives that are intended to overcome the financial barrier to investment. In the 2016-2018 Plan, 71 percent of the gas budget and 74 percent of the electric is returned directly to customers through use of participant incentives, which drive customers to participate. These percentages are in line with the budget allocations approved by the Department historically, demonstrating that the Program Administrators have been able to provide direct benefits to customers and contractors and grow the energy efficiency portfolios while minimizing costs.

The most significant factor in the PA approach to minimizing administrative costs is the statewide collaborative process, which is used by the Program Administrators to coordinate planning, the adoption of consistent programs and processes, program design, EM&V studies, statewide marketing, regulatory proceedings, and the development and sharing of all best practices. Sharing of these costs, which would otherwise be borne by each Program Administrator individually, results in economies of scale that reduce the cost for each Program Administrator. For example, joint releases of RFPs lead to minimization of administrative costs in that the cost for preparation and release of the RFP are shared by the PAs. The Program Administrators also minimize administrative costs by coordinating energy efficiency program delivery, where appropriate, with other customer service activities such as customer acquisition, key account management and trade ally relationships.

Notwithstanding any appropriate coordination with other customer service departments, it is necessary and appropriate for all Program Administrators to maintain a skilled and dedicated administrative staff in order to ensure successful delivery of programs, compliance with the GCA, timely responses to the requests of the Council, Department, and DOER, and documentation and achievement of substantial savings. The Program Administrators seek to balance the need to minimize administrative costs to the extent prudent with the need to maximize program quality and oversight. Councilors have emphasized the need to devote sufficient administrative resources to successfully implement the aggressive programs called for in the Three-Year Plans.

While the economies of scale and other steps taken by the PAs to minimize costs are effective, and administrative costs incurred by the PAs are transparent, exact quantification of the minimization of administrative costs is not possible in a meaningful way. This is because the continuous scaling up and evolution of the plans make it impractical to establish a solid baseline for a comparison. When the variables are constantly (and necessarily) shifting, there is no opportunity to make a meaningful quantitative comparison. Further, a direct quantitative comparison would not be useful because it would only provide a comparison of two points in time. The mandate of the GCA is to seek administrative efficiencies, which is a continuous process that evolves along with energy efficiency planning and programming. Program needs and opportunities for administrative efficiency are always changing. The Program Administrators seek to minimize costs at all available opportunities, and not just from one point in time to another. By collaborating, creating consistent programming, and optimizing staffing needs, the PAs are able to minimize administrative costs to the extent practicable while providing quality energy efficiency services for customers.

E. Competitive Procurement

The Program Administrators utilize competitive procurement processes to engage and retain contractors and vendors to perform activities including, but not limited to: (1) audit delivery; (2) quality control; (3) monitoring and evaluation; (4) marketing; and (5) website design. The PAs are committed to continuing to utilize competitive procurement practices to the fullest extent practicable throughout the implementation of the Plan. Therefore, consistent with past practice, the PAs anticipate that they will continue to issue RFPs to engage appropriate third-party vendors to provide energy efficiency services; consider the input of the Council with respect to the retention of necessary consultants; and, where necessary, work collaboratively to ensure that energy efficiency services have been procured in a manner that minimizes costs to ratepayers, while maximizing the associated benefits of those investments. In order to build upon the progress made in prior plans, the PAs will continue to seek to expand the pool of qualified program vendors, promote the entry of new market actors into contractor and subcontractor roles, and ensure the transparency of the contractor bidding process and selection criteria used to evaluate proposals.

F. Demand Response

Achievement of demand savings in 2016-2018 is a key goal shared by the PAs and the Council. Demand savings through demand response (peak shaving and load shifting efforts) can contribute benefits such as reducing prices and price volatility for consumers, avoiding or deferring future generation, transmission and distribution investments, and reducing environmental impacts from electric generation. Demand response is a flexible, low-carbon resource that can also be used to help integrate renewable resources as more renewables come onto the electric system. Viable demand response strategies, combined with planned aggressive energy efficiency efforts, will contribute to the Commonwealth’s economic and environmental sustainability goals.

PAs are seeking ways to understand both the costs and benefits of demand response in a way that will inform full scale deployment where benefits are expected to exceed costs. PAs are exploring ways to augment demand response provided by other market actors and explore opportunities to partner with such actors, where appropriate. In order to better understand the costs and benefits of demand response, individual PAs have developed or are working on developing individual or joint demonstration projects to gain a better understanding of costs and benefits of demand response. PAs will share the results of demonstration projects in order to gain insight, develop best practices, and utilize demand response strategies where appropriate going forward. Following the implementation of demonstration projects and related evaluation, PAs will use the results, along with related research and analysis, to guide the deployment of larger scale demand response initiatives in the latter years of this Three-Year Plan and going forward.

For PA-specific descriptions of these demonstration projects, please see Appendix L.

VI. COST RECOVERY, FUNDING SOURCES & FINANCING INITIATIVES

A. Cost Recovery

Cost recovery is a critical element of this Plan. Cost recovery associated with the implementation of energy efficiency programs includes the recovery of a performance incentive,[131] and, for those PAs without a Department-approved decoupling mechanism,[132] the replacement of revenues that support system operating costs. In order for the Program Administrators to pursue the aggressive goals set forth in this Plan, it is essential that the Plan provide a full and fair opportunity for the Program Administrators to be made economically whole for aggressively pursuing sales-reducing energy efficiency efforts and to earn a reasonable return on this investment based upon their performance and achievement. Although Department approval of the proposed Plan should ensure cost-recovery of Plan-related costs, lost base revenues ("LBR"), and performance incentives, the details related to individual PA cost-recovery mechanisms will be addressed in separate Department proceedings.

Pursuant to the GCA, for electric PAs, the Plan must include a fully reconciling funding mechanism that may include, but which shall not be limited to, a statutorily authorized mandatory SBC of 2.5 mills per kilowatt hour for all consumers, except those served by a municipal lighting plan. G.L. c. 25, §§ 19(a); 21(b)(2)(vii). In addition to this mandatory charge, the fully reconciling funding mechanisms shall be comprised of the funding sources listed in Section VI.B., herein, and other funding sources approved by the Department. G.L. c. 25, § 19(a). For gas PAs, the Plan must include a fully reconciling funding mechanism to collect costs from customers. G.L. c. 25, §§ 19(b); 21(b)(2)(vii).

The Department must approve such fully reconciling funding mechanisms if, after reviewing a Program Administrator's proposed Plan, it determines that the Plan ensures that the PA has identified and shall capture all energy efficiency and demand reduction resources that are cost-effective or less expensive than supply. G.L. c. 25, § 21(d)(2). As part of this determination, the Department must approve recovery of all expenditures for the Program Administrator's energy efficiency programs that are screened through the cost-effectiveness test described herein in Section IV.G. G.L. c. 25, § 21(d)(2). Therefore, in reviewing a Program Administrator's proposed Plan, the Department must assure that the Program Administrator is able to implement all Plan offerings that are found to be cost-effective, even if the costs associated with providing those offerings are in excess of the established funding sources provided for in the statutorily-authorized energy efficiency charge through other sources, as discussed further below. G.L. c. 25, § 19.

B. Funding Sources

1. Introduction

The Program Administrators seek to leverage available funding sources and financing initiatives in order to increase the benefits of Three-Year Plans and minimize customer bill

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[131] For a discussion of performance incentives, please see supra Section IV.C.

[132] As of January 1, 2016.

impacts. For electric Program Administrators, the GCA identifies four specific funding sources for energy efficiency programs: (1) revenues collected from ratepayers through the SBC; (2) proceeds from the Program Administrators' participation in the FCM; (3) proceeds from cap and trade pollution control programs, including but not limited to the RGGI; and (4) other funding as approved by the Department, including revenues to be recovered from ratepayers through a fully reconciling funding mechanism (*i.e.*, an EES). G.L. c. 25, §§ 19(a); 21(b)(2)(vii). Consistent with the Department's Guidelines, the Program Administrators allocate SBC, FCM, and RGGI revenues to each customer sector in proportion to the kWh consumption of each class.[133] In approving other funding for electric Program Administrators, the Department must consider: (1) the availability of other private or public funds; (2) whether past programs have lowered the cost of electricity to customers; and (3) the effect of any rate increases on customers. G.L. c. 25, § 19(a).

For gas Program Administrators, the GCA does not identify multiple funding sources for energy efficiency programs and instead requires the gas PAs to include a fully reconciling funding mechanism to collect energy efficiency program costs from customers (*i.e.*, EES). G.L. c. 25, § 21(b)(2)(vii); see also G.L. c. 25, § 21(d)(2). In approving funding for gas Program Administrators, the Department considers the effect of any rate increases on customers. Guidelines § 3.2.2.2.

The following funding sources and financing initiatives are currently available to the Program Administrators.

2. Non-EES Revenues

a. System Benefit Charge (electric only)

The SBC is calculated consistent with G.L. c. 25, § 19(a) which states: "The [D]epartment shall require a mandatory charge of 2.5 mills per kilowatt-hour for all customers, except those served by a municipal lighting plant, to fund energy efficiency programs including, but not limited to, demand side management programs." Specifically, each electric PA calculates projected SBC revenues as the product of the statutorily mandated SBC of $0.0025 per kWh and projected sales for the applicable year.

b. Forward Capacity Market Proceeds (electric only)

Pursuant to G.L. c. 25, § 19(a), the Three-Year Plans of electric Program Administrators shall be funded in part by "amounts generated by the distribution companies and municipal aggregators under the Forward Capacity Market program administered by ISO-NE, as defined in section 1 of chapter 164." Specifically, each PA calculates projected FCM revenues as the product of the clearing prices of the FCM in the applicable year and the energy efficiency capacity that is designated by ISO-NE as an FCM capacity resource for the year. The Program Administrators propose to apply all net proceeds from the FCM to energy efficiency programs.

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133 The low-income sector is allocated at least ten percent of the funds for electric energy efficiency programs and 20 percent of the funds for gas energy efficiency programs pursuant to G.L. c. 25, § 19(c).

To minimize ratepayer funding for energy efficiency efforts, each electric Program Administrator seeks to maximize FCM revenues for its customers. FCM bidding strategies are designed to strike an appropriate balance between maximizing revenues through participation in the FCM and avoiding the risks associated with FCM penalties for failure to deliver their capacity-supply obligations. Each PA employs its own individual strategy in bidding capacity into the FCM. For more information on PA bidding strategy see each electric PA's testimony.

The Department has recognized the challenges PAs face in projecting with precision over the term of a Three-Year Plan the level of planned energy efficiency resources that will be installed before and during each FCM commitment period. 2013-2015 Order at 119. One of these challenges is driven by the timing of the FCM auction cycles, which are conducted three years ahead and begin with a "show-of-interest" submission almost four years before the capacity-delivery period. Another is that there are financial penalties for failing to deliver on FCM supply obligations. However, each PA takes all reasonable steps to maximize FCM revenues during the term of a Three-Year Plan by adjusting, if appropriate, their FCM bids.

In developing a bid, each PA uses the best information available at the time. Each PA takes into account historic achieved annual peak period MW reductions from their energy efficiency programs, as well as ongoing studies and evaluations that may affect savings. Given the difficulty in estimating the actual energy efficiency savings that will be eligible to participate in the FCM and potential penalties, however, PAs do not bid into the FCM the total amount of energy efficiency savings they expect to achieve in their Three-Year Plans. In making conservative FCM bids, the PAs avoid compromising system reliability. In addition, the reconciling nature of the EES ensures that customers are made whole if PA FCM revenue projections are overly conservative and the PAs ultimately collect additional FCM revenues.

As noted above, a portion of the funding for energy efficiency efforts, including customer incentives, is derived through participation in the FCM. Although limited, there are some unique opportunities to further benefit customers and increase savings, as well as the region's capacity requirements. The PAs will provide FCM-supported energy efficiency services to electric customers who are not currently eligible for services due to other factors. For these customers, incentives would be limited to the value of the lifetime revenue stream associated with the demand savings from the project less any administrative expenses that are associated with the project.

c. Regional Greenhouse Gas Initiative Proceeds (electric only)

Pursuant to G.L. c. 25, § 19(a), the Three-Year Plans of electric Program Administrators shall be funded in part by "not less than 80 per cent of amounts generated by the carbon dioxide allowance trading mechanism established under the Regional Greenhouse Gas Initiative Memorandum of Understanding, as defined in subsection (a) of section 22 of chapter 21A, and the NOx Allowance Trading Program." As described further below, the electric Program Administrators typically calculate projected RGGI revenues by multiplying projected RGGI clearing prices by a projection of allowances sales in each RGGI auction, with 80 percent of the revenues allocated to electric efficiency programs. RGGI allowances prices are derived from the Avoided Energy Supply Cost Study. See Appendix J.

The electric Program Administrators consulted with DOER about how best to forecast RGGI proceeds for the 2016-2018 Plan. DOER recommended using a forecast developed using RGGI's Integrated Planning Model ("IPM"), which was developed by ICF International. Specifically, the PAs have used "Scenario 2 - IPM 91 Cap" in developing their budgets based upon DOER's recommendation, as set out below.

State	2015	2016	2017	2018
Scenario 2 - IPM 91 Cap				
MA Remaining Balance	7,925,075	10,218,385	10,062,297	9,709,729
Forward Price	$5.44	$6.76	$7.52	$7.52
Remaining Value	$43,112,408	$69,076,283	$75,668,473	$73,017,162
CCR Value	$0	$0	$0	$0
Total Value	**$57,403,962**	**$69,076,283**	**$75,668,473**	**$73,017,162**

DOER has clarified that there are administrative and other costs that reduce the full value option values of these RGGI forecasts. After discussions with DOER, for the 2016-2018 Plan, the PAs are forecasting that they will receive 75 percent of the RGGI proceeds.

The electric PAs have confirmed that DOER will continue to pay their share of the costs of the Council's consultants retained pursuant to G.L. c. 25, §22(c) out of the 75 percent of RGGI auction proceeds that are allocated to the PAs. In forecasting RGGI revenues, the PAs have reduced their expected RGGI proceeds by the amount payable to the consultants. Because the consultant fees will be paid by DOER directly out of the RGGI proceeds, the electric PAs' proposed budgets do not include separate expense amounts for Council consultant costs.

Projections also take into account anticipated lags between when RGGI auctions occur and when DOER is able to transfer funds to each electric PA. The Program Administrators have worked with DOER to develop a forecast that more accurately projects receipt of funds from DOER. The PAs expect to receive RGGI funds from DOER within 90 days or less of an auction.

3. EES Revenues[134]

The EES is a fully reconciling funding mechanism that the Department approves for funding the Three-Year Plans. G.L. c. 25, § 21(d)(2). Electric Program Administrators collect the EES through EERF or EEPCA tariffs. Guidelines §§ 2(9), 3.2.1.6. The electric PAs recover and reconcile energy efficiency costs pursuant to their EERF/EEPCA tariffs[135] for each year of the three-year term as the difference between: (1) the projected budget for the particular year and (2) projected revenues from non-EES funding sources for that year (*e.g.*, funding from SBC, FCM, RGGI and outside sources). For gas PAs, the EES is collected through the LDAC tariff in

[134] The PAs collect funds related to the RCS Act through their EESs. 220 C.M.R. § 7.00 *et seq.* The Department reviews the reconciliation of any over and under collections of RCS funds in the LDAC filings for the gas PAs and in the EERF/EEPCA tariff filings for the electric PAs.

[135] With the exception of the Compact, EERF/EEPCA filings are made coincident with each PAs' residential basic service rate change, creating a lag between energy efficiency program spending and collection. The Compact's rates are effective January 1 of each year, consistent with the 2013-2015 Order at 125, n.106.

accordance with established Department practice. Guidelines §§ 2(9), 3.2.2. The EERF/EEPCA and LDAC filings of the PAs are separate proceedings from the Three-Year Plan proceeding and are implemented on schedules that vary among the PAs.[136]

4. Carryover Information

In determining its EES, a Program Administrator takes into account funds carried over from the previous year's program, whether positive or negative. These "fund balances" are used to adjust projected funding levels in the Plan.

5. Outside Funding Levels

The 2016-2018 Plan does not contain outside funding assumptions at this time given the absence of material viable funding sources. The Program Administrators, as well as Councilors and government agencies, all actively continue to seek new sources of outside funding. The Program Administrators' approach in this regard reflects lessons learned over the course of two prior Three-Year Plans (2010-2012 Plan; 2013-2015 Plan). There continues to be a low likelihood that a major new federal "cap and trade" program will be implemented in the foreseeable future as had been anticipated when the 2010-2012 Plan was initially developed and approved by the Council.

6. Financing Initiatives

During the first two Three-Year Plans, the Program Administrators developed, deployed, and offered customers several financial products in conjunction with the Massachusetts Bankers Association and Credit Unions - with over 60 financial institutions participating in this initiative. The Program Administrators expect to have enough capital infusion from the diverse Massachusetts lending community to meet customer demand for financing in the next three years. The Program Administrators' collaboratively-developed financing initiatives reflect both the strong coordination among the PAs, as well as the Program Administrators' responsiveness to comments and suggestions from Councilors. Program implementers in other states have frequently contacted the Program Administrators to learn from the Massachusetts experience in development of a state-of-the-art lending initiative that leverages the experience of local banks.

The highly successful Mass Save® HEAT Loan offers zero percent interest financing for qualified energy efficient home improvements. Customers may qualify for loans up to $25,000

[136] In 2014, NSTAR Electric and NSTAR Gas agreed pursuant to a Department-approved settlement agreement with the Attorney General to recover energy efficiency-related pension/ post-retirement benefits other than pensions ("PBOP") costs through their respective pension adjustment factors for the term of the 2016-2018 Plan. See D.P.U. 14-151, at 7. National Grid (electric) also recovers its energy-efficiency related pension/PBOP costs through its pension adjustment factor. The remaining PAs collect such costs through their EES charges. To the extent that NSTAR Electric, NSTAR Gas, and/or National Grid (electric) propose to collect energy efficiency-related pension/PBOP costs through the pension adjustment factor ("PAF") for plan year 2016 and beyond, the company seeking such rate treatment will include pre-filed testimony and exhibits in its 2016-2018 Plan filing to support why collecting such costs through the PAF and not the EES is consistent with G.L. c. 25, §§ 19, 21 and otherwise appropriate. See D.P.U. 14-151, at 13, n.6.

with terms up to 7 years, depending on the PA and the loan provider. Examples of improvements that may be financed with a HEAT Loan include:

- Attic, Wall, and Basement Insulation
- High Efficiency Heating Systems
- Central Air Conditioning/ Air Source Heat Pumps
- Ductless Mini Split Heat Pumps
- High Efficiency Domestic Hot Water Systems
- Solar Hot Water Systems
- 7-Day Digital & Wi Fi Thermostats
- ENERGY STAR® Qualified Replacement Windows

Additionally, with the express support of DOER and the Council, a portion of the HEAT Loan may be used to finance the mitigation of barriers preventing the installation of energy efficient measures (*i.e.*, pre-weatherization measures).

The Mass Save® HEAT Loan initiative is the most successful initiative of its kind in the nation, growing from 532 loans in 2006 to over 11,000 loans in 2014 (annual). Since inception, the Mass Save® HEAT Loan has made over $200,000,000 available to thousands of homeowners implementing home energy efficiency improvements. The following chart shows information supporting the HEAT Loan's great success in Massachusetts.

Largest Volume

- Over $250 million financed (residential) in last three years - more than other leading states, combined

Broadest Lender Participation

- Over 60 local Banks and Credit Unions across the Commonwealth

Broad FICO score acceptance

- Since 2011 Heat Loans approved with FICO well into sub-prime category

Broad income distribution

- ~45% of household incomes taking the Heat Loan in 2014 were between $40 to $80K[1]
- Banks indicate income is not a major barrier for heat loan approval

Lowest Cost

- 5% interest; no credit enhancements; no admin; lenders bear principal risk

1. Annual Lender Survey and Home Energy Services Initiative and HEAT Loan Delivery Assessment.

Massachusetts is a leader in the nation for financing of energy efficiency projects, with a larger quantity of cumulative loans than New York and California combined.

State	Category	Program	Total # of Loans (cumulative)	Total Amount Financed since 2011[2]	2014 Population (est)
NY	Green bank	Green Jobs New York	6,690	$66 million	19 Million
CA	PACE	HERO Pace[1]	11,250[3]	$135 million[3]	38 Million
MA	Utility / 3rd Party	HEAT Loan	29,080	$290 million	7 Million

1. HERO Pace accounts for 95 percent of residential PACE market in US.
2. MA Heat Loan operative since 2006; however numbers only show since 2011; CA and NY active since 2011.
3. Actual cumulative total through 2014 is $432 million; data in table assumes energy efficiency projects represent 45 percent of amount financed and amount of projects with the remainder going to solar projects.

In this Plan, similar to the 2013-2015 Plan, certain gas PAs are proposing to allocate additional budgetary dollars in the Residential Home Energy Services initiative to make the HEAT Loan available in support of gas energy efficiency efforts in service territories where electricity is supplied by a municipal light plant. Customers of electric PAs will receive the HEAT Loan applications. Gas PAs that have municipal electric companies within their territories will offer the HEAT Loan to those natural gas/municipal electric customers. Therefore, all customers that pay into the SBC funds will be able to access the HEAT Loan. The gas PAs that have no line-item budget for the HEAT Loan have no municipal electric customers within their respective territories.

Financing allows customers, who may not be able to raise enough capital to pay for their customer contribution, to borrow funds in order to invest in energy efficiency. To the extent that access to low-cost capital is a barrier for certain customers, financing can alleviate that and encourage energy efficiency investments. The Program Administrators are continuing their efforts to understand the nature of barriers for different customer segments, which may be related to accessing capital, and to explore financing products/solutions to address them.

C. <u>Lost Base Revenues</u>

The Department stated in D.P.U. 10-170-B that LBR, like revenue decoupling, removes the disincentive for companies to fully pursue all cost-effective energy efficiency and demand-side resources, so long as such activities occur within a company's own programs. D.P.U. 10-170-B at 45. Although the Department has expressed its preference for full decoupling in both D.P.U. 07-50-A and D.P.U. 10-170, as a transition to full decoupling, the Department determined in D.P.U. 07-50-A that, electric and gas distribution companies would be allowed to recover LBR resulting from their incremental efficiency savings, until they begin operating under a decoupling plan. D.P.U. 07-50A at 83-84, n.24. [137]

In D.P.U. 07-50-A, the Department stated that electric distribution companies seeking to recover LBR must support such request with full documentation and explanation of: (1) how incremental energy efficiency savings will be achieved and accounted for, and (2) the proposed LBR calculation, in their then-upcoming 2010-2012 Plan. D.P.U. 07-50-A at 83. Gas companies then recovering LBR were allowed to continue to do so through the term of their initial Three-Year Plans consistent with then-existing LBR recovery methods. Id. at 83-84. As of the proposed effective date of the present three year plan (*i.e.*, January 1, 2016), the PAs without Department-approved decoupling mechanisms are NSTAR Electric and Berkshire.[138] As such, each of these PAs intends to seek Department approval of LBR recovery in connection with this Three-Year Plan, supported by evidence of how incremental energy efficiency savings will be achieved and accounted for and a calculation of the LBR requested for approval. Information regarding NSTAR Electric and Berkshire LBR is included those PAs' Energy Efficiency Data Tables.

[137] The Department approved LBR recovery for NSTAR Electric for the years 2009-2011 pursuant to the rate settlement filed in D.P.U. 14-151, and for the years 2012-2015 pursuant to the rate settlement filed in D.P.U. 10-170. The LBR recovery approved for NSTAR Electric for 2012-2015 was a settlement-specific methodology applicable to NSTAR Electric only. In connection with the 2016-2018 Plan (or until the Department approves a decoupling proposal for NSTAR Electric or Berkshire), NSTAR Electric and Berkshire intend to seek LBR recovery consistent with the Department's established methodology for LBR recovery articulated in D.P.U. 07-50-A at 83 and D.P.U. 07-50-B at 30-31. See also EERF Filings, D.P.U. 10-07-A/D.P.U. 10-08-A/D.P.U. 10-09-A.

[138] Assuming Department approval of NSTAR Gas Company d/b/a Eversource Energy's petition to approve a decoupling plan in D.P.U. 14-150.

VII. MISCELLANEOUS

A. Streamlining Processes to Reduce Costs for Customers

In conjunction with approving the 2013-2015 Plan, the Department also streamlined regulatory processes, which allowed the PAs to focus more on successful implementation of their energy efficiency plans. In D.P.U. 11-120-A, Phase II, the Department created a true three-year paradigm for implementing energy efficiency plans and adopted revised Guidelines. Treating Three-Year Plans as a three-year term rather than three separate one-year plans reduced the potential need for MTMs and recurring revisions. In addition, starting with the 2013-2015 Plan, the Department reviews the performance of the PAs at the end of each three-year term in adjudicatory processes rather than every calendar year. Instead, the PAs provide Plan-Year reports for informational purposes only. The Department may investigate a PA's performance on its own motion or if the Council requests such an investigation.

In addition, the Department recently determined that performance metrics were no longer necessary to incentivize the PAs' energy efficiency efforts. The Department found that "[n]egotiating, satisfying, and documenting performance metrics is costly and time consuming." Performance Metrics, D.P.U. 13-67 at 13, n.25 (2014). The Department found that "such an investment of time and resources solely for the purpose of verifying metric performance is out of proportion with the potential benefit of metrics." Id. The Department concluded that verifying performance of these metrics would divert the focus of PAs and stakeholders "from the successful implementation of the three-year plans and is inconsistent with the Department's obligation to fulfill its oversight responsibilities in an administratively efficient and effective manner." Id.

The PAs appreciate the streamlining leadership of the Department and, during the 2016-2018 Plan, the PAs will build on the streamlining improvements that benefitted implementation of the 2013-2015 Plan and will continue to seek to improve administrative efficiencies and minimize costs where possible. One important streamlining improvement the PAs have implemented for the 2016-2018 Plan is aligning the AESC study process with the development of a Three-Year Plan. Historically, the AESC study process was conducted every two years. Starting with the 2015 AESC study, which was completed in time to inform the April 30th draft Three-Year Plan, the study will be conducted every three years. Aligning the AESC study process with the Three-Year Plan development should reduce the potential for MTMs and other mid-term updates to the PAs' energy efficiency filings.

Another process improvement the PAs have made is expanding the stakeholder proposal process, which was successfully employed during the 2013-2015 Plan. This process applies to proposals, inquiries and ideas from stakeholders, private companies or individuals, non-profits, community groups, associations, local government, state government, and others that require significant PA commitment of funds or personnel. The improved proposal process will better manage proposals from stakeholders and interested parties to the RMC and C&IMC. This process is not intended to address general inquiries or suggestions or general notices of funding opportunities. To qualify for consideration by the management committees, proposals are expected to have the appropriate level of proponent research conducted and expertise articulated.

The process outlines the criteria for evaluation and the timeline and process expectations. Documents related to the proposal process are available publicly on MassSave.com.[139]

The PAs will continue to identify streamlining and efficiency opportunities for the 2016-2018 Plan. One potential area of opportunity is to consider ways to improve the efficiency of the Council process in general, as discussed in the Assessment of Massachusetts Energy Efficiency Advisory Council conducted by Dr. Jonathan Raab, Raab Associates, Ltd. with Pat Field, CBI, which was completed on December 1, 2014 ("Assessment"). As noted in the Assessment, while the role of the Council in developing a Three-Year Plan is clear, its role during implementation is not as clear, and has led to some frustrations on the part of the Council and the PAs. The PAs remain committed to being actively and productively engaged with the Council in a collaborative manner consistent with the GCA. The PAs appreciate that Council meetings are an important tool in planning for and implementing Three-Year Plans and that they require an investment of time and resources by all Councilors. As the third Three-Year Plan begins, the Program Administrators will have: (1) six years of GCA-related energy efficiency experience with more mature programs, which will inform future efforts to achieve energy efficiency cost-effectively; (2) a better understanding of the concerns and interests of the Councilors and an effective means of continuing dialogue with them (through Council resolutions and other Council documents, Council Executive Committee meetings and individual communications as well as consultant communications); and (3) an established means of reporting data to the Council (through monthly, quarterly and annual reports).

Given the success and experience with this construct, the Program Administrators will seek additional ways to streamline processes in 2016-2018, including ways to spend more time with customers seeking savings, such as fewer Council meetings during implementation years. The PAs appreciate and recognize the work and time invested by Councilors in preparing for Council meetings to ensure the mandates of the GCA are being achieved. The Program Administrators devote time and attention to being as well prepared as possible for each meeting, and respond to Councilors' concerns during and after Council meetings. The Program Administrators continue to strongly support the role of the Council established in the GCA and recognize that their energy efficiency programs have benefitted from the many excellent suggestions of Councilors. The PAs will seek Councilor input on ways to streamline processes and reduce meetings, especially during implementation years, while maintaining transparency and providing the optimal amount of information to the Councilors.[140] The Program Administrators are seeking to leverage collective experience, identify possible efficiencies and

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139 The documents related to the proposal process are available at http://www.masssave.com/professionals/business-opportunities/process-for-managing-unsolicited-proposals.

140 According to the Assessment, "the majority of interviewees thought fewer meetings might be justified during implementation years, especially if meetings are run more efficiently and some work is done in Subcommittees or in more focused, topical meetings. Some felt that a move to a quarterly or every other month Council meeting is appropriate during the implementation phase." Assessment at 18. The Assessment recommended that "[d]uring implementation of the three-year plan, the EEAC can probably meet less frequently (*e.g.*, every other month or quarterly), but with ExCom still meeting monthly, and with the ability to form subcommittees for ongoing topics/issues or focused work sessions on specific topics, and call special meetings of the EEAC, if necessary." Assessment at 19.

optimize all stakeholders' time given the experience gained through the first two Three-Year Plans.

B. **Mid-Term Modifications**

1. Introduction

Mid-Term Modifications ("MTMs") are significant adjustments of specified categories made by PAs during the term of a three-year plan. MTMs are not required and PAs submit such filings based on specific triggers as laid out in the Department's Energy Efficiency Guidelines.

2. Purpose of MTMs

The Department has stated that "the primary purpose of a mid-term modification should be to improve upon how a three-year plan provides for the acquisition of all available cost-effective energy efficiency resources." Energy Efficiency Guidelines, D.P.U. 11-120-A, Phase II at 27 (2013). "In establishing guidelines for the review and approval of proposed mid-term modifications, the Department sought to provide Program Administrators with the flexibility to respond to changing circumstance, while ensuring that they implement their plans in a manner consistent with the Department-approved plan." Id., citing D.P.U. 08-50-A at 63-64.

3. The Exception Not the Rule

The Department issued revised MTM guidelines as part of its streamlining docket in D.P.U. 11-120, which was focused on reducing regulatory burdens where possible. In finding that energy efficiency plans should be treated as true Three-Year Plans and not three annual plans, the Department minimized (but did not eliminate) the potential for mid-term changes to the PAs' Department-approved goals. Energy Efficiency Guidelines, D.P.U. 11-120-A, Phase II (2013). Given this context, and the stated purpose of MTMs, the PAs consider MTMs to be the exception and not the rule. Accordingly, the PAs develop Three-Year Plans with the best available information and without an expectation that they will require MTMs.[141] MTMs are important tools to provide flexibility to address changing circumstances while implementing Department-approved plans.

4. The Guidelines Govern MTMs

MTMs are governed by § 3.8 of the revised Energy Efficiency Guidelines approved by the Department on January 30, 2013 in D.P.U. 11-120-A, Phase II. The Guidelines provide for Category One modifications (Council support only required) and Category Two Modifications

[141] This is especially true for Cape Light Compact ("Compact"), which, for example, could not operate on the expectation that MTMs will provide further funding. As a municipal aggregator, the Compact does not have capital reserves to float the shortfalls in revenue that can occur as a result of energy efficiency program spending and collection. Unlike other PAs, the Compact cannot rely on working capital to make up revenue shortfalls and has no authority to issue municipal bonds. 2013-2015 Order at n.106. In view of its unique circumstances, the Department allowed the Compact to make a proposal to collecting energy efficiency revenues on a calendar-year basis. Id.

(Department approval required). The Guidelines include detailed appeal rights to the Department.

5. Category One MTMs

The Department created "Category One MTMs." Pursuant to § 3.8.1 of the Guidelines, a Category One MTM is a significant modification, as described below, to a PA's Department-approved Energy Efficiency Plan, which must be submitted to the Council for review:

1) the addition of a Hard-to-Measure Energy Efficiency Program;
2) the termination of an existing Energy Efficiency Program or Hard-to-Measure Energy Efficiency Program;
3) a change in the three-year term budget of an Energy Efficiency Program or Hard-to-Measure Energy Efficiency Program of greater than (1) 20 percent, or (2) a dollar value to be specified by the Department; or
4) a modification to the design of an Energy Efficiency Program that is projected to result in a decrease in program benefits over the three-year term that is greater than 20 percent.

Pursuant to § 3.8.1.1, if the Council passes a resolution supporting the proposed modification, the Program Administrator may implement the modification.

6. Category Two MTMs

The Department also created a "Category Two MTM." Pursuant to § 3.8.2 of the Guidelines, a Category Two MTM is a significant modification, as described below, to a PA's Department-approved Energy Efficiency Plan, which must be submitted first for review by the Council, and then for review and approval by the Department:

1) the addition of a new Energy Efficiency Program;
2) the transition of a Hard-to-Measure Energy Efficiency Program to an Energy Efficiency Program; or
3) a change in the three-year term budget of a customer sector that would require a cents per kilowatt-hour (calculated using the method described in § 3.2.1.6) or cents per therm charge for the sector that, if it were to replace the Department-approved Energy Efficiency Surcharge for the applicable year, would result in a bill increase for an average customer in the sector exceeding two percent.

The Program Administrator may not implement the modification pending review and approval by the Department.

7. 2013-2015 MTMs

During implementation of the 2013-2015 Plan, the PAs proposed both Category One and Category Two MTMs. The Council approved Category One MTMs in resolutions adopted on: (1) October 15, 2014; (2) March 31, 2015; (3) May 19, 2015; (4) June 29, 2015; and (5) July 14, 2015. The Council also approved Category Two MTMs in resolutions adopted on

March 31, 2015 and July 14, 2015. The Council did not support or oppose MTMs seeking to decrease budgets in certain C&I programs. See Resolutions dated March 31, 2015 and July 14, 2015. As required by the Guidelines, the PAs also filed their Category Two MTMs with the Department for approval.

The MTMs proposed by the PAs during implementation of the 2013-2015 Plan were done sparingly in order to meet changing circumstances such as meeting unexpected customer demand or to satisfy certain triggers in the Department's revised Guidelines. The majority of the MTMs seeking to increase program budgets in order to meet customer demand for program products and services were also expected to result in increased savings.

8. MTMs Do Not Revise Department-Approved Budgets or Goals

In proposing MTMs pursuant to the Department's revised Energy Efficiency Guidelines, the PAs have not revised the goals approved by the Department in their 2013-2015 Plan. The PAs have proposed that all reporting on the 2013-2015 Plan, including the Plan-Year Reports and Term Report, will report and compare actual results to the Department-approved budgets and goals. The PAs will submit the resolutions of the Council to the Department to support any variance explanations related to the MTMs in Plan-Year Reports and Term Reports. In addition, the performance incentive model filed in D.P.U. 14-05 remains unchanged (there is no increase or decrease to the performance incentive pool or any change to the payout rates derived in the performance incentive model).

Historically, as shown in more detail in Appendix B (describing regulatory background), the PAs filed MTMs to adjust certain goals in their 2010-2012 Plans. In those MTM filings, the PAs provided revisions to their Department-approved 2010-2012 Plan goals to reflect the proposed MTMs. These filings led to confusion about what baseline to use in assessing PA performance. It is important to avoid such confusion in the future, while providing transparency into factors affecting the PAs' performance. The PAs believe that their treatment of MTMs for the 2013-2015 Plan strikes an appropriate balance between transparency and simplicity. The PAs will report and compare actual results against the Department-approved goals and explain any variances related to MTMs with supporting documentation from the Council.

C. Statewide Energy Efficiency Database

1. Database Development

The Council has identified the development of a comprehensive, accessible, secure statewide energy efficiency database as a priority. See Resolution of the Council Regarding its Priorities for 2014 (February 25, 2014); Draft Council Priorities for 2015; see also Resolution of the Council Regarding its Priorities for 2013 (February 12, 2013). The Department has also encouraged the development of a "uniform energy efficiency program data tracking system that is efficient, reliable, and useful to all parties." Massachusetts Electric Company, D.P.U. 10-98, at 16 (2011); Western Massachusetts Electric Company, D.P.U. 10-90, at 21 (2011); Fitchburg Gas and Electric Light Company, d/b/a Unitil, D.P.U. 10-89 at 17 (2011).

In compliance with the Department's Order approving the 2013-2015 Plan and the development of a database, the PAs developed an initial statewide energy efficiency database, which became available for use during the second year of the 2013-2015 Plan. Specifically, in 2014, the PAs developed, implemented, maintained and improved a number of initial tabs on Mass Save Data ("MSD"), their publicly accessible energy efficiency database, which is live at http://www.MassSaveData.com. MSD provides quantitative data similar to that in the PAs' public reports, including information related to participants, expenditures, annual and lifetime savings, electric capacity savings, and benefits. MSD provides data on both a PA-specific and statewide basis and allows the public to download data to Excel or PDF formats. The platform can continue to grow and provide accessible, meaningful information to customers and stakeholders over time. The PAs understand that database matters are important and that stakeholders have varying views on the best path forward. The PAs submit that MSD is the most effective approach and is already providing significant benefits for users. MSD can be enhanced and added to over time.

The development of MSD is a direct result of database discussions with stakeholders that began in 2011 and continued throughout much of 2014. See 2013-2015 Plan at III.N & App. I; 2016-2018 Plan Appendix W (chart of database events). Although these discussions included a range of views on the purpose of a statewide database, there was consensus that the extensive data already contained in individual and statewide public reports of the PAs should be more easily accessible. In November 2013, the PAs jointly hired a vendor who had previously developed a similar energy efficiency database project in Connecticut. Cost-effectively building on its prior work, the vendor proposed a scope of work for the initial phase of MSD. The PAs held demonstrations for stakeholders in May 2014 to preview the expected functionality of this database and continued to provide updates to stakeholders throughout 2014 and 2015.

2. EEAC Database Process

After the Department approved the development of a statewide database in 2013, the PAs continued to actively participate in stakeholder database discussions. See Appendix W (chart of database events). As reflected in Appendix W, the PAs participated in 17 EEAC-related database meetings between April 8, 2013 and April 28, 2014. The PAs participated in both EEAC Database Subcommittee and Working Group meetings, which met separately but discussed the same issues. The PAs also met with the consultant hired by the EEAC to develop database specifications.

The PAs, along with other stakeholders, actively participated in the EEAC-related database meetings. The PAs expressed strong support for a statewide database that improves access to the extensive data that the PAs already report. The PAs also provided extensive written feedback to the EEAC on December 23, 2013 with respect to the consultant's conceptual proposal. On April 2, 2014, the PAs provided written comments explaining in more detail the customer privacy issues at issue in the conceptual proposal. On April 15, 2014, the PAs provided detailed comments on a database vision statement and database specifications. See Appendix W.

The PAs were not the only participants with concerns about the proposed database specifications. Indeed, notwithstanding diligent efforts and work by all parties involved, there was not consensus among the participants in the EEAC Database Subcommittee and Working Group about the purpose or contents of a statewide energy efficiency database. This lack of consensus was reflected in the database resolution adopted by the EEAC on May 13, 2014. As stated in the resolution, "A *Massachusetts Statewide Energy Efficiency Database System Specification* and a *Massachusetts Statewide Energy Efficiency Database System Cost and Schedule Estimate* were completed pursuant to the EEAC Database Subcommittee process where there was not full consensus." See Appendix W (database resolution).

Historically, stakeholder working groups and a consensus approach have been the hallmark of energy efficiency programming in Massachusetts. It was through a stakeholder working group that the D.P.U. 08-50 tables, and the data needed to support them, were developed, agreed to, and ultimately, approved by the Department. Energy Efficiency Guidelines, D.P.U. 08-50-B (2009); Energy Efficiency Guidelines, D.P.U. 08-50-C (2011); Energy Efficiency Guidelines, D.P.U. 11-120-A, Phase II (2013).[142] However, consensus is not always possible, notwithstanding good faith efforts by all. For a general discussion of the PAs' perspective and approach to developing a database, please see the PAs' database comments and Appendix W.[143]

Because the EEAC database process did not reach consensus, the EEAC submitted its database resolution to the Department seeking assistance. On December 1, 2014, the Department issued an order in D.P.U. 14-141 in response to the EEAC's database resolution. On December 22, 2014, the PAs jointly filed a motion asking the Department to reconsider its order on various grounds, and filed an informal database update report on March 5, 2015. As reflected in the Hearing Officer's ruling dated February 20, 2015, "[t]he substance of the Program Administrators'' Joint Motion is currently pending before the Commission." Consequently, the Hearing Officer stayed the compliance filing ordered by the Department "until such time as the Commission rules on the substance of the Joint Motion." This matter is currently pending before the Department.

3. MSD Overview

The MSD tabs currently available for the public are the following: home page, portfolio overview, sector overview, performance details, HES activity, GHG reductions, sales and savings, cost to deliver, monthly reporting, and glossary.[144] All of these tabs were developed and deployed in 2014 and 2015. The website is populated with 2010-2012 data (plan and evaluated); 2013-2014 data (plan, preliminary and evaluated), and 2015 plan, quarterly and monthly data. After the October plan filing, the website will display all plan data for 2016 to

[142] The Department has defined stakeholder consensus as those "decisions and documents adopted by the group [that] were acceptable to all members, even if there was not 100 percent agreement about every item." Energy Efficiency Guidelines, D.P.U. 08-50-B at 10 (2009).

[143] Although the Department afforded DOER "a" leadership role in the development of a statewide database, the PAs necessarily played an important leadership role in developing a database since they must comply with the requirements of the GCA, answer to the Department on expenditures of customer funds, and have a fiduciary duty to customers.

[144] The PAs are working on displaying additional data on MSD and are currently developing measure, regulatory reporting and geographic tabs.

2018. The PAs will update the 2016-2018 plan data to comply with the Department's final Order in January 2016. Since launching the website, the PAs have continued to improve MSD by enhancing the home page; providing external links to MassSave.com, evaluations studies, and the websites for the Council and Department; and updating the look and feel to be more user friendly and consistent with www.MassSave.com. The PAs continue to identify other needed improvements as they work with the data in MSD.

4. MSD – Purpose and Benefits

MSD is an online statewide database that improves public and stakeholder access to the extensive data already reported by PAs. It provides a single, reliable and timely data source for currently reported data on an individual PA and statewide basis that can be accessed at any time. MSD enables users to export data to spreadsheets for further analysis and queries. The PAs designed MSD to export data easily for those stakeholders like the Council and DOER who file data-driven reports on energy efficiency and, at the same time, to display data in a user-friendly, understandable manner for those users who prefer charts and graphs. MSD has been implemented in a manner that is cost efficient, protects customer privacy and is compatible with (but not duplicative of) PA tracking systems. The PAs were able to deploy the initial phase of MSD in a cost efficient manner by leveraging similar work the vendor had performed in another state.

One of the primary benefits of MSD is as a single source for the most current data reported by the PAs, both individually and in statewide roll ups. It provides access to the most up-to-date reported initiative-level PA data in easy-to-understand formats and automates the statewide view from eleven individual PAs.[145] As discussed in the Section II.C, the PAs provide monthly, quarterly, annual and term energy efficiency reports, which document their performance in implementing energy efficiency programs. MSD provides one source for the quantitative data contained in these public reports.

In addition, MSD appropriately protects customer privacy and reduces the need for expensive data security measures because the website is populated with aggregated and not customer-specific energy efficiency data.[146] Protecting customer data is a core database concern of the Department, PAs and stakeholders. Safeguarding the confidentiality of sensitive customer-specific account data is both a legal obligation and an important corporate responsibility for the PAs.[147]

145 Data related to Blackstone customers will be reported as part of National Grid gas data.

146 In Massachusetts, the PAs strictly control access to sensitive customer-specific account information like customer names, account numbers, rate class, location, usage and demand data. Customer consent is necessary to permit third-party access to sensitive customer-specific account information outside the conduct of regulated PA business. Disclosure of customer information to a third-party without customer authorization would violate corporate privacy policies and expose a PA to liability under the Massachusetts Right to Privacy Act, M.G.L. c. 214, § 1B or Chapter 93A, and potentially other statutes.

147 The PAs have each adopted strict corporate privacy policies and safeguards to protect sensitive customer-specific account information. These corporate privacy policies explicitly state that customers' personal information will be safeguarded and only disclosed for a regulated PA business purpose.

5. MSD – Future Data Reporting and Considerations

During the 2016-2018 Plan term, the PAs will continue to collaborate with the Council and stakeholders to ensure that MSD is efficient, reliable, and useful. The PAs expect to develop and implement additional MSD tabs as well as update, improve and maintain the existing tabs. Currently, the PAs are working to provide geographic information, with appropriate aggregation to protect customer privacy. The PAs are also working on providing measure level information on Mass Save Data for 2016-2018. These important new enhancements, which are directly responsive to specific Councilor requests, are under development by the PAs. The core focus for the next plan term will be to: (1) ensure that MSD continues to provide accurate statewide data; (2) enhance the usability of the tabs; and (3) improve the user experience and visual presentation, all within the context of enhancing the understanding of energy efficiency and its benefits and costs over time.

The PAs understand that stakeholders have found MSD to be a useful resource for energy efficiency data as part of planning for 2016-2018. The PAs look forward to additional stakeholder feedback to help identify reporting improvements that are cost-efficient and serve a statewide energy efficiency purpose. Additional data reporting on MSD will benefit from clearly identifying: (1) the purpose of the new data; (2) the value of the new data; and (3) whether the benefits of the new data justify the cost. Given cost considerations and the PAs' obligation to protect customer privacy, a statewide database will not be able to answer every possible question or provide all data points possible. Reporting of new data will be prioritized based on the cost and the benefit that can be achieved through the data collection and disclosure. The PAs must also consider the deep wealth of data already tracked and available (including through the extensive EM&V process), while being mindful of cost, customer privacy issues, and differences in individual PA tracking systems when reviewing requests for new or additional data on MSD. All efforts will be taken to minimize costs, consider alternative ways to acquire new data and avoid excessive and redundant data collection, which is a barrier to customer participation. Consideration of these issues will facilitate productive stakeholder discussions and identify meaningful data reporting that can be implemented cost-efficiently and with consideration of administrative costs, consistent with the PAs' statutory obligations.

MSD will also focus on reporting aggregate data that is combined in a manner that leaves individual customers unidentifiable.[148] Disclosure of aggregate data reduces customer privacy risks while still enabling trend analysis.[149] Individual, customer-level account, measure and

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148 Limited data such as customer name and address information or aggregate data that is combined in a manner that leaves individual customers unidentifiable is generally not considered sensitive, is not required to be under strict PA controls, and is not subject to customer consent requirements.

149 Customers have a reasonable expectation of privacy in their sensitive customer account data and, particularly, their energy usage information, which provides insight into their behavior. In Massachusetts, customer consent is required for third-party access to such information when disclosure is not related to a PA regulated business purpose. The Department has recognized the right to confidentiality of sensitive customer account data, including usage, even in the context of promoting policies mandated by the Legislature. See 220 C.M.R. § 11.04; 220 C.M.R. § 14.03; Low Income Discount Rate Enrollment, D.T.E. 01-106-A at 11-12 (2003) (customer authorization in context of legislative directive to participate in low-income discount matching program); Competitive Market Initiatives, D.T.E. 01-54-A (2001)

usage data is of limited use for analysis of trends or program improvement unless it is studied within the larger context of other customers' data. The EM&V efforts of the PAs, under the supervision of the Council, already provide that necessary context and include robust mechanisms for gathering, aggregating and verifying data.

As part of the PAs' EM&V work, two separate databases have been developed to support two Customer Profile Studies.[150] Direct access by stakeholders to these databases is not possible because of the need for customer consent for access to sensitive customer account and usage information.[151] The PAs will accept Council requests to query the data in these databases and will prioritize these requests based on the cost of providing answers, the purpose and benefit of the data query and the timing of the request relative to study cycles.[152]

6. MSD – Budget

The PAs have collectively budgeted approximately $500,000 in each year for a total statewide database budget of approximately $1.5 million over the term of the 2016-2018 Plan. These funds will be used to improve, add to and maintain MSD. The statewide database budget covers both direct statewide expenses as well as individual PA costs incurred to comply with statewide database reporting.[153] The PAs have invested significant time and resources to develop, test and populate the tabs in the initial phases of MSD. They have not, however, incurred costs to change their current data systems and processes because MSD is consistent with the PAs' internal tracking systems.[154] Direct statewide expenditures for development of the initial phase of MSD have been less than $400,000. The PAs were able to deploy the initial phase cost efficiently by leveraging similar work the vendor had performed in another state.

(customer authorization in context of legislative directive to develop competitive choice under Restructuring Act).

150 These databases support the 2011-2013 C&I Customer Profile Studies and the Residential Profile Study. The creation of these databases was an enormous and expensive undertaking from both a PA resource and vendor cost perspective. There was time and effort required to obtain the data needed to populate the databases from each PA's rate operations, which is separate and distinct from each PA's energy efficiency operations. In addition, the vendor had to clean, estimate, prorate gaps and outliers and otherwise normalize the data from 11 distinct PAs.

151 Neither database is accessible by the public or by the PAs because they contain private customer billing and usage data. Each EM&V vendor secures and controls the data pursuant to strict, legally enforceable, nondisclosure agreements and other important terms and conditions. PA vendors must meet certain privacy, insurance, and security requirements in order to receive sensitive customer-specific data. The contractual terms and conditions imposed on PA vendors require them to, among other things, indemnify the PAs, employ industry standard data system security measures and maintain certain types and levels of insurance.

152 The PAs will obtain estimates from their vendors for running the queries and would anticipate charging the costs to the budget for the statewide database. The PAs reserve the right to limit the scope and number of data queries from the Council in order to preserve their ability to maintain and work on MSD and to prioritize the work of their EM&V vendors.

153 As discussed in the previous section, the PAs anticipate charging certain Council-requested data queries against the budget for the statewide database.

154 The PAs have invested significant customer funds in their tracking systems. These systems have been developed to support PA business purposes, are integrated into other PA business systems, and were designed to comply with Department regulation.

Future phases of MSD, however, are unlikely to be achieved with such economy. Even if PA tracking systems do not require updates, vendor costs are likely to increase as the PAs develop tabs that are specific to Massachusetts and thus new to the vendor.

D. **Effect of Carbon Docket, D.P.U. 14-86**

On May 16, 2014, the DOER and DEP (collectively "Petitioners") filed a joint petition requesting that the Department adopt a value for the avoided cost of complying with the GWSA calculated using a marginal abatement cost curve method. Method for Calculating Avoided Costs of Complying with Global Warming Solutions Act, D.P.U. 14-86. Following the filing of pre-filed testimony and discovery responses, evidentiary hearings were held on December 8^{th} and 10^{th} 2014. Intervenors filed initial briefs on December 31, 2014, and the Petitioners, after seeking an extension, filed their initial brief on January 23, 2015. Intervenors filed reply briefs on February 13, 2015. The PAs (except for the Compact and Blackstone Gas) filed a joint reply brief asking the Department to deny the petition on the grounds that the GWSA does not impose costs on the PAs or their customers, the petitioners did not sufficiently quantify the proposed GWSA compliance value and GHG reductions are an important byproduct, but are not a specific requirement, of energy efficiency programs implemented pursuant to the GCA. The Department later permitted additional discovery on the Petitioners with respect to a record request update filed with their initial brief. Briefs related to this issue were filed on April 10, 2015.

The outcome of this docket may affect the PAs' final 2016-2018 Plan. Approval of the petition may necessitate changes in the avoided costs that are used to assess the cost effectiveness of Plan efforts. Specifically, the Department may approve a GHG emissions add-on to the results of the AESC study. The AESC study process includes, among many other attributes of avoided costs, an assessment of GHG emission costs potentially incurred and reflected in customers' rates absent additional energy efficiency efforts. In order to inform the initial draft of the 2016-2018 Plan, required to be filed with the Council by April 30, 2015, the 2015 AESC was completed on March 27, 2015, and revised on April 3, 2015. The 2015 AESC quantified the reasonably foreseeable effect of carbon dioxide regulations under RGGI through 2020 and under the Clean Power Plan proposed by the Environmental Protection Agency between 2021 and 2030. The PAs have relied on the 2015 AESC in developing the 2016-2018 Plan. Accordingly, changes in the final 2016-2018 Plan may be necessary to either comply with the Department's decision in D.P.U. 14-86, or to implement any final 2016-2018 Plan approved by the Department prior to its order in D.P.U. 14-86.

E. **Effect of DOER's proposed RCS Regulations**

On January 16, 2015, DOER proposed updates to its RCS regulations set forth at 225 CMR § 4.00. The purpose of these proposed regulations, as articulated by DOER, is to encourage broader consumer reach and better consumer protections, update and streamline the regulation, better integrate efficiency and renewable energy opportunities, and provide more consistent, comprehensive services to Massachusetts residents regardless of the fuel being used to heat a building or the number of units in a building. The proposed updates are comprehensive and have been issued for a public comment period that closed on March 31, 2015. The PAs and other stakeholders provided comments on the proposed amendments. The outcome of these updates may affect the PAs' final 2016-2018 Plan, including the savings goals and budgets.

F. Integration of Eversource Companies for Three-Year Plan

For the 2016-2018 term, NSTAR Electric Company ("NSTAR Electric") and Western Massachusetts Electric Company ("WMECo"), each d/b/a Eversource Energy (together, "Eversource" or the "Companies") are seeking approval from the Department of a single electric energy efficiency plan for the 2016-2018 Plan.

The Companies previously requested that the Department approve a single integrated Three-Year Plan for 2013-2015 in D.P.U. 12-110 and D.P.U. 12-111.[155] In support of their request, the Companies filed their D.P.U. 08-50 tables and all other documents relating to the Department's review of the Companies' Three-Year Plans for 2013-2015 both jointly and separately. The Companies specifically requested approval of: (1) common program design and implementation activities; (2) separate energy efficiency surcharges; (3) an aggregate program budget; (4) review of program cost-effectiveness on a combined basis; (5) a common performance incentive mechanism; and (6) aggregate common savings goals. See D.P.U. 12-110, Exh. DPU-NSTAR-2-59; see also D.P.U. 12-111, Exh. DPU-WMECO-2-39.

The Department approved the Companies' request with the following exceptions: (1) the Companies were directed to submit all energy efficiency filings related to the 2013-2015 Three-Year Plans, including tables, in a combined and separate format; (2) the Companies were directed to meet their low-income spending obligations on an individual company-specific basis; and (3) the Companies were directed not to include any costs associated with integrating their energy efficiency tracking systems into the 2013-2015 Plan. See 2013-2015 Order at 137-139. In addition, the Department noted that it would: (1) review the Companies' performance to assess whether their energy efficiency programs, as implemented, are cost-effective on both an individual and combined basis; (2) review performance with respect to savings goals on an individual basis; and (3) review performance incentives on an individual PA basis. See id. at 142. The Companies submitted revised D.P.U. 08-50 tables and performance incentive tables for NSTAR Electric and WMECo consistent with these directives on March 22, 2013. In addition, the Companies have submitted all subsequent filings related to the 2013-2015 Plan, including tables, in individual and combined format for the Department's review.

These filings, submitted in individual and combined format, have provided the Department sufficient documentation in support of approving the Companies request to submit a single, integrated Three-Year Plan.

Below is a brief overview of the Eversource energy efficiency proposal to integrate key aspects of energy efficiency program implementation including: Savings Goals; Program/Pilot Design and Implementation; Program Budgets/Spending; Cost Effectiveness; Funding; Performance Incentives; EM&V; and MTMs.

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155 On April 4, 2012, the Department approved a merger between Northeast Utilities, parent company for WMECo, and NSTAR, parent company for NSTAR Electric and NSTAR Gas in D.P.U. 10-170. On February 2, 2015 all Northeast Utilities companies, including WMECo and NSTAR Electric, began doing business as Eversource.

1. Savings Goals

The Settlement Agreement between NSTAR Electric, NSTAR Gas Company, WMECo and the DOER approved by the Department in D.P.U. 10-170 required NSTAR Electric and WMECo to increase their aggregate energy efficiency savings target as of January 1, 2013 to at least 2.5 percent of retail sales annually through energy efficiency, so long as there is no material change in the framework for assessing the success of the program and associated incentives, or providing for program funding. NSTAR/NU Merger, (NSTAR/WMECo/DOER Settlement Agreement at Article 2.3, NSTAR/WMECo/DOER/AG Settlement Agreement at Articles 2(3)(Base Rate Freeze) and 2.7 (Lost Base Revenues)). This annual commitment ends at the expiration of the Base-Rate Freeze period (*i.e.*, January 1, 2016). However, the Companies are committed to proposing and achieving a common savings goal for both Eversource electric distribution companies during the 2016-2018 term. Accordingly, pursuing this common savings goal through a single plan is reasonable, and is consistent with the Companies' commitments during the 2013-2015 term.

2. Program/Pilot Design and Implementation

The 2013-2015 Plan contemplated uniform electric energy efficiency programs across Massachusetts. The Companies expect that the statewide electric 2016-2018 Three-Year Plan will similarly include uniform energy efficiency programs. Accordingly consistent with the Department's approval of a single Eversource electric energy efficiency plan in D.P.U. 12-101 through 12-111, at 137-139 for purposes of pursuing common program/pilot designs and implementation, the Companies request approval of a single Eversource electric energy efficiency Plan for the 2016-2018 term.

3. Program Budgets/Spending

The Eversource electric energy efficiency budgets for 2013-2015 were structurally identical. The Companies similarly propose to submit energy efficiency budgets that are structurally identical for the 2016-2018 term. Maintaining separate budgets through separate energy efficiency plans presents unnecessary administrative and regulatory burdens on the Companies that could be eliminated through an integrated budget and plan and streamlined regulatory review. Spending for each operating company for the 2016-2018 term will continue to be tracked separately in each operating company's respective accounting systems.

With respect to low-income energy efficiency programs, the Companies will maintain their spending on such programs at a minimum of 10 percent of the integrated budget, as required by law, with an apportioned low-income budget directly allocated to each company. Operational differences in the low-income programs will be reconciled in cooperation with LEAN.

4. Program Cost-Effectiveness

The Companies' respective energy efficiency programs are designed to be cost-effective, as measured by the Department's Total Resource Cost test. The Companies' 2013 and 2014 Plan

Year reports demonstrated that their energy efficiency programs are also cost-effective if integrated. See D.P.U. 14-87 (2013 NU Electric Plan Year Report at PDF page 32 of 46, citing evaluated cost-benefit ratios) and D.P.U. 15-49 (Eversource Electric 2014 EE Plan-Year Report at PDF page 32 of 46). Based on the foregoing, the Companies request approval for the 2016-2018 term to submit one, integrated cost-effectiveness analysis for the Eversource electric companies, and have their programs reviewed for cost-effectiveness on that basis.

5. Funding/Cost Recovery

a. Funding

Given that the GCA makes funding sources for energy efficiency programs uniform for electric PAs, as demonstrated by the Companies during the 2013-2015 term, an integrated electric energy efficiency plan does not present any issues with respect to the structure and sources of program funding. First, a statewide formula exists for allocating RGGI proceeds to individual PAs. Second, forward capacity auctions applicable to the 2016-2018 term have occurred already, and the proceeds from such auctions will be based on the individual PA's energy efficiency assets and how they are bid into forward capacity auctions. Finally, although the carryover amounts for NSTAR Electric and WMECo differ, as noted previously, the Companies will track and allocate funds appropriately. As directed by the Department in D.P.U. 12-100 through D.P.U. 12-111, the Companies tracked all funding separately with respect to the 2013-2015 term without issue. Thus, funding does not present a barrier to the Department's approval of an integrated energy efficiency plan.

b. Cost Recovery

Although the Companies' plan will integrate key aspects of energy efficiency goals outlined above, the Companies are not proposing at this time to consolidate energy efficiency cost recovery tariffs. LBR recovery will be based on cost recovery proposals specific to NSTAR Electric Company. Lost revenues associated with WMECo's energy efficiency programs are recovered through WMECo's decoupling mechanism.

c. Avoidance of Cross Subsidization

The Companies have demonstrated in their 2013 and 2014 Plan Year Reports that they have served each of the NSTAR Electric and WMECO service territories by maximizing benefits and minimizing overall costs to the extent possible, while being cognizant of the separate funding sources provided by customers in each service area in the form of the NSTAR Electric EERF and the WMECO EEPCA. Each service territory was served within the bounds of their approved budgets, with costs tracked separately, as reported in each service territory's distinct Plan Year Report filing.

6. Bill Impacts

In recognition of the fact that the acquisition of all cost-effective energy efficiency could require funding above that provided through existing funding sources (*i.e.*, the SBC, FCM, and RGGI), the GCA provides that PAs may collect additional revenue from ratepayers through a mechanism such as the EES. G.L. c. 25, § 19(a). Given that the energy efficiency cost recovery tariffs for the Companies are not proposed at this time to be integrated, the Companies do not anticipate adverse bill impact issues arising in the context of plan integration.

7. Performance Incentives

The GCA provides that the Statewide Plan shall include a proposed mechanism that provides incentives to PAs based on their success in meeting or exceeding the goals in the plan. G.L. c. 25, § 21(b)(2). The Companies will follow the performance incentive mechanism ultimately developed by the electric PAs and the Council. Filings submitted to the Department in D.P.U. 12-110 and D.P.U. 12-111, and in subsequent Plan Year reports demonstrated that the Companies have independently satisfied their performance commitments without issue and there is thus no reason to continue to require the Companies to calculate and report performance incentives on an individual basis. Because of the Companies satisfaction of all performance commitments there is no risk that integration would result in using one company's stellar performance to mask the other's subpar performance.

8. EM&V

The Department's Guidelines require each Three-Year Plan to include an evaluation plan describing how the PA will evaluate energy efficiency programs during the course of its plan. Guidelines § 3.5. The Department's Guidelines are intended to create a collaboratively-developed (between the Council and the PAs), statewide EM&V strategy. The Companies will use the same EM&V strategy and apply EM&V results similarly during the 2016-2018 term. Accordingly, EM&V strategy and application will not be affected by plan integration.

9. MTMs

In D.P.U. 08-50-A and the D.P.U. 08-50-B Guidelines, the Department directed the PAs to seek Department approval for certain specified MTMs, including adding or terminating a program, and changes in a program budget, savings goals, or performance incentives of greater than 20 percent. D.P.U. 08-50-A at 64; D.P.U. 08-50-B Guidelines at § 3.8.2. Subsequent to D.P.U. 08-50-A and B, the Department provided further guidance regarding the need for Department approval of proposed mid-term program modifications. Specifically, in Cape Light Compact, D.P.U. 10-106 (2011), the Department clarified that PAs are required to seek Department approval only for a program budget modification that is 20 percent greater than the program's three-year budget.

The Department modified the D.P.U. 08-50 Guidelines with respect to MTM filings in D.P.U. 11-120-A, Phase II. The Department established two categories of MTMs, Category One and Category Two. D.P.U. 11-120-A, Phase II at 28; see also Final Revised Guidelines, §§ 3.8.1 and 3.8.2. A Category One MTM includes (1) addition of a Hard-to-Measure energy efficiency Program; (2) termination of an existing energy efficiency program or Hard-to-Measure energy efficiency program; (3) program budget modifications that are a 20 percent deviation from the Department approved program budget or modifications that are a change to the program-budget greater than a dollar amount specified by the Department; or (4) a modification to an energy efficiency program that is projected to decrease program benefits by greater than 20 percent. See D.P.U. 11-120-A, Phase II at 28; see also Final Revised Guidelines, § 3.8.1. A Category Two modification is (1) the addition of a new energy efficiency program; (2) the transition of a Hard-to-Measure energy efficiency program to an energy efficiency program; or (3) a change in the three-year term budget of a customer sector that would result in a bill increase for an average customer in the sector exceeding two percent. Final Revised Guidelines, § 3.8.2. Category Two modifications require Department approval, while Category One modifications require only a Council resolution. D.P.U. 11-120-A, Phase II, at 28-29; Final Revised Guidelines, §§ 3.8.1, 3.8.2.

Under an integrated plan, the Companies intend to apply the Department's MTM Guidelines to the integrated budgets, savings and performance incentives of the two Companies, and with respect to the addition or termination of an integrated program. The Companies will continue to apply the Department's MTM Guidelines with respect to bill impacts to NSTAR Electric Company and WMECO individually, given their separate energy efficiency cost recovery mechanisms. And, the two-tiered review and approval process set forth in the Final Revised Guidelines ensures that the Department and Council remain apprised of any changes to the Companies' plan.

10. Conclusion

Based on the foregoing, the Companies are requesting that the Department: (1) permit the Companies to submit a single, fully integrated Three Year Plan for the Eversource electric companies as outlined above; and (2) review the Companies' compliance with G.L. c. 25, §§ 19(c) and 21(d) based on their combined performance against their integrated Three Year Plan. NSTAR Electric and WMECo will continue to individually track their energy efficiency costs and savings (and provide such information upon request), and file individual energy efficiency reconciliation factors with the Department for review and approval. The Companies are confident that implementing energy efficiency programs through a single plan will not only fulfill each company's energy efficiency obligations, but also provide the potential for administrative and regulatory efficiencies over time, while imposing no adverse impacts on the customers of either company.

G. **Service of Blackstone Customers**

In the 2013-2015 Order, the Department stated, "with the Council's help and support, we encourage Blackstone Gas to pursue an agreement with another Program Administrator to deliver energy efficiency services in its service territory." 2013-2015 Order at 155. In accordance with that direction, Blackstone entered into discussions with National Grid, the electric Program Administrator that provides electric distribution services to Blackstone's gas customers, to determine an appropriate manner in which National Grid may provide comprehensive electric and gas energy efficiency services for Blackstone's customers. Following agreement in principle on an arrangement through which National Grid would provide gas energy efficiency services to all Blackstone customers, under the same terms and conditions as it provides energy efficiency services to its native load customers, on March 31, 2015, the Council voted to approve the proposal. In June 2015, Blackstone and National Grid entered into a formal agreement to implement the proposed service arrangement, and filed a joint petition for approval of the arrangement with the Department, docketed as D.P.U. 15-79. On October 7, 2015 the Department approved the service arrangement commencing on January 1, 2016. Blackstone Gas Company, and Boston Gas Company and Colonial Gas Company, each d/b/a National Grid, D.P.U. 15-79, at 3 (2015).

In summary, National Grid and Blackstone have agreed to an arrangement under which National Grid, commencing with the 2016-2018 Energy Efficiency Plan, will provide gas energy efficiency services to all Blackstone customers under the same terms and conditions as it provides energy efficiency services to its native load customers. Blackstone's customers and all related budgets, savings, and performance incentives will be fully integrated into National Grid's gas territory and filings, with no separate goals, tracking, or reporting related to Blackstone's customers to be required of National Grid as a result of this arrangement. This integration will allow Blackstone's customers to take full advantage of all the energy efficiency programs that are available in Massachusetts without placing any additional burdens on National Grid's customers. This agreement would also provide Blackstone's customers with representation at the Council through National Grid.

Accordingly, National Grid has included bill impacts for Blackstone's customers in its Three-Year Plan filing pursuant to the Department's directive. Id.

VIII. APPENDICES

A. **Glossary**

GLOSSARY OF TERMS AND ABBREVIATIONS	
2012-2012 Electric Plan	2010-2012 Electric Three-Year Energy Efficiency Plan, D.P.U. 09-116 through D.P.U. 09-120
2010-2012 Gas Plan	2010-2012 Gas Three-Year Energy Efficiency Plan, D.P.U. 09-121 through D.P.U. 09-128
2010-2012 Orders	Orders issued by the Department on January 28, 2010 for the 2010-2012 Plans in dockets D.P.U. 09-121 through D.P.U. 09-128 and D.P.U. 09-116 through D.P.U. 09-120
2010-2012 Plans	2010-2012 Electric Plan and 2010-2012 Gas Plan
2013-2015 Order	Order issued by the Department on January 31, 2013 for the 2013-2015 Plans in in dockets D.P.U.12-100 through 12-111
2013-2015 Plan	2013-2015 Three-Year Energy Efficiency Plan, D.P.U. 12-100 through D.P.U. 12-111
2015 AESC	Avoided Energy Supply Cost in New England: 2015 Report
2016-2018 Plan	2016-2018 Three-Year Energy Efficiency Plan
AB	Advanced Buildings
ABCD	Action for Boston Community Development
ACEEE	American Council for an Energy-Efficient Economy
Act Relative to Competitively Priced Electricity in the Commonwealth	Chapter 209 of the Acts of 2012. Signed into law on August 23, 2012.
AE	Account Executive
AESC	Avoided Energy Supply Costs
AESP	Association of Energy Service Professionals
AFUE	Annual Fuel Utilization Efficiency
AG	Office of the Attorney General of Massachusetts
AIA	American Institute of Architects
AIM	Associated Industries of Massachusetts
ARRA	American Recovery and Reinvestment Act
BBRS	Board of Building Regulations and Standards
BCR	Benefit/Cost Ratio
BPI	Building Performance Institute
C&F	Chain & Franchise
C&I	Commercial and Industrial
C&IMC	Commercial and Industrial Management Committee
CAP	Community Action Program
CDA	Comprehensive Design Approach
CECP	Massachusetts Clean Energy and Climate Plan for 2020
CFL	Compact Fluorescent Lightbulb

CHP	Combined Heat and Power
CMI	Community Mobilization Initiatives
Consultants	Consultants employed by the Energy Efficiency Advisory Council
Council	Energy Efficiency Advisory Council
Department	Massachusetts Department of Public Utilities
DEP	Massachusetts Department of Environmental Protection
DER	Deep Energy Retrofit
DHCD	Massachusetts Department of Housing and Community Development
DOE	Department of Energy
DOER	Massachusetts Department of Energy Resources
DPU	Massachusetts Department of Public Utilities
D.P.U. 08-50	Energy Efficiency Guidelines, D.P.U. 08-50 (2008)
D.P.U. 08-50-B Guidelines	Energy efficiency guidelines established in D.P.U. 08-50-B (2009)
D.T.E. 98-100 Guidelines	Energy efficiency guidelines established in Investigation to Establish Methods and Procedures to Evaluate and Approve Energy Efficiency Programs, D.T.E. 98-100 (2000)
D.P.U. 11-120 Guidelines	Energy efficiency guidelines established in D.P.U. 11-120-A, Phase II (2013)
DSM	Demand-Side Management
ECM	Electronically Commutated Motor
EEAC	Energy Efficiency Advisory Council
EEPCA	Energy Efficiency Program Cost Adjustment
EERF	Energy Efficiency Reconciliation Factor
EES	Energy Efficiency Surcharge
EISA	Energy Independence and Security Act
Energy Act of 2012	Act Relative to Competitively Priced Electricity in the Commonwealth
EMC	Evaluation Management Committee
EM&V	Evaluation, Measurement and Verification
EM&V Consultant	A third-party expert consultant who has primary responsibility for working with the PAs to plan and implement high-quality EM&V in Massachusetts.
ENERGY STAR®	Brand name for the voluntary energy efficiency labeling initiative sponsored by the U.S. Environmental Protection Agency and Department of Energy.
EPA	U.S. Environmental Protection Agency
FCM	Forward Capacity Market
FR	Free Rider

Free Riders	Customers who participate in an energy efficiency program but would have installed the same measure(s) on their own if the program had not been available.
Free-Ridership Rate	The percent of savings attributable to Free Riders.
FTE	Full-Time Equivalent.
GCA	Green Communities Act
GHG	Greenhouse Gas
Green Communities Act	An Act Relative to Green Communities, Chapter 169 of the Acts of 2008. Signed into law on July 2, 2008.
Guidelines	Department's D.P.U. 11-120 Guidelines
GWSA	Global Warming Solutions Act, St. 2008, c. 298
HEHE	High Efficiency Heating and Water Heating
HERS	Home Energy Rating System
HES	Home Energy Services
HPCs	Home Performance Contractors
HVAC	Heating, Ventilation, and Air Conditioning
IECC	International Energy Conservation Code
IIC	Independent Installation Contractors
Impact Factor	Generic term for persistence, realization rates, in-service rates, non-coincident connected demand factors, etc., developed during the evaluation of energy efficiency programs and used to calculate net savings.
ISO-NE	Independent System Operator – New England
JMC	Joint Management Committee of PA and non-PA parties that manages the Residential and Low-Income New Construction Core Initiatives
LDAF	Local Distribution Adjustment Factor
LDAC	Local Distribution Adjustment Clause
LEAN	The Low-Income Energy Affordability Network
LED	Light Emitting Diode
LBR	Lost Base Revenue (For companies not operating under decoupled rate structure, these costs account for revenues not collected by the Company's distribution business as a result of the energy efficiency undertaken during the program year)
LCIEC	Large Commercial & Industrial Evaluation Contractor
Lifetime	The expected length of time, in years, that an installed measure will be in service and producing savings.
MassCEC	Massachusetts Clean Energy Center
Measure	Specific technology or practice that produces energy and/or demand savings for which the Company provides financial incentives.

MFNC	Multi-Family New Construction
Mid-Term Modification	Modification to approved Three-Year Plan during term of Plan.
MMI	Multi-Family Market Integrator
MOU	Memorandum of Understanding
MSD	Mass Save Data
MTAC	Massachusetts Technical Assessment Committee
MTM	Mid-Term Modification
NBI	New Building Institute
NCP	Negotiated Cooperative Promotions
NEED	National Energy Education Development
Net to Gross Ratio or NTGR	A factor representing net program savings divided by gross program savings that is applied to gross program impacts to convert them into net program load impacts.
NEI	Non-Energy Impacts
Network	Low-Income Weatherization and Fuel Assistance Program Network
NPS	Non Participant Spillover
NTG	Net-to-Gross
NWA	Non-Wires Alternative
PA	Program Administrator
PAF	Pension Adjustment Factor
PBOP	Post-Retirement Benefits Other than Pensions
Participant Cost	The total cost of a project or measure less the customer incentive.
Performance Incentive	Compensation for the Company's successful execution of the energy efficiency programs during the program year as determined by Massachusetts Department of Public Utilities.
PEx	Program Expediter
PI	Performance Incentive
Plan	Three-Year Energy Efficiency Plans approved by the Department by its Orders, dated January 28, 2010, in dockets D.P.U. 09-121 to D.P.U. 09-128 and D.P.U. 09-116 to D.P.U. 09-120, and dated January 31, 2013 in dockets D.P.U.12-100 through 12-111.
PP&A	Program Planning and Administration
Program Administrators	Utilities and municipal aggregators that offer energy efficiency programs.
QA/QC	Quality Assurance/Quality Control
RCS	Residential Conservation Service, established in An Act Establishing The Massachusetts Residential Conservation Service, Chapter 465 of the Acts of 1980, July 11, 1980.

RFP	Request For Proposal
RGGI	Regional Greenhouse Gas Initiative
RMC	Residential Management Committee
RNC	Residential New Construction
SBC	System Benefit Charge
SO	Participant Spillover
STAT	Sales, Technical Assistance & Training
Spillover	Additional energy efficient equipment installed by customers that was influenced by the Company's sponsored program, but without direct financial or technical assistance from the program. Spillover is separated into Participant and Non-participant factors. Non-participating customers may be influenced by product availability, publicity, education and other factors that are affected by the program.
Spillover Rate	Estimate of energy savings attributable to spillover effects expressed as a percent of savings installed by participants through an energy efficiency program.
T&D	Transmission and Distribution
Term	Three-year term of the energy efficiency plan
Three-Year Plan	Energy Efficiency Investment Plans required by the GCA every three years. To date, the Department has approved two Three-Year Plans by its Orders in dockets D.P.U. 09-121 to D.P.U. 09-128 and D.P.U. 09-116 to D.P.U. 09-120 (January 28, 2010), and dockets D.P.U. 12-100 to D.P.U. 12-111 (January 31, 2013).
TRC	Total Resource Cost
TRL	Technical Resource Library
TRM	Technical Reference Manual
WAP	Weatherization Assistance Program

B. **Regulatory Background and History**

Regulatory Background and History

1. Regulatory Context
   a. Green Communities Act
   b. Residential Conservation Service Act
   c. Energy Act of 2012
   d. Investigation instituting a rulemaking pursuant to the Energy Act of 2012, D.P.U. 14-53 (2014)
   e. Proposed updates to DOER RCS Regulations

2. Orders Approving Three-Year Plans
   a. 2010-2012 Plan Orders
      i. Gas Plan Order, D.P.U. 09-121 through D.P.U. 09-128 (2010)
      ii. Electric Plan Order, D.P.U. 09-116 through 09-120 (2010)
   b. 2013-2015 Plan Order, D.P.U. 12-100 through 12-111 (2013)

3. Energy Efficiency Guidelines
   a. D.P.U. 08-50-A (2009)
   b. D.P.U. 08-50-B (2009)
   c. D.P.U. 08-50-C (2011)
   d. D.P.U. 08-50-D (2012)
   e. D.P.U. 11-120, Phase I (2012)
   f. D.P.U. 11-120-A, Phase II (2013)

4. Mid-Term Modifications
   a. Compact's 2010 MTM, D.P.U. 10-106 (2011)
   b. 2011 MTMs, D.P.U. 10-140 through 10-150
   c. 2012 MTMs, D.P.U. 11-106 through D.P.U. 11-116
   d. Order approving 2011 and 2012 MTMs (2014)

5. Annual Reports
   a. 2010 Annual Report Orders - D.P.U. 11-63 through D.P.U 11-73, D.P.U. 11-126
      i. Gas Orders (2013)
      ii. Electric Orders (2014)
   b. 2011 and 2012 Annual Report Orders (2014) - D.P.U. 12-51 through D.P.U 12-61; D.P.U. 13-110 through D.P.U. 13-122
      i. Gas Orders
      ii. Electric Orders

6. Miscellaneous
   a. 2013-2015 Performance Metrics, D.P.U. 13-67 (2014)
   b. 2013 Avoided Energy Supply Component Study Energy Efficiency Updates, D.P.U. 14-05
   c. Method for Calculating Avoided Costs of Complying with Global Warming Solutions Act, D.P.U. 14-86

1. Regulatory Context		
a.	Green Communities Act	The GCA was signed into law on July 2, 2008. The legislation promotes enhanced energy efficiency throughout the Commonwealth and requires the PAs to develop energy efficiency plans that will "provide for the acquisition of all available energy efficiency and demand reduction resources that are cost effective or less expensive than supply." G.L. c. 25, § 21(b)(1). The GCA requires the PAs to submit a statewide energy efficiency investment plan every three years on or before April 30 to the Council. The contents of those plans, which are specified in the statute, are to be prepared by the PAs in coordination with the Council. In accordance with the GCA, the PAs are required to file their respective PA-specific three-year plans, "together with the Council's approval or comments and a statement of any unresolved issues, to the Department . . . on or before October 31." Id. § 21(d).
b.	Residential Conservation Service Act	The RCS, as established through chapter 465 of the Acts of 1980, was Massachusetts' response to federal efforts for consumer protection and energy independence, and sought to encourage increased energy efficiency in residential buildings.
c.	Energy Act of 2012	On August 23, 2012, Chapter 209 of the Acts of 2012, "An Act relative to competitively priced electricity in the Commonwealth" was signed into law. Notably, the Energy Act of 2012 increased the membership of the Council, amended statutory provisions concerning RCS, established an energy policy review commission, and implemented an accelerated rebate pilot program. Section 5 of the Energy Act of 2012 implemented a voluntary accelerated rebate pilot program, which the PAs offered and is now completed. Sections 8 through 11 of the Energy Act of 2012 amended the existing statutory provisions concerning the Council by expanding the membership from 11 to 15 members, with the additional 4 members representing: the Massachusetts Non-profit Network, a Massachusetts city or town, the Massachusetts association of realtors and a small energy efficiency contractor. Section 32 of the Energy Act of 2012 amended the RCS by permitting the inclusion of RCS service as part of an efficiency investment plan under the GCA, in order to slightly reduce the administrative burdens of separate filings and hearings on utilities. Section 41 of the Energy Act of 2012 established an energy policy review commission to study and report to the Legislature on energy policy in Massachusetts, and the PAs participated in the commission under the statute.
d.	Investigation instituting a rulemaking pursuant to the Energy Act of 2012, D.P.U. 14-53 (2014)	On November 5, 2014, the Department issued an Order Adopting Final Regulations revising 220 C.M.R. § 7.00 et seq., Residential and Commercial Energy Conservation Service Program Cost Recovery to comply with the Energy Act of 2012 by reducing the administrative burden of reporting RCS separately from weatherization for cost-effectiveness, but declining to adopt the additional recommendations proposed by the PAs, including the suggestion that PAs report RCS as a part of weatherization for budget purposes.
e.	Proposed updates to DOER RCS Regulations	On January 16, 2015, DOER proposed regulatory updates to the RCS to encourage broader consumer reach and better consumer protections. The proposed updates have been issued for a public comment period that closed

	on March 31, 2015.
2. Orders Approving Three-Year Plans	
a. 2010-2012 Plan Orders -Gas Plan Order, D.P.U. 09-121 through D.P.U. 09-128 (2010) -Electric Plan Order, D.P.U. 09-116 through D.P.U. 09-120 (2010)	For the plan term 2010-2012, the PAs developed separate gas and electric energy efficiency plans. On October 31, 2009, the PAs filed their respective PA-specific 2010-2012 Plans, together with the Council's Resolution of October 27, 2009 (which Resolution constituted the Council's approval, comments and statement of any unresolved issues) with the Department pursuant to G.L. c. 25, § 21(d). The 2010-2012 Plans sought to capture all available cost-effective energy efficiency for the three-year period beginning January 1, 2010, with the consideration of factors and concerns noted at the Council, including, but not limited to, bill impacts, environmental benefits, and the need for a reasonable ramp-up schedule. On January 28, 2010, the Department issued Orders approving the 2010-2012 Plans subject to limited specified exceptions and directives.
b. 2013-2015 Plan Order, D.P.U. 12-100 through 12-111 (2013)	For the plan term 2013-2015, the PAs developed a single integrated gas and electric energy efficiency plan. On November 2, 2012, the PAs filed their respective PA-specific 2013-2015 Plans with the Department pursuant to G.L. c. 25, § 21(d).. On November 13, 2012, the Council approved a resolution (which constituted the Council's approval, comments and statement of any unresolved issues). The 2013-2015 Plans sought to capture all available cost-effective energy efficiency for the three-year period beginning January 1, 2013, with the consideration of factors and concerns noted at the Council, including, but not limited to, bill impacts, environmental benefits, and sustained energy efficiency efforts. On January 31, 2013, the Department issued an Order approving the 2013-2015 Plans subject to limited specified exceptions and directives. The Department found each program cost-effective, approved each PA's savings and budgets, and with a limited threshold level exception, approved the performance incentive mechanism. The Department found each PA's Plan to be consistent with the GCA, the Guidelines, and Department precedent.
3. Energy Efficiency Guidelines	
a. D.P.U. 08-50-A (2009)	After the passage of the GCA, and in conjunction with the PAs' well-established energy efficiency programs, the Department opened an investigation to update the Department's energy efficiency guidelines, as previously established in the D.T.E. 98-100 Guidelines, to ensure that they were consistent with the GCA. During the Department's proceedings in D.P.U. 08-50, it solicited comments from the PAs, governmental bodies, and other interested stakeholders. The PAs participated with the Department, DOER, and other interested stakeholders in various collaborative D.P.U. 08-50 working group sessions convened and moderated by the Department. The resulting first Order, D.P.U. 08-50-A, issued on March 16, 2009, provided a clarification of the criteria to be applied in demonstrating cost-effectiveness and the process by which three-year energy efficiency plans should be prepared and reviewed. In D.P.U. 08-50-A, the Department mandated that the PAs seek Department approval for certain specified MTMs. As a result, the PAs filed MTMs for 2011 and 2012 in accordance with D.P.U. 08-50-A and D.P.U. 08-50-B, discussed below.
b. D.P.U. 08-50-B (2009)	The Department supplemented its D.P.U. 08-50-A Order with the issuance of an Order in D.P.U. 08-50-B, which was issued on October 26, 2009. In D.P.U. 08-50-B, the Department provided further directives clarifying how the PAs are to conduct and present their bill impact analysis and EM&V

	processes, and established the D.P.U. 08-50-B Guidelines. The revised guidelines addressed issues such as: (1) funding sources; (2) budgets; (3) cost-effectiveness test; (4) evaluation plans; (5) performance incentives; (6) review of three-year plans; and (7) MTMs. Through the D.P.U. 08-50-A and D.P.U. 08-50-B Orders, the Department established standards that sought to balance the need for PAs to make improvements to energy efficiency programs during the course of a three-year plan, with the need for adequate regulatory review and stakeholder input of significant changes to the PAs' planning assumptions and parameters.
c. D.P.U. 08-50-C (2011)	Following its Order in D.P.U. 08-50-B, the Department established a working group to review existing practices and develop an annual report template for review and comment, resulting in an Order in D.P.U. 08-50-C issued on May 5, 2011, which established a template for energy efficiency annual reports. The Department noted that the purpose of the annual report template is: (1) to clearly identify the information that a PA is required to provide to fully review the PA's energy efficiency program performance for a particular year; and (2) to specify the format for providing the required information. The PAs have used the annual report template, in preparing their respective annual reports for 2011 and 2012, which were filed with the Department each year on or about August 1st, and in compliance with G.L. c. 25, § 21(b)(3).
d. D.P.U. 08-50-D (2012)	On October 19, 2012, the Department issued an order on bill impacts, explaining that the pace at which the PAs acquire all available cost-effective energy efficiency resources "is moderated in part by the requirement that the Department consider the effect of any rate increases on residential and commercial customers' bills before the approval of ratepayer funding for energy efficiency programs." D.P.U. 08-50-D, *Order on Bill Impacts*, at 9 (2012). The Department acknowledged the efforts of the D.P.U. 08-50 bill impact working group, a large group of stakeholders who developed various bill impact models consistent with Department directives in D.P.U. 08-50. The Department, however, declined to adopt the bill impact models under discussion. The Department determined that its statutory mandate to consider the effect of any rate increases on residential and commercial customers is "best satisfied through a traditional bill impact analysis which, with its short-term perspective that isolates the effect of a proposed change in the [energy efficiency surcharge], will provide an accurate and understandable assessment of the increase that will actually appear on customers' bills." Id. The Department agreed "with the stakeholders who argue that, when considering the reasonableness of a short-term bill impact from energy efficiency activities, it is important to look at it the long-term benefits that energy efficiency will achieve." D.P.U. 08-50-D, at 11. The Department stated that the "long-term benefits of energy efficiency are fully documented by the PAs and reviewed by the Department and stakeholders in the context of evaluating program cost-effectiveness" and that the Department will consider bill impacts through "the lens of the long-term benefits that energy efficiency can achieve." Id. at 11-12 (citations omitted). The Department directed the PAs to conduct bill impact analyses going forward for energy efficiency participants as well as non-participants. This methodology is discussed in more detail in Section III.E.
e. D.P.U. 11-120, Phase 1 (2012)	On November 29, 2011, the Department opened an investigation to examine issues associated with the PAs' Three-Year Plans, through D.P.U. 11-120. In the first phase of the investigation, the Department announced that it

	would examine the following issues associated with energy efficiency program benefits that are included in the cost-effectiveness determination: (1) the method used to calculate program net savings; and (2) the method used to calculate reasonably anticipated environmental compliance costs, in particular those associated with the emission of carbon dioxide. Interested parties filed initial and reply comments and participated in a Department technical session to discuss issues related to net savings. On August 10, 2012, the Department issued D.P.U. 11-120-A, *Order on Program Net Savings and Environmental Compliance Costs* (2012), addressing two issues related to program net savings: (1) alternate methods to determine program net savings; and (2) the prospective or retrospective application of evaluation study results. In addition, the Department declined to adopt an interim proxy value for carbon dioxide to be used in the cost-effectiveness determination of energy efficiency programs. With respect to net savings, the Department indicated support for alternative approaches to determining net savings that look at effects that occur over multi-year periods and across programs, which is consistent with the approach recommended in the joint comments of the PAs, DOER, DEP, ENE and NEEP. The Department announced that it would convene a working group to explore if and how an alternate (i.e., market-focused) approach to determine program net savings could be developed and implemented. With respect to EM&V results, the Department found that it is appropriate for PAs, when calculating post-implementation program savings (gross and net), to use: (1) the most recently updated gross savings impact factors; and (2) the net savings impact factors that were used when the programs were designed and developed.
f. D.P.U. 11-120-A, Phase II (2013)	On May 25, 2012, the Department opened a second phase of this investigation with D.P.U. 11-120, Phase II to examine issues associated with the PAs' Three-Year Plans. In the second phase of this investigation, the Department decided to examine recurring filings that the Department has reviewed during the term of the first Three-Year Plans, including: (1) MTMs; (2) the performance reports submitted by each PA annually, which include the calculation of a performance incentive payment; and (3) the calculation and reconciliation of each PA's energy efficiency surcharges. Interested parties filed comments and attended a Department-convened technical session. On January 31, 2013, the Department issued D.P.U. 11-120-A, Phase II, *Order Approving Revised Energy Efficiency Guidelines* (2013). Key themes of the revised guidelines include treating the PAs' Three-Year Plans under the GCA as one Three-Year Plan as opposed to three one-year plans, and reducing (but not eliminating) the potential for MTMs and recurring annual Department energy efficiency reviews. The Department also determined that only performance reports at the end of each three-year term will be litigated instead of litigating each annual performance report. The Department also addressed performance incentives, energy efficiency surcharges, and MTMs.
4. Mid-Term Modifications	
a. Compact's 2010 MTM, D.P.U. 10-106 (2011)	On August 13, 2010, Cape Light Compact filed a request with the Department for a MTM of its 2010-2012 Plan, consisting of an adjustment of its 2010 program budgets. The Cape Light Compact sought Department approval for a program budget change that was 20 percent greater than the

	program's annual budget. While § 3.8.2 of the D.P.U. 08-50-B Guidelines describes the conditions that require a filing of a MTM, that section did not state whether the 20 percent thresholds should be applied on a three-year or an annual basis. On January 10, 2011, the Department issued D.P.U. 10-106, stating that the three-year plan review process should move away from routine MTMs, and clarifying that D.P.U. 08-50-B Guidelines "§ 3.8.2 should be interpreted such that Department approval is required for a program budget change that is 20 percent greater than the program's three-year budget." D.P.U. 10-106, at 7-8. Additionally, the Department noted that the D.P.U. 08-50-B Guidelines are not fixed and are intended to be updated over time.
b. 2011 MTMs, D.P.U. 10-140 through D.P.U. 10-150	Each PA individually filed MTMs to its 2010-2012 Plan for effect in calendar year 2011 on or about October 29, 2010, pursuant to § 3.8 of the Department's D.P.U. 08-50-B Guidelines and the Department's 2010-2012 Orders. The PAs developed their MTMs for 2011 based on a set of four operating assumptions which were based on their interpretation of D.P.U. 08-50-B Guidelines, particularly §3.8.2 which relates to the timing and substantive requirements for MTMs. The PAs responded to numerous statewide and individual information responses from the Department and intervenors. Finally and significantly, on December 14, 2010, the Council adopted a resolution in support of the MTMs for 2011. On April 15, 2011, following comprehensive negotiations, the PAs, DOER, the Low-Income Weatherization and Fuel Assistance Network, Massachusetts Energy Directors Association, the Low-Income Energy Affordability Network and Environment Northeast jointly filed for approval with the Department a Memorandum of Agreement intended to resolve all issues related to the respective requests for the 2011 MTMs. The Memorandum of Agreement resolved eleven docketed matters of first impression and had the support of a broad array of stakeholders, including the approval of the Council. On July 1, 2011, the AG filed comments in the 2011 MTM proceedings, making a number of recommendations but not opposing approval of the Memorandum of Agreement by the Department.
c. 2012 MTMs, D.P.U. 11-106 through D.P.U. 11-116	Each PA individually filed MTMs to its 2012-2015 Plan for effect in calendar year 2012 on October 31, 2011, also pursuant to § 3.8 of the Department's D.P.U. 08-50-B Guidelines and the Department's 2010-2012 Orders. The PAs responded to numerous statewide and individual information requests from the Department and other intervenors. On December 12, 2011, DOER filed with the Department the Council's resolution in support of the MTMs for 2012, which was adopted on November 8, 2011. On May 2, 2012, the Department approved a Partial Settlement on Scope of the Proceedings, submitted jointly by the PAs and the AG, DOER, and the Low-Income Weatherization and Fuel Assistance Program Network, the Massachusetts Energy Directors Association, the Low-Income Energy Affordability Network, and Environment Northeast. Accordingly, any issue with respect to the use of estimated avoided costs based on the 2011 Avoided Energy Supply Costs in New England: 2011 Report (July 21, 2011, amended August 11, 2011) and estimated non-energy benefits (also known as non-energy impacts) based on the Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts Evaluation (August 15, 2011) would not be addressed in the proceedings for the MTMs for 2012.
d. Order approving 2011 and	On November 26, 2014, the Department issued an order approving, with

2012 MTMs, D.P.U. 10-140 through D.P.U. 10-150; and D.P.U. 11-106 through D.P.U. 11-116 (2014)	exceptions the PAs' 2011 and 2012 MTMs. The Department found the MTMs for 2011 and 2012 were consistent with the D.P.U. 08-50-B Guidelines and resulted in a modified Plan that is designed to capture all available energy efficient and demand reduction resources that are cost-effective or less expensive than supply. With regard to the 2011 and 2012 statewide incentive pool allocations, the Department approved the PI payout allocations of the statewide incentive pool as proposed. The Department did not approve the Cost-Efficiency Metric for 2011 or 2012, finding that the PAs had not sufficiently demonstrated that the Cost Efficiency metric will cause the PAs to undertake actions that they otherwise would not have taken. The Department approved the electric pilot program budgets for 2011 and 2012, as well as the proposed 2011 and 2012 statewide EM&V plan. With regard to the AG's recommendations for additional documentation and/or the development of a common project screening tool, the Department did not adopt the recommendations because cost-effectiveness is reviewed at the program level and not the project level. The Department also allowed the PAs to claim incremental energy efficiency savings associated with the ARRA-funded residential gas program. For the Low-Income Single Family Retrofit and the Multi-Family Retrofit programs, the Department directed the PAs to track spending and savings associated with each pre-consolidated programs, but the Department concluded not require the PAs to report data on pre-consolidated programs.
5. Annual Reports	
a. 2010 Annual Reports - D.P.U. 11-63 through D.P.U 11-73, D.P.U. 11-126	
i. Gas Orders (2013)	
D.P.U. 11-64 NSTAR Gas Company D.P.U 11-65 Bay State Gas Company, d/b/a Columbia Gas of Massachusetts D.P.U. 11-66 New England Gas Company D.P.U. 11-67 The Berkshire Gas Company D.P.U. 11-70 Fitchburg Gas & Electric Light Company d/b/a Unitil D.P.U. 11-73 Boston Gas Company and Colonial Gas Company, d/b/a National Grid D.P.U. 11-126 Blackstone Gas Company	On November 21, 2013, the Department issued orders approving the 2010 Gas Energy Efficiency Annual Report, as outlined to the left. While the Department found certain programs were not cost-effective in program year 2010, the Department did find the decision to continue each such program as reasonable because of projections that such programs will be cost-effective in the future. The Department found that each company clearly presented and sufficiently explained with adequate supporting documentation their residential, low-income, and C&I EM&V program evaluations. The Department found that each company that requested may collect lost base revenues resulting from the savings and each Company shall submit all necessary documentation supporting the calculation of lost base revenues for program year 2010 in its next LDAF filing. The Department determined the companies have minimized its administrative costs to the fullest extent practicable. The Department found that the companies either met the statutory requirement to spend at least 20 percent of total program costs on low-income programs, or will work to improve delivery of low-income programs in future program years if the company did not meet the statutory minimum for low-income expenditures because it is first program year with the 20 percent requirement. The Department found each company used competitive procurement processes to the fullest extent practicable. Where requested, the Department found that each company may recover performance incentives. Additionally, the Department recognized that collaboration among PAs is beneficial, but stated that a PA must demonstrate its clear and distinct role in bringing about the desired outcome. The Department declined to address the recommended policy changes of the AG and DOER, as such changes were outside the scope of the annual report proceedings.

ii. Electric Orders (2014)	
D.P.U 11-63 NSTAR Electric Company D.P.U. 11-68 Cape Light Compact D.P.U. 11-69 Western Massachusetts Electric Company D.P.U. 11-71 Fitchburg Gas and Electric Light Company d/b/a Unitil D.P.U. 11-72 Massachusetts Electric Company and Nantucket Electric Company, d/b/a National Grid	On May 2, 2014, the Department issued orders approving the 2010 Energy Efficiency Annual Reports, as outlined to the left. The Department found that nearly all energy efficiency programs were cost-effective as implemented. In the instances where a program was not cost-effective, the Department found decisions to continue such programs reasonable because of projections that the programs would be cost effective going forward. The Department found that each company clearly presented and sufficiently explained with adequate supporting documentation their residential, low-income, and C&I EM&V program evaluations. The Department found that each company minimized its administrative costs to the fullest extent practicable. In instances where there was administrative cost overrun, the Department expects such Companies will continue to work to minimize its administrative costs. The company has met the statutory requirement to spend at least 10 percent of total program costs on low-income programs. The Department found each company used competitive procurement processes to the fullest extent practicable. Where requested, the Department found that each company may recover performance incentives. Additionally, the Department recognized that collaboration among PAs is beneficial, but stated that a PA must demonstrate its clear and distinct role in bringing about the desired outcome. The Department declined to address the recommended policy changes of the AG and DOER, as such changes were outside the scope of the Annual Report proceedings.
b. 2011 and 2012 Annual Reports (2014) - D.P.U. 12-51 through D.P.U 12-61; D.P.U. 13-110 through D.P.U. 13-122	
i. Gas	
D.P.U 12-51; D.P.U. 13-113 The Berkshire Gas Company D.P.U. 12-52; D.P.U. 13-112 Bay State Gas Company D.P.U. 12-53; D.P.U. 13-115 New England Gas Company D.P.U. 12-59; D.P.U. 13-114 Fitchburg Gas and Electric Light Company d/b/a Unitil Gas Company D.P.U. 13-110; D.P.U. 13-111 Blackstone Gas Company D.P.U. 12-56; D.P.U. 13-116 Boston Gas Company and	On November 26, 2014, the Department issued orders approving the 2011 and 2012 Gas Energy Efficiency Annual Reports, as outlined to the left. The Department found that each company's energy efficiency programs were cost effective as implemented for program years 2011 and 2012, and in instances where the program was not cost-effective, the Department determined that the decision to decision to continue these programs, as modified, was reasonable because of projections to be cost-effective going forward. The Department determined, after review of each company's invoices, that expenditures were reasonable and prudently incurred. The Department found each Company, that requested may collect lost base revenues resulting from the savings and shall submit all necessary documentation supporting the calculation of lost base revenues for program years 2011 and 2012, as applicable, in its next LDAF filing. The Department found that each company clearly presented and sufficiently explained with adequate supporting documentation their residential, low-income, and C&I EM&V program evaluations. The Department determined each company minimized its administrative costs to the fullest extent practicable. The Department found that the companies either met the statutory requirement to spend at least 20 percent of total program costs on low-income programs, or will work to improve participation in its low-income programs in future years. The Department found each company has used competitive procurement processes to the fullest extent practicable in program years 2011 and 2012. The Department approved the performance incentives requested by each company with some limited exceptions. The Department allowed the companies to include NEIs in the calculation of performance incentives, even though these NEI values were not originally planned. The Department declined to implement a uniform cap on administrative costs or a threshold for competitive procurement as requested by the AG because the Department evaluates performance on a company-by-company basis. The Department did not

Colonial Gas Company d/b/a National Grid D.P.U. 12-61; D.P.U. 13-117 NSTAR Gas Company	address DOER's issues regarding the consistency of nomenclature and reporting because such issues were outside the scope of the annual reports proceeding.
ii. Electric	
D.P.U. 12-54; D.P.U. 13-118 Cape Light Compact D.P.U. 12-55; D.P.U. 13-122 Western Massachusetts Electric Company D.P.U. 12-57; D.P.U. 13-120 Boston Gas Company and Colonial Gas Company d/b/a National Grid D.P.U. 12-58; D.P.U. 13-119 Fitchburg Gas and Electric Light Company d/b/a Unitil Gas Company D.P.U. 12-60; D.P.U. 13-121 NSTAR Electric Company	On December 19, 2014, the Department issued and order, approving the 2011 and 2012 Electric Energy Efficiency Annual Reports submitted, as outlined to the left. The Department found that each company's energy efficiency programs were cost effective as implemented for program years 2011 and 2012, and in instances where the program was not cost-effective, the Department determined that the decision to decision to continue such program as modified, was reasonable. The Department determined, after review of each company's invoices, that expenditures were reasonable and prudently incurred. The Department found that each company has demonstrated that actual savings, at the levels documented in annual reports, resulted from activities during program years 2011 and 2012. The Department found that each company clearly presented and sufficiently explained with adequate supporting documentation their residential, low-income, and C&I EM&V program evaluations. The Department determined each company minimized its administrative costs to the fullest extent practicable. The Department found that the companies met the statutory requirement to spend at least 10 percent of its energy efficiency budget on low-income programs. The Department found each company used competitive procurement processes to the fullest extent practicable in program years 2011 and 2012. The Department found that NEIs were properly included in calculation of performance incentive, including the NEIs for National Security, Refrigerator/Freezer Turn-in and Economic Development (although these three NEIs may not be included going forward). Where requested, the Department found that each company may recover performance incentives. The Department declined to implement a uniform cap on administrative costs or a threshold for competitive procurement as requested by the AG because the Department evaluates performance on a company-by-company basis. The Department did not address DOER's issues regarding the consistency of nomenclature and reporting because such issues were outside the scope of the annual reports proceeding.
6. Miscellaneous	
A. 2013-2015 Performance Metrics, D.P.U. 13-67 (2014)	In D.P.U. 13-67, the Department concluded that performance metrics are no longer a necessary component of the PAs' performance incentive mechanism and, therefore, did not approve the metrics for 2013. As noted in this Order and the 2013-2015 Order, the portion of the statewide incentive pool allocated to performance metrics will be reallocated to the savings and value components of the performance incentive mechanism. Therefore, the PI pool will remain intact and PAs retain the ability to earn the total amount of PI allocated to them. This Order states that metrics were originally intended to incentivize specific activities, but now that the GCA requires all available cost-effective energy efficiency, metrics would only seek to incentivize activities that are already required. This Order also states that the PAs do not need the guidance traditionally provided by metrics to the PAs, noting that the "Program Administrators, in conjunction with the Council and other stakeholders, have developed a comprehensive infrastructure to promote statewide energy

	efficiency program integration and continuous improvement in program delivery." D.P.U. 13-67, at 11. The Order specifically notes that the PA management committees and low-income best practices working group address program implementation barriers and foster communication with the Council and other stakeholders. The Department also found that "[n]egotiating, satisfying, and documenting performance metrics is costly and time consuming." Id. at 13, n.25. The Department found that such an investment of time and resources solely for the purpose of verifying metric performance is out of proportion with the potential benefit of metrics. Further, verifying performance of these metrics would divert PA and stakeholders focus from the successful implementation of the Three-Year Plans and is inconsistent with the Department's obligation to fulfill its oversight responsibilities in an administratively efficient and effective manner.
B. 2013 Avoided Energy Supply Component Study Energy Efficiency Updates, D.P.U. 14-05	Following discussions at Department technical sessions on application of the 2013 AESC, on January 27, 2014, the Department issued a Memorandum indicating that each PA shall submit: (i) individually, revised D.P.U. 08-50 tables with a revised benefit-cost ratio screening model to incorporate the AESC 2013 avoided cost factors for program years 2014 and 2015; and (ii) jointly, revised statewide electric and gas D.P.U. 08-50 tables with a revised performance incentive model to incorporate the AESC 2013 avoided cost factors. PAs submitted revised PA-specific and statewide electric and gas D.P.U. 08-50 tables and performance incentive models that incorporated the Avoided Energy Supply Cost study ("AESC") 2013 avoided cost factors on February 28, 2014. As part of the revised electric and gas performance incentive models, the PAs proposed to eliminate performance metrics as a component of the performance incentive mechanism, while retaining the savings and value mechanisms and their relative weights. Several parties, including DOER, the AG, LEAN, Environment Northeast (n/k/a Acadia Center), and the PAs filed comments in this docket.
C. Method for Calculating Avoided Costs of Complying with Global Warming Solutions Act, D.P.U. 14-86	On May 16, 2014, DEP and DOER (collectively "Petitioners") filed a joint petition requesting that the Department adopt a value for the avoided cost of complying with the Global Warming Solutions Act ("GWSA") calculated using a marginal abatement cost curve method. Method for Calculating Avoided Costs of Complying with Global Warming Solutions Act, D.P.U. 14-86. Following the filing of pre-filed testimony and discovery responses, evidentiary hearings were held on December 8 and 10, 2014. Intervenors filed initial briefs on December 31, 2014, and the Petitioners, after seeking an extension, filed their initial brief on January 23, 2015. Intervenors filed reply briefs on February 13, 2015. The PAs (except for the Compact and Blackstone Gas) filed a joint reply brief asking the Department to deny the petition on the grounds that the GWSA does not impose costs on the PAs or their customers, the petitioners did not sufficiently quantify the proposed GWSA compliance value and GHG reductions are an important byproduct, but are not a specific requirement, of energy efficiency programs implemented pursuant to the GCA. The Department later permitted additional discovery on the Petitioners with respect to a record request update filed with their initial brief. Briefs related to this issue were filed on April 10, 2015.

C. **<u>Statewide Energy Efficiency Data Tables</u>**

Energy Efficiency Tables

Overview

DPU 15-160 - 15-169
Exh. 1, Appendix C
H.O.s Leupold and Hale

Statewide Electric
October 30, 2015

OVERVIEW

The following data tables provide a summary of the Program Administrator's benefits, costs, savings, and cost-effectiveness for 2013 through 2018. The 2013 through 2015 planned values are consistent with each Program Administrator's 2013-2015 Three-Year Plan. The 2013 and 2014 evaluated values are consistent with each Program Administrator's 2013 and 2014 Plan-Year Reports. The 2015 year-to-date data represents the most up-to-date estimated actual values available. Specifically, 2015 year-to-date costs and each Program Administrator's primary-fuel savings are estimated actuals through August 2015, while the 2015 year-to-date benefits and each Program Administrator's non-primary-fuel savings are estimated actuals through June 2015 consistent with the 2015 Second Quarterly Report. The 2016-2018 planned values are consistent with each Program Administrator's 2016-2018 Three-Year Plan.

The data included in these tables is based on other supporting models. The primary supporting models used by the Program Administrators are the Benefit-Cost Screening model, each Program Administrator's EES calculation support documents, and the Performance Incentive model. These exhibits should be referenced when looking for more detailed analyses, such as measure level detail and EES calculations. High-level summaries for each of these models are provided below, along with information on plan details that are not summarized in the following plan tables.

BENEFIT-COST SCREENING MODEL

The Benefit-Cost Screening model provides measure level savings and benefits. This model uses the avoided cost values from the 2015 Avoided Energy Supply Cost study prepared by Tabors Caramanis Rudkevich.

EES CALCULATIONS

Each Program Administrator's Energy Efficiency Surcharge analysis provides supporting information on the EES rates proposed for effect in 2016-2018, including how the rates are calculated for each customer sector, and how revenue is collected from each customer sector.

PERFORMANCE INCENTIVE MODEL

The Performance Incentive model filed as part of the Joint Statewide Three-Year Plan provides support for the performance incentive dollars proposed for collection by the Program Administrator. Note that performance incentives are not applicable to the Cape Light Compact.

EM&V ACTIVITIES

The Evaluation, Monitoring & Verification Section of the Joint Statewide Three-Year Plan describes in detail the EM&V activities planned for 2016-2018.

OTHER FUNDING

For the electric Program Administrators, "Other Funding" are those funds, private or public utility administered or otherwise, that may be available for energy efficiency or demand resources and do not include SBC Funds, FCM Revenue, or RGGI Proceeds. The electric Program Administrators assume no other funding sources for 2016-2018.

IV.D. Cost Effectiveness

Additional Filing Requirements

Statewide Electric

October 30, 2015

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2013 Evaluated Additional Filing Requirements

Program	Participants	Annual Savings			Total Energy Benefits	Total Costs		Savings per TRC Costs			Savings per Participant per TRC Costs			Total Energy Benefits		
		Electric Energy	Natural Gas	Oil		Program Costs	TRC Test Costs	Electric Energy	Natural Gas	Oil	Electric Energy	Natural Gas	Oil	per Program Costs	per TRC Costs	per Participant per TRC Costs
	(#)	(MWh)	(Therms)	(MMBTU)	($)	(Nominal $)	(2013$)	(kWh/$)	(Therms/$)	(MMBTU/$)	(kWh/#/$)	(Therms/#/$)	(MMBTU/#/$)	($/$)	($/$)	($/#/$)
A - Residential	**2,655,894**	**414,357**	**275,082**	**448,401**	**647,383,686**	**176,028,158**	**254,074,390**	**1.631**	**0.001**	**0.0018**	**0.0000**	**0.000000**	**0.0000000**	**3.678**	**2.548**	**0.000**
A1 - Residential Whole House	933,412	178,896	306,048	448,401	372,249,186	109,130,479	143,400,453	1.248	0.002	0.0031	0.0000	0.000000	0.0000000	3.411	2.596	0.000
Residential New Construction & Major Renovation	4,082	8,045	17,233	1,458	37,269,226	4,452,346	17,697,294	0.455	0.001	0.0001	0.0001	0.000000	0.0000000	8.371	2.106	0.001
Residential Multi-Family Retrofit	29,376	21,134	1,063	7	23,793,059	18,563,958	18,254,816	1.158	0.000	0.0000	0.0000	0.000000	0.0000000	1.282	1.303	0.000
Residential Home Energy Services	45,507	59,056	287,751	446,936	300,226,292	77,578,224	98,780,301	0.598	0.003	0.0045	0.0000	0.000000	0.0000001	3.870	3.039	0.000
Residential Behavior/Feedback Program	854,447	90,662	-	-	10,960,609	8,535,951	8,668,042	10.459	-	-	0.0000	-	-	1.284	1.264	0.000
A2 - Residential Products	1,722,482	235,461	(30,966)	-	275,134,500	47,205,855	90,978,666	2.588	(0.000)	-	0.0000	(0.000000)	-	5.828	3.024	0.000
Residential Cooling & Heating Equipment	17,723	12,175	(30,966)	-	22,326,318	10,561,908	15,284,598	0.797	(0.002)	-	0.0000	(0.000000)	-	2.114	1.461	0.000
Residential Lighting	1,586,782	207,161	-	-	236,181,547	30,160,444	67,004,656	3.092	-	-	0.0000	-	-	7.831	3.525	0.000
Residential Consumer Products	117,977	16,125	-	-	16,626,635	6,483,503	8,689,412	1.856	-	-	0.0000	-	-	2.564	1.913	0.000
A3 - Residential Hard-to-Measure	-	-	-	-	-	19,691,825	19,695,271	-	-	-				-	-	
B - Low-Income	**35,793**	**34,522**	**38,500**	**92,096**	**92,083,166**	**50,434,512**	**52,741,787**	**0.655**	**0.001**	**0.0017**	**0.0000**	**0.000000**	**0.0000000**	**1.826**	**1.746**	**0.000**
B1 - Low-Income Whole House	35,793	34,522	38,500	92,096	92,083,166	49,506,588	51,813,864	0.666	0.001	0.0018	0.0000	0.000000	0.0000000	1.860	1.777	0.000
Low-Income New Construction	663	490	36,383	35	2,674,882	485,245	902,930	0.543	0.040	0.0000	0.0008	0.000061	0.0000001	5.512	2.962	0.004
Low-Income Single Family Retrofit	11,813	15,045	4,373	92,033	68,889,299	30,048,459	31,394,118	0.479	0.000	0.0029	0.0000	0.000000	0.0000002	2.293	2.194	0.000
Low-Income Multi-Family Retrofit	23,317	18,986	(2,255)	28	20,518,985	18,972,884	19,516,816	0.973	(0.000)	0.0000	0.0000	(0.000000)	0.0000000	1.081	1.051	0.000
B2 - Low-Income Hard-to-Measure	-	-	-	-	-	927,923	927,923	-	-	-				-	-	
C - Commercial & Industrial	**30,717**	**667,562**	**(5,954,148)**	**(67,456)**	**1,170,786,588**	**196,289,244**	**325,517,997**	**2.051**	**(0.018)**	**(0.0002)**	**0.0001**	**(0.000001)**	**(0.0000000)**	**5.965**	**3.597**	**0.000**
C1 - C&I New Construction	22,982	215,009	(679,649)	(40,064)	411,110,851	53,361,126	83,209,513	2.584	(0.008)	(0.0005)	0.0001	(0.000000)	(0.0000000)	7.704	4.941	0.000
C&I New Construction	22,982	215,009	(679,649)	(40,064)	411,110,851	53,361,126	83,209,513	2.584	(0.008)	(0.0005)	0.0001	(0.000000)	(0.0000000)	7.704	4.941	0.000
C2 - C&I Retrofit	7,735	452,553	(5,274,499)	(27,391)	759,675,737	139,118,386	238,493,149	1.898	(0.022)	(0.0001)	0.0002	(0.000003)	(0.0000000)	5.461	3.185	0.000
C&I Retrofit	2,184	349,260	(4,445,145)	(26,652)	590,167,937	78,768,031	160,755,675	2.173	(0.028)	(0.0002)	0.0010	(0.000013)	(0.0000001)	7.492	3.671	0.002
C&I Direct Install	5,551	103,293	(829,354)	(739)	169,507,800	60,350,355	77,737,473	1.329	(0.011)	(0.0000)	0.0002	(0.000002)	(0.0000000)	2.809	2.181	0.000
C3 - C&I Hard-to-Measure	-	-	-	-	-	3,809,732	3,815,335	-	-	-				-	-	
Grand Total	**2,722,404**	**1,116,442**	**(5,640,566)**	**473,041**	**1,910,253,441**	**422,751,913**	**632,334,174**	**1.766**	**(0.009)**	**0.0007**	**0.0000**	**(0.000000)**	**0.0000000**	**4.519**	**3.021**	**0.000**

2014 Evaluated Additional Filing Requirements

Program	Participants	Annual Savings			Total Energy Benefits	Total Costs		Savings per TRC Costs			Savings per Participant per TRC Costs			Total Energy Benefits		
		Electric Energy	Natural Gas	Oil		Program Costs	TRC Test Costs	Electric Energy	Natural Gas	Oil	Electric Energy	Natural Gas	Oil	per Program Costs	per TRC Costs	per Participant per TRC Costs
	(#)	(MWh)	(Therms)	(MMBTU)	($)	(Nominal $)	(2013$)	(kWh/$)	(Therms/$)	(MMBTU/$)	(kWh/#/$)	(Therms/#/$)	(MMBTU/#/$)	($/$)	($/$)	($/#/$)
A - Residential	**3,770,105**	**520,010**	**383,265**	**489,635**	**798,081,039**	**206,769,165**	**322,262,215**	**1.614**	**0.001**	**0.0015**	**0.0000**	**0.000000**	**0.000000**	**3.860**	**2.476**	**0.000**
A1 - Residential Whole House	1,098,407	247,714	386,775	489,422	454,931,613	128,169,698	167,500,324	1.479	0.002	0.0029	0.0000	0.000000	0.000000	3.549	2.716	0.000
Residential New Construction & Major Renovation	5,786	9,013	11,015	1,231	40,917,819	5,682,029	19,117,647	0.471	0.001	0.0001	0.0001	0.000000	0.000000	7.201	2.140	0.000
Residential Multi-Family Retrofit	31,716	26,517	1,125	8	32,299,494	23,112,891	22,328,892	1.188	0.000	0.0000	0.0000	0.000000	0.000000	1.397	1.447	0.000
Residential Home Energy Services	45,402	84,532	374,635	488,184	369,433,463	89,773,098	116,558,832	0.725	0.003	0.0042	0.0000	0.000000	0.000000	4.115	3.170	0.000
Residential Behavior/Feedback Program	1,015,503	127,651	-	-	12,280,836	9,601,679	9,494,952	13.444	-	-	0.0000	-	-	1.279	1.293	0.000
A2 - Residential Products	2,671,698	272,296	(3,510)	212	343,149,426	55,572,698	132,336,500	2.058	(0.000)	0.0000	0.0000	(0.000000)	0.000000	6.175	2.593	0.000
Residential Cooling & Heating Equipment	20,313	11,263	(26,503)	-	21,554,148	11,005,450	15,593,716	0.722	(0.002)	-	0.0000	(0.000000)	-	1.958	1.382	0.000
Residential Lighting	2,548,428	247,134	-	-	299,879,428	36,745,259	106,404,206	2.323	-	-	0.0000	-	-	8.161	2.818	0.000
Residential Consumer Products	102,957	13,899	22,993	212	21,715,850	7,821,990	10,338,578	1.344	0.002	0.0000	0.0000	0.000000	0.000000	2.776	2.100	0.000
A3 - Residential Hard-to-Measure	-	-	-	-	-	23,026,769	22,425,391	-	-	-				-	-	
B - Low-Income	**36,419**	**45,872**	**46,402**	**74,468**	**97,597,675**	**58,338,399**	**58,403,772**	**0.785**	**0.001**	**0.0013**	**0.0000**	**0.000000**	**0.000000**	**1.673**	**1.671**	**0.000**
B1 - Low-Income Whole House	36,419	45,872	46,402	74,468	97,597,675	57,461,035	57,549,814	0.797	0.001	0.0013	0.0000	0.000000	0.000000	1.699	1.696	0.000
Low-Income New Construction	885	422	45,788	-	2,132,182	771,052	985,677	0.428	0.046	-	0.0005	0.000052	-	2.765	2.163	0.002
Low-Income Single Family Retrofit	10,485	15,480	614	74,440	61,613,529	26,330,204	26,495,721	0.584	0.000	0.0028	0.0001	0.000000	0.000000	2.340	2.325	0.000
Low-Income Multi-Family Retrofit	25,049	29,970	-	28	33,851,964	30,359,779	30,068,416	0.997	-	0.0000	0.0000	-	0.000000	1.115	1.126	0.000
B2 - Low-Income Hard-to-Measure	-	-	-	-	-	877,364	853,958	-	-	-				-	-	
C - Commercial & Industrial	**16,971**	**773,144**	**(3,003,851)**	**(81,799)**	**1,176,837,557**	**238,735,325**	**365,021,009**	**2.118**	**(0.008)**	**(0.0002)**	**0.0001**	**(0.000000)**	**(0.000000)**	**4.929**	**3.224**	**0.000**
C1 - C&I New Construction	9,555	321,885	(1,477,742)	(79,405)	491,694,565	70,992,549	104,903,271	3.068	(0.014)	(0.0008)	0.0003	(0.000001)	(0.000000)	6.926	4.687	0.000
C&I New Construction	9,555	321,885	(1,477,742)	(79,405)	491,694,565	70,992,549	104,903,271	3.068	(0.014)	(0.0008)	0.0003	(0.000001)	(0.000000)	6.926	4.687	0.000
C2 - C&I Retrofit	7,416	451,259	(1,526,109)	(2,394)	685,142,991	163,618,258	256,095,913	1.762	(0.006)	(0.0000)	0.0002	(0.000001)	(0.000000)	4.187	2.675	0.000
C&I Retrofit	2,110	347,084	(658,322)	(1,823)	527,392,191	100,872,322	178,553,704	1.944	(0.004)	(0.0000)	0.0009	(0.000002)	(0.000000)	5.228	2.954	0.001
C&I Direct Install	5,306	104,175	(867,787)	(572)	157,750,801	62,745,936	77,542,209	1.343	(0.011)	(0.0000)	0.0003	(0.000002)	(0.000000)	2.514	2.034	0.000
C3 - C&I Hard-to-Measure	-	-	-	-	-	4,124,518	4,021,825	-	-	-				-	-	
Grand Total	**3,823,495**	**1,339,026**	**(2,574,185)**	**482,303**	**2,072,516,271**	**503,842,890**	**745,686,996**	**1.796**	**(0.003)**	**0.0006**	**0.0000**	**(0.000000)**	**0.000000**	**4.113**	**2.779**	**0.000**

IV.D. Cost Effectiveness
Additional Filing Requirements
Statewide Electric
October 30, 2015

DPU 15-160 - 15-169
Exh. 1, Appendix C
H.O.s Leupold and Hale

2015 YTD Additional Filing Requirements

Program	Participants	Annual Savings			Total Energy Benefits	Total Costs		Savings per PA Costs*			Savings per Participant per PA Costs*			Total Energy Benefits		
		Electric Energy	Natural Gas	Oil		Program Costs	Program Costs*	Electric Energy	Natural Gas	Oil	Electric Energy	Natural Gas	Oil	per Program Costs (Nominal)	per PA Costs (2013$)*	per Participant per PA Costs*
	(#)	(MWh)	(Therms)	(MMBTU)	($)	(Nominal $)	(2013$)	(kWh/$)	(Therms/$)	(MMBTU/$)	(kWh/#/$)	(Therms/#/$)	(MMBTU/#/$)	($/$)	($/$)	($/#/$)
A - Residential	**2,260,217**	**357,248**	**214,200**	**178,997**	**545,931,597**	**94,224,872**	**89,277,862**	**4.002**	**0.002**	**0.0020**	**0.0000**	**0.000000**	**0.000000**	**5.794**	**6.115**	**0.000**
A1 - Residential Whole House	840,334	166,029	220,943	178,801	251,289,518	60,242,660	57,081,286	2.909	0.004	0.0031	0.0000	0.000000	0.000000	4.171	4.402	0.000
Residential New Construction & Major Renovation	2,457	6,132	2,542	436	26,540,161	2,237,966	2,121,487	2.891	0.001	0.0002	0.0012	0.000000	0.000000	11.859	12.510	0.005
Residential Multi-Family Retrofit	16,489	18,965	1,132	1	20,171,575	9,342,948	8,852,136	2.142	0.000	0.0000	0.0001	0.000000	0.000000	2.159	2.279	0.000
Residential Home Energy Services	20,843	78,938	210,230	178,364	200,217,633	41,789,499	39,602,151	1.993	0.005	0.0045	0.0001	0.000000	0.000000	4.791	5.056	0.000
Residential Behavior/Feedback Program	800,545	61,994	7,039	-	4,360,149	6,872,247	6,505,513	9.529	0.001	-	0.0000	0.000000	-	0.634	0.670	0.000
A2 - Residential Products	1,419,883	191,219	(6,743)	196	294,642,079	25,855,614	24,498,838	7.805	(0.000)	0.0000	0.0000	(0.000000)	0.000000	11.396	12.027	0.000
Residential Cooling & Heating Equipment	6,795	15,725	(17,270)	-	13,422,487	4,961,971	4,702,059	3.344	(0.004)	-	0.0005	(0.000001)	-	2.705	2.855	0.000
Residential Lighting	1,385,708	166,960	-	-	267,444,887	17,877,741	16,936,552	9.858	-	-	0.0000	-	-	14.960	15.791	0.000
Residential Consumer Products	27,380	8,534	10,527	196	13,774,704	3,015,902	2,860,227	2.984	0.004	0.0001	0.0001	0.000000	0.000000	4.567	4.816	0.000
A3 - Residential Hard-to-Measure	-	-	-	-	-	8,126,598	7,697,738	-	-	-				-	-	
B - Low-Income	**15,267**	**36,450**	**5,071**	**28,979**	**47,834,771**	**25,947,659**	**24,581,708**	**1.483**	**0.000**	**0.0012**	**0.0001**	**0.000000**	**0.000000**	**1.844**	**1.946**	**0.000**
B1 - Low-Income Whole House	15,267	36,450	5,071	28,979	47,834,771	25,664,626	24,313,507	1.499	0.000	0.0012	0.0001	0.000000	0.000000	1.864	1.967	0.000
Low-Income New Construction	250	289	4,894	-	807,024	226,027	215,781	1.341	0.023	-	0.0054	0.000091	-	3.570	3.740	0.015
Low-Income Single Family Retrofit	5,624	11,717	177	28,889	29,788,237	13,034,111	12,352,506	0.949	0.000	0.0023	0.0002	0.000000	0.000000	2.285	2.412	0.000
Low-Income Multi-Family Retrofit	9,393	24,443	-	90	17,239,510	12,404,488	11,745,220	2.081	-	0.0000	0.0002	-	0.000000	1.390	1.468	0.000
B2 - Low-Income Hard-to-Measure	-	-	-	-	-	283,034	268,202	-	-	-				-	-	
C - Commercial & Industrial	**4,529**	**278,958**	**(1,019,620)**	**(8,861)**	**276,625,535**	**70,611,115**	**66,917,063**	**4.169**	**(0.015)**	**(0.0001)**	**0.0009**	**(0.000003)**	**(0.000000)**	**3.918**	**4.134**	**0.001**
C1 - C&I New Construction	1,444	117,232	(364,616)	(7,922)	106,291,362	14,921,092	14,140,613	8.290	(0.026)	(0.0006)	0.0057	(0.000018)	(0.000000)	7.124	7.517	0.005
C&I New Construction	1,444	117,232	(364,616)	(7,922)	106,291,362	14,921,092	14,140,613	8.290	(0.026)	(0.0006)	0.0057	(0.000018)	(0.000000)	7.124	7.517	0.005
C2 - C&I Retrofit	3,085	161,726	(655,004)	(938)	170,334,173	53,428,040	50,633,666	3.194	(0.013)	(0.0000)	0.0010	(0.000004)	(0.000000)	3.188	3.364	0.001
C&I Retrofit	876	97,981	(247,466)	(698)	97,206,278	32,655,134	30,936,037	3.167	(0.008)	(0.0000)	0.0036	(0.000009)	(0.000000)	2.977	3.142	0.004
C&I Direct Install	2,209	63,745	(407,538)	(241)	73,127,895	20,772,907	19,697,629	3.236	(0.021)	(0.0000)	0.0015	(0.000009)	(0.000000)	3.520	3.713	0.002
C3 - C&I Hard-to-Measure	-	-	-	-	-	2,261,983	2,142,784	-	-	-				-	-	
Grand Total	**2,280,013**	**672,656**	**(800,349)**	**199,115**	**870,391,903**	**190,783,646**	**180,776,633**	**3.721**	**(0.004)**	**0.0011**	**0.0000**	**(0.000000)**	**0.000000**	**4.562**	**4.815**	**0.000**

2013-2015 YTD Additional Filing Requirements

Program	Participants	Annual Savings			Total Energy Benefits	Total Costs		Savings per TRC Costs			Savings per Participant per TRC Costs			Total Energy Benefits		
		Electric Energy	Natural Gas	Oil		Program Costs	TRC Test Costs	Electric Energy	Natural Gas	Oil	Electric Energy	Natural Gas	Oil	per Program Costs	per TRC Costs	per Participant per TRC Costs
	(#)	(MWh)	(Therms)	(MMBTU)	($)	(Nominal $)	(2013$)	(kWh/$)	(Therms/$)	(MMBTU/$)	(kWh/#/$)	(Therms/#/$)	(MMBTU/#/$)	($/$)	($/$)	($/#/$)
A - Residential	**8,686,216**	**1,291,615**	**872,546**	**1,117,032**	**1,991,396,322**	**477,022,196**	**665,614,467**	**1.940**	**0.001**	**0.0017**	**0.0000**	**0.000000**	**0.000000**	**4.175**	**2.992**	**0.000**
A1 - Residential Whole House	2,872,153	592,639	913,766	1,116,624	1,078,470,317	297,542,837	367,982,063	1.611	0.002	0.0030	0.0000	0.000000	0.000000	3.625	2.931	0.000
Residential New Construction & Major Renovation	12,325	23,190	30,790	3,125	104,727,207	12,372,341	38,936,428	0.596	0.001	0.0001	0.0000	0.000000	0.000000	8.465	2.690	0.000
Residential Multi-Family Retrofit	77,581	66,617	3,320	15	76,264,128	51,019,797	49,435,844	1.348	0.000	0.0000	0.0000	0.000000	0.000000	1.495	1.543	0.000
Residential Home Energy Services	111,752	222,526	872,616	1,113,484	869,877,389	209,140,822	254,941,284	0.873	0.003	0.0044	0.0000	0.000000	0.000000	4.159	3.412	0.000
Residential Behavior/Feedback Program	2,670,495	280,306	7,039	-	27,601,594	25,009,877	24,668,507	11.363	0.000	-	0.0000	0.000000	-	1.104	1.119	0.000
A2 - Residential Products	5,814,063	698,976	(41,219)	408	912,926,005	128,634,166	247,814,004	2.821	(0.000)	0.0000	0.0000	(0.000000)	0.000000	7.097	3.684	0.000
Residential Cooling & Heating Equipment	44,831	39,163	(74,740)	-	57,302,953	26,529,329	35,580,374	1.101	(0.002)	-	0.0000	(0.000000)	-	2.160	1.611	0.000
Residential Lighting	5,520,918	621,255	-	-	803,505,861	84,783,443	190,345,414	3.264	-	-	0.0000	-	-	9.477	4.221	0.000
Residential Consumer Products	248,314	38,558	33,520	408	52,117,190	17,321,395	21,888,216	1.762	0.002	0.0000	0.0000	0.000000	0.000000	3.009	2.381	0.000
A3 - Residential Hard-to-Measure	-	-	-	-	-	50,845,192	49,818,399	-	-	-				-	-	
B - Low-Income	**87,479**	**116,844**	**89,973**	**195,543**	**237,515,612**	**134,720,570**	**135,727,268**	**0.861**	**0.001**	**0.0014**	**0.0000**	**0.000000**	**0.000000**	**1.763**	**1.750**	**0.000**
B1 - Low-Income Whole House	87,479	116,844	89,973	195,543	237,515,612	132,632,249	133,677,185	0.874	0.001	0.0015	0.0000	0.000000	0.000000	1.791	1.777	0.000
Low-Income New Construction	1,798	1,201	87,064	35	5,614,088	1,482,324	2,104,389	0.571	0.041	0.0000	0.0003	0.000023	0.000000	3.787	2.668	0.001
Low-Income Single Family Retrofit	27,922	42,243	5,164	195,361	160,291,065	69,412,774	70,242,344	0.601	0.000	0.0028	0.0000	0.000000	0.000000	2.309	2.282	0.000
Low-Income Multi-Family Retrofit	57,759	73,400	(2,255)	147	71,610,459	61,737,151	61,330,452	1.197	(0.000)	0.0000	0.0000	(0.000000)	0.000000	1.160	1.168	0.000
B2 - Low-Income Hard-to-Measure	-	-	-	-	-	2,088,322	2,050,083	-	-	-				-	-	
C - Commercial & Industrial	**52,217**	**1,719,665**	**(9,977,619)**	**(158,116)**	**2,624,249,680**	**505,635,684**	**757,456,069**	**2.270**	**(0.013)**	**(0.0002)**	**0.0000**	**(0.000000)**	**(0.000000)**	**5.190**	**3.465**	**0.000**
C1 - C&I New Construction	33,981	654,127	(2,522,008)	(127,392)	1,009,096,779	139,274,766	202,253,398	3.234	(0.012)	(0.0006)	0.0001	(0.000000)	(0.000000)	7.245	4.989	0.000
C&I New Construction	33,981	654,127	(2,522,008)	(127,392)	1,009,096,779	139,274,766	202,253,398	3.234	(0.012)	(0.0006)	0.0001	(0.000000)	(0.000000)	7.245	4.989	0.000
C2 - C&I Retrofit	18,236	1,065,538	(7,455,612)	(30,724)	1,615,152,901	356,164,685	545,222,728	1.954	(0.014)	(0.0001)	0.0001	(0.000001)	(0.000000)	4.535	2.962	0.000
C&I Retrofit	5,170	794,326	(5,350,932)	(29,173)	1,214,766,406	212,295,487	370,245,416	2.145	(0.014)	(0.0001)	0.0004	(0.000003)	(0.000000)	5.722	3.281	0.001
C&I Direct Install	13,066	271,212	(2,104,679)	(1,551)	400,386,495	143,869,198	174,977,312	1.550	(0.012)	(0.0000)	0.0001	(0.000001)	(0.000000)	2.783	2.288	0.000
C3 - C&I Hard-to-Measure	-	-	-	-	-	10,196,233	9,979,943	-	-	-				-	-	
Grand Total	**8,825,912**	**3,128,124**	**(9,015,100)**	**1,154,459**	**4,853,161,614**	**1,117,378,450**	**1,558,797,803**	**2.007**	**(0.006)**	**0.0007**	**0.0000**	**(0.000000)**	**0.000000**	**4.343**	**3.113**	**0.000**

IV.D. Cost Effectiveness

Additional Filing Requirements

Statewide Electric

October 30, 2015

DPU 15-160 - 15-169

Exh. 1, Appendix C

H.O.s Leupold and Hale

2016 Planned Additional Filing Requirements

Program	Participants	Annual Savings			Total Energy Benefits	Total Costs		Savings per TRC Costs			Savings per Participant per TRC Costs			Total Energy Benefits		
		Electric Energy	Natural Gas	Oil		Program Costs	TRC Test Costs	Electric Energy	Natural Gas	Oil	Electric Energy	Natural Gas	Oil	per Program Costs	per TRC Costs	per Participant per TRC Costs
	(#)	(MWh)	(Therms)	(MMBTU)	($)	(Nominal $)	(2016$)	(kWh/$)	(Therms/$)	(MMBTU/$)	(kWh/#/$)	(Therms/#/$)	(MMBTU/#/$)	($/$)	($/$)	($/#/$)
A - Residential	**3,538,503**	**627,236**	**(3,790,452)**	**212,313**	**734,372,268**	**261,977,427**	**351,606,465**	**1.784**	**(0.011)**	**0.0006**	**0.0000**	**(0.000000)**	**0.000000**	**2.803**	**2.089**	**0.000**
A1 - Residential Whole House	1,154,109	238,676	324,318	460,949	396,134,709	155,728,180	203,328,088	1.174	0.002	0.0023	0.0000	0.000000	0.000000	2.544	1.948	0.000
A1a - Residential New Construction	5,138	7,800	15,240	3,019	39,988,241	6,843,668	18,134,264	0.430	0.001	0.0002	0.0001	0.000000	0.000000	5.843	2.205	0.000
A1b - Residential Multi-Family Retrofit	18,691	9,336	281	6,912	13,368,279	17,628,801	16,765,740	0.557	0.000	0.0004	0.0000	0.000000	0.000000	0.758	0.797	0.000
A1c - Residential Home Energy Services - Measures	14,146	92,713	302,037	450,640	321,871,671	106,680,355	143,412,888	0.646	0.002	0.0031	0.0000	0.000000	0.000000	3.017	2.244	0.000
A1d - Residential Home Energy Services - RCS	23,608	-	-	-	-	14,814,226	14,814,226	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	1,092,526	128,828	6,760	378	20,906,518	9,761,130	10,200,971	12.629	0.001	0.0000	0.0000	0.000000	0.000000	2.142	2.049	0.000
A2 - Residential Products	2,384,394	388,560	(4,114,770)	(248,636)	338,237,559	77,220,824	119,249,953	3.258	(0.035)	(0.0021)	0.0000	(0.000000)	(0.000000)	4.380	2.836	0.000
A2a - Residential Heating & Cooling Equipment	28,235	11,277	(27,181)	-	18,793,200	12,099,231	19,942,876	0.565	(0.001)	-	0.0000	(0.000000)	-	1.553	0.942	0.000
A2b - Residential Consumer Products	37,030	12,484	5,459	157	13,034,665	6,725,589	8,782,059	1.422	0.001	0.0000	0.0000	0.000000	0.000000	1.938	1.484	0.000
A2c - Residential Lighting	2,319,129	364,799	(4,093,048)	(248,793)	306,409,694	58,396,004	90,525,018	4.030	(0.045)	(0.0027)	0.0000	(0.000000)	(0.000000)	5.247	3.385	0.000
A3 - Residential Hard-to-Measure	-	-	-	-	-	29,028,424	29,028,424	-	-	-				-	-	
B - Low-Income	**31,829**	**40,615**	**317**	**93,803**	**84,308,599**	**67,526,840**	**69,691,518**	**0.583**	**0.000**	**0.0013**	**0.0000**	**0.000000**	**0.000000**	**1.249**	**1.210**	**0.000**
B1 - Low-Income Whole House	31,829	40,615	317	93,803	84,308,599	66,065,611	68,230,289	0.595	0.000	0.0014	0.0000	0.000000	0.000000	1.276	1.236	0.000
B1a - Low-Income Single Family Retrofit	10,220	16,195	317	75,130	53,929,416	33,784,696	35,162,737	0.461	0.000	0.0021	0.0000	0.000000	0.000000	1.596	1.534	0.000
B1b - Low-Income Multi-Family Retrofit	21,609	24,420	-	18,673	30,379,183	32,280,916	33,067,553	0.738	-	0.0006	0.0000	-	0.000000	0.941	0.919	0.000
B2 - Low-Income Hard-to-Measure	-	-	-	-	-	1,461,229	1,461,229	-	-	-				-	-	
C - Commercial & Industrial	**22,754**	**703,733**	**(3,036,614)**	**(184,554)**	**924,726,599**	**269,276,486**	**422,615,847**	**1.665**	**(0.007)**	**(0.0004)**	**0.0001**	**(0.000000)**	**(0.000000)**	**3.434**	**2.188**	**0.000**
C1 - C&I New Construction	1,124	109,468	(32,114)	(7,825)	248,403,756	57,140,311	74,053,380	1.478	(0.000)	(0.0001)	0.0013	(0.000000)	(0.000000)	4.347	3.354	0.003
C1a - C&I New Buildings & Major Renovations	610	61,888	46,769	(8,088)	131,169,184	34,958,810	44,202,409	1.400	0.001	(0.0002)	0.0023	0.000002	(0.000000)	3.752	2.967	0.005
C1b - C&I Initial Purchase & End of Useful Life	514	47,580	(78,884)	263	117,234,572	22,181,501	29,850,971	1.594	(0.003)	0.0000	0.0031	(0.000005)	0.000000	5.285	3.927	0.008
C2 - C&I Retrofit	21,630	594,265	(3,004,499)	(176,729)	676,322,843	207,049,405	343,475,697	1.730	(0.009)	(0.0005)	0.0001	(0.000000)	(0.000000)	3.266	1.969	0.000
C2a - C&I Existing Building Retrofit	1,924	286,462	(1,552,355)	(30,770)	405,434,934	112,619,315	209,871,495	1.365	(0.007)	(0.0001)	0.0007	(0.000004)	(0.000000)	3.600	1.932	0.001
C2b - C&I Small Business	4,636	100,475	(703,516)	(2,242)	127,485,708	59,019,417	74,279,334	1.353	(0.009)	(0.0000)	0.0003	(0.000002)	(0.000000)	2.160	1.716	0.000
C2c - C&I Multifamily Retrofit	533	9,133	(26,404)	(3,225)	9,278,334	11,084,885	11,224,064	0.814	(0.002)	(0.0003)	0.0015	(0.000004)	(0.000001)	0.837	0.827	0.002
C2d - C&I Upstream Lighting	14,537	198,194	(722,224)	(140,492)	134,123,867	24,325,788	48,100,804	4.120	(0.015)	(0.0029)	0.0003	(0.000001)	(0.000000)	5.514	2.788	0.000
C3 - C&I Hard-to-Measure	-	-	-	-	-	5,086,770	5,086,770	-	-	-				-	-	
Grand Total	**3,593,086**	**1,371,584**	**(6,826,749)**	**121,563**	**1,743,407,466**	**598,780,754**	**843,913,830**	**1.625**	**(0.008)**	**0.0001**	**0.0000**	**(0.000000)**	**0.000000**	**2.912**	**2.066**	**0.000**

2017 Planned Additional Filing Requirements

Program	Participants	Annual Savings			Total Energy Benefits	Total Costs		Savings per TRC Costs			Savings per Participant per TRC Costs			Total Energy Benefits		
		Electric Energy	Natural Gas	Oil		Program Costs	TRC Test Costs	Electric Energy	Natural Gas	Oil	Electric Energy	Natural Gas	Oil	per Program Costs	per TRC Costs	per Participant per TRC Costs
	(#)	(MWh)	(Therms)	(MMBTU)	($)	(Nominal $)	(2016$)	(kWh/$)	(Therms/$)	(MMBTU/$)	(kWh/#/$)	(Therms/#/$)	(MMBTU/#/$)	($/$)	($/$)	($/#/$)
A - Residential	**3,574,796**	**583,876**	**(3,348,889)**	**253,563**	**711,246,221**	**270,415,016**	**347,709,668**	**1.679**	**(0.010)**	**0.0007**	**0.0000**	**(0.000000)**	**0.000000**	**2.630**	**2.046**	**0.000**
A1 - Residential Whole House	1,158,303	232,983	338,395	476,325	399,887,323	162,190,433	208,573,167	1.117	0.002	0.0023	0.0000	0.000000	0.000000	2.466	1.917	0.000
A1a - Residential New Construction	5,134	7,186	15,604	3,301	40,333,890	7,066,422	18,104,907	0.397	0.001	0.0002	0.0001	0.000000	0.000000	5.708	2.228	0.000
A1b - Residential Multi-Family Retrofit	19,417	9,310	281	7,322	13,225,515	18,039,118	16,754,376	0.556	0.000	0.0004	0.0000	0.000000	0.000000	0.733	0.789	0.000
A1c - Residential Home Energy Services - Measures	14,585	87,652	315,750	465,324	326,784,599	111,800,317	148,645,197	0.590	0.002	0.0031	0.0000	0.000000	0.000000	2.923	2.198	0.000
A1d - Residential Home Energy Services - RCS	24,608	-	-	-	-	15,633,002	15,245,760	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	1,094,559	128,835	6,760	378	19,543,319	9,651,574	9,822,928	13.116	0.001	0.0000	0.0000	0.000000	0.000000	2.025	1.990	0.000
A2 - Residential Products	2,416,493	350,893	(3,687,285)	(222,762)	311,358,898	77,929,733	109,592,078	3.202	(0.034)	(0.0020)	0.0000	(0.000000)	(0.000000)	3.995	2.841	0.000
A2a - Residential Heating & Cooling Equipment	28,545	11,398	(26,256)	-	18,947,989	12,565,693	19,946,468	0.571	(0.001)	-	0.0000	(0.000000)	-	1.508	0.950	0.000
A2b - Residential Consumer Products	37,422	12,618	6,537	168	12,986,866	7,041,078	8,878,966	1.421	0.001	0.0000	0.0000	0.000000	0.000000	1.844	1.463	0.000
A2c - Residential Lighting	2,350,526	326,878	(3,667,566)	(222,930)	279,424,043	58,322,961	80,766,644	4.047	(0.045)	(0.0028)	0.0000	(0.000000)	(0.000000)	4.791	3.460	0.000
A3 - Residential Hard-to-Measure	-	-	-	-	-	30,294,851	29,544,423	-	-	-				-	-	
B - Low-Income	**31,989**	**39,222**	**317**	**97,453**	**84,268,687**	**67,979,499**	**68,449,944**	**0.573**	**0.000**	**0.0014**	**0.0000**	**0.000000**	**0.000000**	**1.240**	**1.231**	**0.000**
B1 - Low-Income Whole House	31,989	39,222	317	97,453	84,268,687	66,506,316	67,013,253	0.585	0.000	0.0015	0.0000	0.000000	0.000000	1.267	1.257	0.000
B1a - Low-Income Single Family Retrofit	10,300	15,979	317	77,574	55,239,824	34,613,116	35,156,580	0.455	0.000	0.0022	0.0000	0.000000	0.000000	1.596	1.571	0.000
B1b - Low-Income Multi-Family Retrofit	21,689	23,243	-	19,879	29,028,863	31,893,200	31,856,673	0.730	-	0.0006	0.0000	-	0.000000	0.910	0.911	0.000
B2 - Low-Income Hard-to-Measure	-	-	-	-	-	1,473,183	1,436,691	-	-	-				-	-	
C - Commercial & Industrial	**24,884**	**749,394**	**(5,213,204)**	**(187,507)**	**978,356,428**	**282,846,041**	**438,896,418**	**1.707**	**(0.012)**	**(0.0004)**	**0.0001**	**(0.000000)**	**(0.000000)**	**3.459**	**2.229**	**0.000**
C1 - C&I New Construction	1,175	113,707	73,038	(7,721)	262,523,585	59,932,605	75,614,818	1.504	0.001	(0.0001)	0.0013	0.000001	(0.000000)	4.380	3.472	0.003
C1a - C&I New Buildings & Major Renovations	638	65,449	59,429	(7,984)	141,386,152	37,325,024	46,235,980	1.416	0.001	(0.0002)	0.0022	0.000002	(0.000000)	3.788	3.058	0.005
C1b - C&I Initial Purchase & End of Useful Life	537	48,258	13,609	263	121,137,433	22,607,581	29,378,838	1.643	0.000	0.0000	0.0031	0.000001	0.000000	5.358	4.123	0.008
C2 - C&I Retrofit	23,709	635,687	(5,286,242)	(179,786)	715,832,843	217,815,707	358,310,146	1.774	(0.015)	(0.0005)	0.0001	(0.000001)	(0.000000)	3.286	1.998	0.000
C2a - C&I Existing Building Retrofit	1,925	319,804	(3,777,800)	(31,326)	446,451,665	118,573,187	220,968,610	1.447	(0.017)	(0.0001)	0.0008	(0.000009)	(0.000000)	3.765	2.020	0.001
C2b - C&I Small Business	4,884	103,376	(722,599)	2,589	129,876,548	61,643,098	75,375,090	1.371	(0.010)	0.0000	0.0003	(0.000002)	0.000000	2.107	1.723	0.000
C2c - C&I Multifamily Retrofit	542	9,217	(27,031)	(3,343)	9,204,158	11,096,684	10,949,011	0.842	(0.002)	(0.0003)	0.0016	(0.000005)	(0.000001)	0.829	0.841	0.002
C2d - C&I Upstream Lighting	16,358	203,290	(758,813)	(147,707)	130,300,472	26,502,738	51,017,434	3.985	(0.015)	(0.0029)	0.0002	(0.000001)	(0.000000)	4.916	2.554	0.000
C3 - C&I Hard-to-Measure	-	-	-	-	-	5,097,729	4,971,454	-	-	-				-	-	
Grand Total	**3,631,669**	**1,372,492**	**(8,561,777)**	**163,508**	**1,773,871,336**	**621,240,557**	**855,056,030**	**1.605**	**(0.010)**	**0.0002**	**0.0000**	**(0.000000)**	**0.000000**	**2.855**	**2.075**	**0.000**

IV.D. Cost Effectiveness

Additional Filing Requirements

Statewide Electric

October 30, 2015

DPU 15-160 - 15-169
Exh. 1, Appendix C
H.O.s Leupold and Hale

2018 Planned Additional Filing Requirements

Program	Participants	Annual Savings			Total Energy Benefits	Total Costs		Savings per TRC Costs			Savings per Participant per TRC Costs			Total Energy Benefits		
		Electric Energy	Natural Gas	Oil		Program Costs	TRC Test Costs	Electric Energy	Natural Gas	Oil	Electric Energy	Natural Gas	Oil	per Program Costs	per TRC Costs	per Participant per TRC Costs
	(#)	(MWh)	(Therms)	(MMBTU)	($)	(Nominal $)	(2016$)	(kWh/$)	(Therms/$)	(MMBTU/$)	(kWh/#/$)	(Therms/#/$)	(MMBTU/#/$)	($/$)	($/$)	($/#/$)
A - Residential	**3,546,733**	**528,881**	**(2,784,865)**	**301,145**	**683,446,362**	**275,247,527**	**339,629,892**	**1.557**	**(0.008)**	**0.0009**	**0.0000**	**(0.000000)**	**0.000000**	**2.483**	**2.012**	**0.000**
A1 - Residential Whole House	1,157,912	227,383	358,748	490,520	402,670,425	168,800,789	210,836,153	1.078	0.002	0.0023	0.0000	0.000000	0.000000	2.385	1.910	0.000
A1a - Residential New Construction	5,137	7,519	15,660	3,305	42,692,409	7,259,719	18,033,094	0.417	0.001	0.0002	0.0001	0.000000	0.000000	5.881	2.367	0.000
A1b - Residential Multi-Family Retrofit	20,179	9,269	290	7,749	13,348,042	18,545,898	16,807,941	0.551	0.000	0.0005	0.0000	0.000000	0.000000	0.720	0.794	0.000
A1c - Residential Home Energy Services - Measures	14,926	81,754	336,038	479,087	331,259,930	116,822,536	150,776,943	0.542	0.002	0.0032	0.0000	0.000000	0.000000	2.836	2.197	0.000
A1d - Residential Home Energy Services - RCS	25,108	-	-	-	-	16,349,515	15,549,565	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	1,092,562	128,841	6,760	378	15,370,045	9,823,121	9,668,609	13.326	0.001	0.0000	0.0000	0.000000	0.000000	1.565	1.590	0.000
A2 - Residential Products	2,388,821	301,498	(3,143,613)	(189,375)	280,775,937	75,491,562	99,353,139	3.035	(0.032)	(0.0019)	0.0000	(0.000000)	(0.000000)	3.719	2.826	0.000
A2a - Residential Heating & Cooling Equipment	28,860	11,531	(25,412)	-	19,286,090	13,017,148	19,927,768	0.579	(0.001)	-	0.0000	(0.000000)	-	1.482	0.968	0.000
A2b - Residential Consumer Products	33,567	12,043	8,067	169	12,588,742	7,017,628	8,532,961	1.411	0.001	0.0000	0.0000	0.000000	0.000000	1.794	1.475	0.000
A2c - Residential Lighting	2,326,394	277,924	(3,126,268)	(189,544)	248,901,105	55,456,786	70,892,411	3.920	(0.044)	(0.0027)	0.0000	(0.000000)	(0.000000)	4.488	3.511	0.000
A3 - Residential Hard-to-Measure	-	-	-	-	-	30,955,176	29,440,599	-	-	-				-	-	
B - Low-Income	**32,149**	**38,215**	**317**	**98,082**	**84,956,536**	**67,730,777**	**66,588,634**	**0.574**	**0.000**	**0.0015**	**0.0000**	**0.000000**	**0.000000**	**1.254**	**1.276**	**0.000**
B1 - Low-Income Whole House	32,149	38,215	317	98,082	84,956,536	66,251,394	65,181,634	0.586	0.000	0.0015	0.0000	0.000000	0.000000	1.282	1.303	0.000
B1a - Low-Income Single Family Retrofit	10,380	15,633	317	78,609	56,197,301	35,289,787	34,974,855	0.447	0.000	0.0022	0.0000	0.000000	0.000000	1.592	1.607	0.000
B1b - Low-Income Multi-Family Retrofit	21,769	22,582	-	19,473	28,759,235	30,961,606	30,206,780	0.748	-	0.0006	0.0000	-	0.000000	0.929	0.952	0.000
B2 - Low-Income Hard-to-Measure	-	-	-	-	-	1,479,383	1,407,000	-	-	-				-	-	
C - Commercial & Industrial	**25,102**	**806,368**	**(8,245,786)**	**(178,912)**	**1,063,702,747**	**294,576,727**	**461,058,174**	**1.749**	**(0.018)**	**(0.0004)**	**0.0001**	**(0.000001)**	**(0.000000)**	**3.611**	**2.307**	**0.000**
C1 - C&I New Construction	1,218	118,999	108,727	(7,852)	276,730,098	62,640,529	77,769,739	1.530	0.001	(0.0001)	0.0013	0.000001	(0.000000)	4.418	3.558	0.003
C1a - C&I New Buildings & Major Renovations	673	69,752	74,887	(8,115)	150,790,480	37,818,964	46,530,036	1.499	0.002	(0.0002)	0.0022	0.000002	(0.000000)	3.987	3.241	0.005
C1b - C&I Initial Purchase & End of Useful Life	545	49,247	33,840	263	125,939,618	24,821,565	31,239,703	1.576	0.001	0.0000	0.0029	0.000002	0.000000	5.074	4.031	0.007
C2 - C&I Retrofit	23,884	687,368	(8,354,512)	(171,060)	786,972,649	226,884,746	378,484,141	1.816	(0.022)	(0.0005)	0.0001	(0.000001)	(0.000000)	3.469	2.079	0.000
C2a - C&I Existing Building Retrofit	1,904	369,555	(6,850,529)	(32,102)	505,469,435	122,696,447	240,847,584	1.534	(0.028)	(0.0001)	0.0008	(0.000015)	(0.000000)	4.120	2.099	0.001
C2b - C&I Small Business	5,188	106,905	(718,721)	12,004	134,135,401	64,169,726	76,432,503	1.399	(0.009)	0.0002	0.0003	(0.000002)	0.000000	2.090	1.755	0.000
C2c - C&I Multifamily Retrofit	552	9,354	(27,666)	(3,464)	9,125,474	11,432,063	10,987,034	0.851	(0.003)	(0.0003)	0.0015	(0.000005)	(0.000001)	0.798	0.831	0.002
C2d - C&I Upstream Lighting	16,240	201,554	(757,597)	(147,497)	138,242,338	28,586,510	50,217,020	4.014	(0.015)	(0.0029)	0.0002	(0.000001)	(0.000000)	4.836	2.753	0.000
C3 - C&I Hard-to-Measure	-	-	-	-	-	5,051,452	4,804,295	-	-	-				-	-	
Grand Total	**3,603,984**	**1,373,464**	**(11,030,333)**	**220,314**	**1,832,105,646**	**637,555,030**	**867,276,701**	**1.584**	**(0.013)**	**0.0003**	**0.0000**	**(0.000000)**	**0.000000**	**2.874**	**2.112**	**0.000**

2016-2018 Planned Additional Filing Requirements

Program	Participants	Annual Savings			Total Energy Benefits	Total Costs		Savings per TRC Costs			Savings per Participant per TRC Costs			Total Energy Benefits		
		Electric Energy	Natural Gas	Oil		Program Costs	TRC Test Costs	Electric Energy	Natural Gas	Oil	Electric Energy	Natural Gas	Oil	per Program Costs	per TRC Costs	per Participant per TRC Costs
	(#)	(MWh)	(Therms)	(MMBTU)	($)	(Nominal $)	(2013$)	(kWh/$)	(Therms/$)	(MMBTU/$)	(kWh/#/$)	(Therms/#/$)	(MMBTU/#/$)	($/$)	($/$)	($/#/$)
A - Residential	**10,660,031**	**1,739,994**	**(9,924,206)**	**767,021**	**2,129,064,851**	**807,639,970**	**1,038,946,025**	**1.675**	**(0.010)**	**0.0007**	**0.0000**	**(0.000000)**	**0.000000**	**2.636**	**2.049**	**0.000**
A1 - Residential Whole House	3,470,324	699,042	1,021,462	1,427,794	1,198,692,457	486,719,402	622,737,409	1.123	0.002	0.0023	0.0000	0.000000	0.000000	2.463	1.925	0.000
A1a - Residential New Construction	15,409	22,505	46,504	9,625	123,014,540	21,169,808	54,272,265	0.415	0.001	0.0002	0.0000	0.000000	0.000000	5.811	2.267	0.000
A1b - Residential Multi-Family Retrofit	58,287	27,914	852	21,983	39,941,835	54,213,817	50,328,057	0.555	0.000	0.0004	0.0000	0.000000	0.000000	0.737	0.794	0.000
A1c - Residential Home Energy Services - Measures	43,657	262,119	953,826	1,395,051	979,916,200	335,303,208	442,835,028	0.592	0.002	0.0032	0.0000	0.000000	0.000000	2.922	2.213	0.000
A1d - Residential Home Energy Services - RCS	73,324	-	-	-	-	46,796,743	45,609,551	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	3,279,647	386,504	20,280	1,134	55,819,882	29,235,825	29,692,508	13.017	0.001	0.0000	0.0000	0.000000	0.000000	1.909	1.880	0.000
A2 - Residential Products	7,189,708	1,040,952	(10,945,668)	(660,773)	930,372,394	230,642,118	328,195,170	3.172	(0.033)	(0.0020)	0.0000	(0.000000)	(0.000000)	4.034	2.835	0.000
A2a - Residential Heating & Cooling Equipment	85,640	34,206	(78,849)	-	57,027,279	37,682,072	59,817,112	0.572	(0.001)	-	0.0000	(0.000000)	-	1.513	0.953	0.000
A2b - Residential Consumer Products	108,019	37,145	20,062	495	38,610,273	20,784,295	26,193,985	1.418	0.001	0.0000	0.0000	0.000000	0.000000	1.858	1.474	0.000
A2c - Residential Lighting	6,996,049	969,601	(10,886,882)	(661,268)	834,734,842	172,175,751	242,184,074	4.004	(0.045)	(0.0027)	0.0000	(0.000000)	(0.000000)	4.848	3.447	0.000
A3 - Residential Hard-to-Measure	-	-	-	-	-	90,278,450	88,013,446	-	-	-				-	-	
B - Low-Income	**95,968**	**118,051**	**952**	**289,338**	**253,533,822**	**203,237,116**	**204,730,097**	**0.577**	**0.000**	**0.0014**	**0.0000**	**0.000000**	**0.000000**	**1.247**	**1.238**	**0.000**
B1 - Low-Income Whole House	95,968	118,051	952	289,338	253,533,822	198,823,321	200,425,177	0.589	0.000	0.0014	0.0000	0.000000	0.000000	1.275	1.265	0.000
B1a - Low-Income Single Family Retrofit	30,900	47,807	952	231,313	165,366,541	103,687,599	105,294,171	0.454	0.000	0.0022	0.0000	0.000000	0.000000	1.595	1.571	0.000
B1b - Low-Income Multi-Family Retrofit	65,068	70,245	-	58,025	88,167,281	95,135,722	95,131,006	0.738	-	0.0006	0.0000	-	0.000000	0.927	0.927	0.000
B2 - Low-Income Hard-to-Measure	-	-	-	-	-	4,413,795	4,304,920	-	-	-				-	-	
C - Commercial & Industrial	**72,740**	**2,259,494**	**(16,495,603)**	**(550,974)**	**2,966,785,774**	**846,699,254**	**1,322,570,439**	**1.708**	**(0.012)**	**(0.0004)**	**0.0000**	**(0.000000)**	**(0.000000)**	**3.504**	**2.243**	**0.000**
C1 - C&I New Construction	3,517	342,174	149,650	(23,398)	787,657,439	179,713,445	227,437,938	1.504	0.001	(0.0001)	0.0004	0.000000	(0.000000)	4.383	3.463	0.001
C1a - C&I New Buildings & Major Renovations	1,921	197,089	181,085	(24,188)	423,345,816	110,102,798	136,968,425	1.439	0.001	(0.0002)	0.0007	0.000001	(0.000000)	3.845	3.091	0.002
C1b - C&I Initial Purchase & End of Useful Life	1,596	145,085	(31,435)	789	364,311,623	69,610,646	90,469,512	1.604	(0.000)	0.0000	0.0010	(0.000000)	0.000000	5.234	4.027	0.003
C2 - C&I Retrofit	69,223	1,917,320	(16,645,254)	(527,575)	2,179,128,335	651,749,858	1,080,269,983	1.775	(0.015)	(0.0005)	0.0000	(0.000000)	(0.000000)	3.344	2.017	0.000
C2a - C&I Existing Building Retrofit	5,752	975,821	(12,180,683)	(94,198)	1,357,356,035	353,888,949	671,687,689	1.453	(0.018)	(0.0001)	0.0003	(0.000003)	(0.000000)	3.836	2.021	0.000
C2b - C&I Small Business	14,708	310,757	(2,144,836)	12,351	391,497,657	184,832,241	226,086,927	1.375	(0.009)	0.0001	0.0001	(0.000001)	0.000000	2.118	1.732	0.000
C2c - C&I Multifamily Retrofit	1,627	27,704	(81,101)	(10,032)	27,607,966	33,613,632	33,160,109	0.835	(0.002)	(0.0003)	0.0005	(0.000002)	(0.000000)	0.821	0.833	0.001
C2d - C&I Upstream Lighting	47,136	603,039	(2,238,634)	(435,696)	402,666,677	79,415,036	149,335,258	4.038	(0.015)	(0.0029)	0.0001	(0.000000)	(0.000000)	5.070	2.696	0.000
C3 - C&I Hard-to-Measure	-	-	-	-	-	15,235,951	14,862,518	-	-	-				-	-	
Grand Total	**10,828,739**	**4,117,539**	**(26,418,858)**	**505,385**	**5,349,384,448**	**1,857,576,341**	**2,566,246,561**	**1.604**	**(0.010)**	**0.0002**	**0.0000**	**(0.000000)**	**0.000000**	**2.880**	**2.085**	**0.000**

Notes:

On September 29, 2015, the Department of Public Utilities issued a Hearing Officer Memorandum from Jeffrey Leupold identifying additional information that the Program Administrators must include in their respective 2016-2018 plan filings (revised October 2, 2015). The above tables provide the information requested in 2.a through 2.e of that Memorandum. Note that 2.c, Resource Benefits Per Program Costs, is also provided on the Budget Summary table (Table IV.C.1).

*Note that performance incentives and participant costs are not available for 2015 at this time. Therefore, the 2015 YTD table analyzes the Program Administrator's costs in 2013$, rather than the TRC Costs in 2013$.

IV.B. Electric PA Funding Sources

1. Summary Table

Statewide Electric

October 30, 2015

2016 Total Electric Funding Sources							
Sector	**SBC**	**FCM**	**RGGI**	**Other**	**Carryover**	**EERF**	**Total**
A - Residential	38,838,769	13,102,139	18,198,343	-	(20,720,107)	244,477,450	293,896,593
B - Low-Income	5,262,307	1,775,555	2,465,713	-	(946,419)	60,672,056	69,229,213
C - Commercial & Industrial	73,183,065	24,680,464	34,290,751	-	35,474,166	160,622,994	328,251,440
Grand Total	**117,284,141**	**39,558,158**	**54,954,807**	**-**	**13,807,640**	**465,772,500**	**691,377,246**

2016 Funding as a Percent of Total Electric Funding Sources							
Sector	**SBC**	**FCM**	**RGGI**	**Other**	**Carryover**	**EERF**	**Total**
A - Residential	13%	4%	6%	0%	-7%	83%	100%
B - Low-Income	8%	3%	4%	0%	-1%	88%	100%
C - Commercial & Industrial	22%	8%	10%	0%	11%	49%	100%
Grand Total	**17%**	**6%**	**8%**	**0%**	**2%**	**67%**	**100%**

2017 Total Electric Funding Sources							
Sector	**SBC**	**FCM**	**RGGI**	**Other**	**Carryover**	**EERF**	**Total**
A - Residential	38,802,221	33,255,781	21,085,616	-	(8,257,664)	214,669,878	299,555,833
B - Low-Income	5,381,148	4,614,228	2,924,184	-	(2,686,119)	62,051,506	72,284,946
C - Commercial & Industrial	72,897,537	62,467,026	39,613,442	-	14,525,319	160,137,370	349,640,693
Grand Total	**117,080,906**	**100,337,035**	**63,623,242**	**-**	**3,581,536**	**436,858,754**	**721,481,472**

2017 Funding as a Percent of Total Electric Funding Sources							
Sector	**SBC**	**FCM**	**RGGI**	**Other**	**Carryover**	**EERF**	**Total**
A - Residential	13%	11%	7%	0%	-3%	72%	100%
B - Low-Income	7%	6%	4%	0%	-4%	86%	100%
C - Commercial & Industrial	21%	18%	11%	0%	4%	46%	100%
Grand Total	**16%**	**14%**	**9%**	**0%**	**0%**	**61%**	**100%**

2018 Total Electric Funding Sources							
Sector	**SBC**	**FCM**	**RGGI**	**Other**	**Carryover**	**EERF**	**Total**
A - Residential	38,675,639	45,271,642	21,511,159	-	(8,257,664)	204,541,748	301,742,525
B - Low-Income	5,493,804	6,435,753	3,055,621	-	(2,686,119)	58,648,190	70,947,249
C - Commercial & Industrial	72,260,051	84,581,267	40,190,608	-	14,525,319	135,256,542	346,813,787
Grand Total	**116,429,494**	**136,288,662**	**64,757,389**	**-**	**3,581,536**	**398,446,480**	**719,503,561**

2018 Funding as a Percent of Total Electric Funding Sources							
Sector	**SBC**	**FCM**	**RGGI**	**Other**	**Carryover**	**EERF**	**Total**
A - Residential	13%	15%	7%	0%	-3%	68%	100%
B - Low-Income	8%	9%	4%	0%	-4%	83%	100%
C - Commercial & Industrial	21%	24%	12%	0%	4%	39%	100%
Grand Total	**16%**	**19%**	**9%**	**0%**	**0%**	**55%**	**100%**

2016-2018 Total Electric Funding Sources							
Sector	**SBC**	**FCM**	**RGGI**	**Other**	**Carryover**	**EERF**	**Total**
A - Residential	116,316,629	91,629,561	60,795,119	-	(37,235,434)	663,689,076	895,194,951
B - Low-Income	16,137,259	12,825,536	8,445,518	-	(6,318,657)	181,371,751	212,461,408
C - Commercial & Industrial	218,340,652	171,728,757	114,094,801	-	64,524,804	456,016,906	1,024,705,919
Grand Total	**350,794,540**	**276,183,855**	**183,335,438**	**-**	**20,970,713**	**1,301,077,733**	**2,132,362,279**

2016-2018 Funding as a Percent of Total Electric Funding Sources							
Sector	**SBC**	**FCM**	**RGGI**	**Other**	**Carryover**	**EERF**	**Total**
A - Residential	13%	10%	7%	0%	-4%	74%	100%
B - Low-Income	8%	6%	4%	0%	-3%	85%	100%
C - Commercial & Industrial	21%	17%	11%	0%	6%	45%	100%
Grand Total	**16%**	**13%**	**9%**	**0%**	**1%**	**61%**	**100%**

Notes:

For supporting information on SBC collections, see Table IV.B.3.1.
For supporting information on FCM revenue, see Table IV.B.3.2.
For supporting information on RGGI proceeds, see Table IV.B.3.3.
For supporting information on other funding see, Additional Sources of Information.
For supporting information on estimated carryover, see Table IV.B.3.5.
For supporting information on the EERF, see Table IV.B.3.6.
Funding sources for each year in 2016-2018 are represented in nominal dollars (2016$, 2017$, 2018$).

IV.B. Electric PA Funding Sources

3.1. System Benefit Charge Funds

DPU 15-160 - 15-169

Statewide Electric

Exh. 1, Appendix C

October 30, 2015

H.O.s Leupold and Hale

2016 System Benefit Charge Collections				
Sector	Sales (kWh)	SBC Charge ($/kWh)	Collections ($)	Collections (% of Total)
A - Residential	15,535,507,509	0.0025	38,838,769	33.1%
B - Low-Income	2,104,922,758	0.0025	5,262,307	4.5%
C - Commercial & Industrial	29,273,225,971	0.0025	73,183,065	62.4%
Grand Total	**46,913,656,237**		**117,284,141**	**100%**

2017 System Benefit Charge Collections				
Sector	Sales (kWh)	SBC Charge ($/kWh)	Collections ($)	Collections (% of Total)
A - Residential	15,520,888,233	0.0025	38,802,221	33.1%
B - Low-Income	2,152,459,235	0.0025	5,381,148	4.6%
C - Commercial & Industrial	29,159,014,738	0.0025	72,897,537	62.3%
Grand Total	**46,832,362,206**		**117,080,906**	**100%**

2018 System Benefit Charge Collections				
Sector	Sales (kWh)	SBC Charge ($/kWh)	Collections ($)	Collections (% of Total)
A - Residential	15,470,255,667	0.0025	38,675,639	33.2%
B - Low-Income	2,197,521,677	0.0025	5,493,804	4.7%
C - Commercial & Industrial	28,904,020,205	0.0025	72,260,051	62.1%
Grand Total	**46,571,797,549**		**116,429,494**	**100%**

2016-2018 System Benefit Charge Collections				
Sector	Sales (kWh)	SBC Charge ($/kWh)	Collections ($)	Collections (% of Total)
A - Residential	46,526,651,409	0.0025	116,316,629	33.2%
B - Low-Income	6,454,903,670	0.0025	16,137,259	4.6%
C - Commercial & Industrial	87,336,260,914	0.0025	218,340,652	62.2%
Grand Total	**140,317,815,992**		**350,794,540**	**100%**

Notes:

Collections are the sales multiplied by the SBC charge.

Consistent with the Department's Energy Efficiency Guidelines § 3.2.1.2, electric Program Administrators allocate revenue from the System Benefits Charge to the residential, low-income, and commercial and industrial customer sectors in proportion to the sector’s kilowatt-hour consumption.

2016 Forward Capacity Market Revenue							
Program Administrator	**Jan 2016 - May 2016**			**June 2016 - Dec 2016**			**Total**
	Savings (kW)	**Price ($)**	**Revenue ($)**	**Savings (kW)**	**Price ($)**	**Revenue ($)**	**Revenue ($)**
Unitil	5,403		84,557	6,295		123,387	207,944
CLC	22,352		368,129	24,679		542,725	910,855
National Grid	409,416		6,713,992	342,900		10,868,831	17,582,823
Eversource	350,318		5,527,489	342,105		15,329,046	20,856,536
							-
							-
							-
							-
							-
							-
							-
							-
							-
							-
							-
Grand Total	**787,489**	**n/a**	**12,694,168**	**715,979**	**n/a**	**26,863,990**	**39,558,158**

2017 Forward Capacity Market Revenue							
Program Administrator	**Jan 2017 - May 2017**			**June 2017 - Dec 2017**			**Total**
	Savings (kW)	**Price ($)**	**Revenue ($)**	**Savings (kW)**	**Price ($)**	**Revenue ($)**	**Revenue ($)**
Unitil	6,295		88,134	7,644		447,517	535,650
CLC	24,679		387,661	31,398		1,641,409	2,029,070
National Grid	342,900		7,763,451	424,866		30,133,978	37,897,429
Eversource	342,105		10,949,319	520,144		48,925,566	59,874,885
							-
							-
							-
							-
							-
							-
							-
							-
							-
							-
							-
Grand Total	**715,979**	**n/a**	**19,188,564**	**984,052**	**n/a**	**81,148,470**	**100,337,035**

2018 Forward Capacity Market Revenue							
Program Administrator	**Jan 2018 - May 2018**			**June 2018 - Dec 2018**			**Total**
	Savings (kW)	**Price ($)**	**Revenue ($)**	**Savings (kW)**	**Price ($)**	**Revenue ($)**	**Revenue ($)**
Unitil	7,644		319,496	8,376		559,936	879,431
CLC	31,398		1,172,435	45,948		4,288,339	5,460,774
National Grid	424,866		21,524,270	472,613		34,228,725	55,752,995
Eversource	520,144		34,946,833	569,713		39,248,629	74,195,462
							-
							-
							-
							-
							-
							-
							-
							-
							-
							-
							-
Grand Total	**984,052**	**n/a**	**57,963,034**	**1,096,650**	**n/a**	**78,325,628**	**136,288,662**

Allocation of 2016-2018 Forward Capacity Market Revenue								
Sector	**2016**		**2017**		**2018**		**2016-2018**	
	FCM Revenue ($)	**% of FCM Revenue**	**FCM Revenue ($)**	**% of FCM Revenue**	**FCM Revenue ($)**	**% of FCM Revenue**	**FCM Revenue ($)**	**% of FCM Revenue**
Residential	13,102,139	33.1%	33,255,781	33.1%	45,271,642	33.2%	91,629,561	33.2%
Low-Income	1,775,555	4.5%	4,614,228	4.6%	6,435,753	4.7%	12,825,536	4.6%
Commercial & Industrial	24,680,464	62.4%	62,467,026	62.3%	84,581,267	62.1%	171,728,757	62.2%
Grand Total	**39,558,158**	**100%**	**100,337,035**	**100%**	**136,288,662**	**100%**	**276,183,855**	**100%**

Notes:

Revenue is allocated across customer sector based on percentage allocation of kWh sales. See Table IV.B.3.1.

Each Program Administrator completes this table according to how their FCM resources have cleared in each auction.

IV.B. Electric PA Funding Sources

3.3. RGGI Proceeds

Statewide Electric

October 30, 2015

Forecasted Massachusetts RGGI CO_2 Allowances and Proceeds

Annual Allowance Base Budget	**2015**	**2016**	**2017**	**2018**
Allowance Budget, based on the RGGI Adjusted Cap	10,591,981	10,238,857	10,079,934	9,739,612
Voluntary Renewable Energy (VRE)	25,214	20,472	17,637	29,883
Final Allowances Available for Auction	10,566,767	10,218,385	10,062,297	9,709,729
2015 Auction Results	**Auction 27**	**Auction 28**	**Auction 29**	
Allowances Sold	2,641,692	2,641,692	4,255,660	
Clearing Price ($/allowance)	$ 5.41	$ 5.50	$ 6.02	
Proceeds from Allowances Sold	$ 14,291,554	$ 14,529,306	$ 25,619,073	
Forecasted Proceeds	**2015**	**2016**	**2017**	**2018**
Remaining Allowance Budget	1,027,723	10,218,385	10,062,297	9,709,729
Forward Price, based on IPM 91 Cap ($/allowance) (2010$)	$ 5.44	$ 6.76	$ 7.52	$ 7.52
Forward Price, based on IPM 91 Cap ($/allowance) (nominal dollars)	$ 6.04	$ 7.68	$ 8.74	$ 8.94
Proceeds from Remaining Allowance Budget	$ 6,207,447	$ 78,477,197	$ 87,944,476	$ 86,804,977
Cost Containment Reserve (CCR)	$ -	$ -	$ -	$ -
Total Massachusetts RGGI Proceeds	**$ 60,647,380**	**$ 78,477,197**	**$ 87,944,476**	**$ 86,804,977**

Notes:

The information in the above table was provided to the Massachusetts Program Administrators by the Massachusetts Department of Energy Resources. The forecasts are based on the modeling tool used to forecast RGGI, Integrated Planning Model (IPM). The 91 Cap refers to the 2014 total RGGI Cap of 91 million allowances for all RGGI states. The RGGI Adjusted Cap accounts for banked allowances. For more information, refer to https://www.rggi.org/design/overview/cap.

The Forward Prices from the IPM results were converted from 2010$ to nominal dollars (2016$, 2017$, 2018$) using the consumer price index (CPI) for 2010 through 2015, and the ten year average CPI.

Allocation of Forecasted Massachusetts RGGI Proceeds

Allocation of Total Massachusetts RGGI Proceeds	**2015**	**2016**	**2017**	**2018**	**Total**
DOER's RGGI Administration Costs (about 6% of total proceeds)	$ 3,790,461	$ 4,904,825	$ 5,496,530	$ 5,425,311	
Remaining Proceeds After Allocation to DOER	$ 56,856,919	$ 73,572,372	$ 82,447,946	$ 81,379,666	
80% of Remaining Proceeds Allocated to Energy Efficiency	$ 45,485,535	$ 58,857,898	$ 65,958,357	$ 65,103,733	
EEAC Consultants Budget, based on 2015 EEAC Consultant Budget	$ 560,000	$ 560,000	$ 560,000	$ 560,000	
Proceeds Allocated to Program Administrators	$ 44,925,535	$ 58,297,898	$ 65,398,357	$ 64,543,733	
PA Proceeds Received in 2016 (last 2015 auction, first three 2016 auctions)	$ 11,231,384	$ 43,723,423			$ 54,954,807
PA Proceeds Received in 2017 (last 2016 auction, first three 2017 auctions)		$ 14,574,474	$ 49,048,768		$ 63,623,242
PA Proceeds Received in 2018 (last 2017 auction, first three 2018 auctions)			$ 16,349,589	$ 48,407,800	$ 64,757,389
Allocation of Proceeds to Statewide Electric	**2015**	**2016**	**2017**	**2018**	**Total**
Allocation to Statewide Electric, based on Percentage of Statewide Customers	100.00%	100.00%	100.00%	100.00%	
Statewide Electric's Forecasted Proceeds	$ 44,925,535	$ 58,297,898	$ 65,398,357	$ 64,543,733	
Proceeds Received in 2016 (last 2015 auction, first three 2016 auctions)	$ 11,231,384	$ 43,723,423			$ 54,954,807
Proceeds Received in 2017 (last 2016 auction, first three 2017 auctions)		$ 14,574,474	$ 49,048,768		$ 63,623,242
Proceeds Received in 2018 (last 2017 auction, first three 2018 auctions)			$ 16,349,589	$ 48,407,800	$ 64,757,389

Notes:

There is an approximately three-month lag between the completion of an auction and receipt of proceeds from that auction by the Program Administrators. The Program Administrators have accounted for this time lag in the table above to better reflect calendar-year energy efficiency revenue.

Program Administrator Allocation of RGGI Proceeds to Customer Sectors

Sector	**2016**		**2017**		**2018**		**TOTAL**	
	RGGI Funds	**% of Total RGGI Funds**	**RGGI Funds**	**% of Total RGGI Funds**	**RGGI Funds**	**% of Total RGGI Funds**	**RGGI Funds**	**% of Total RGGI Funds**
A - Residential	$18,198,343	33.1%	$21,085,616	33.1%	$21,511,159	33.2%	$60,795,119	33.2%
B - Low-Income	$2,465,713	4.5%	$2,924,184	4.6%	$3,055,621	4.7%	$8,445,518	4.6%
C - Commercial & Industrial	$34,290,751	62.4%	$39,613,442	62.3%	$40,190,608	62.1%	$114,094,801	62.2%
Grand Total	**$54,954,807**	**100.0%**	**$63,623,242**	**100.0%**	**$64,757,389**	**100.0%**	**$183,335,438**	**100.0%**

Notes:

RGGI Proceeds are allocated to each customer sector based on the sector's percentage of kWh sales. See Table IV.B.3.1.

IV.B. Program Administrator Funding Sources

3.5. Carryover

Statewide Electric
October 30, 2015

Estimated 2015 Carryover into 2016

Sector	2013-2015 Planned		2013-2015 Actual		2013-2015 Beginning Balance (Carryover from 2012)	2015 Ending Balance w/o Interest (Carryover from 2015)	Interest on Carryover	Total 2015 Carryover into 2016	Total 2015 Carryover into 2017	Total 2015 Carryover into 2018
	Funding	Budget	Revenue	Expenditures						
A - Residential	$ 549,502,015	$ 528,845,016	$ 641,748,477	$ 629,904,107	$ (48,367,510)	$ (7,549,001)	$ (709,264)	$ (20,720,107)	$ (8,257,664)	$ (8,257,664)
B - Low-Income	$ 98,219,924	$ 170,815,303	$ 182,993,838	$ 178,886,813	$ (10,269,444)	$ 881,972	$ (157,327)	$ (946,419)	$ (2,686,119)	$ (2,686,119)
C - Commercial & Industrial	$ 902,746,139	$ 942,911,857	$ 843,513,684	$ 817,190,685	$ 37,908,484	$ 51,310,509	$ 300,805	$ 35,474,166	$ 14,525,319	$ 14,525,319
Grand Total	**$ 1,550,468,077**	**$ 1,642,572,175**	**$ 1,668,255,998**	**$ 1,625,981,605**	**$ (20,728,470)**	**$ 44,643,480**	**$ (565,785)**	**$ 13,807,640**	**$ 3,581,536**	**$ 3,581,536**

Notes:
The above table provides an estimate of the carryover from the 2013-2015 Three-Year Plan. The Program Administrator's actual 2013-2015 carryover for collection in 2016 will be presented in its Energy Efficiency Reconciliation Factor filing.

The 2015 Carryover into 2016 includes carryover from the 2010-2012 plan into the 2013-2015 plan, as well as the ending balance from the 2013-2015 plan.
A positive carryover value indicates an under-spending/over-recovery, while a negative carryover value indicates an over-spending/under-recovery.
2015 Actuals are projected through the end of the year.
The 2015 Carryover into 2017 and 2018 is intended to be completed by National Grid only.

IV.B. Electric PA Funding Sources

3.6. EERF

Statewide Electric

October 30, 2015

2016 Energy Efficiency Reconciliation Factor Funds						
Sector	**Total Program Administrator Budget**	**Lost Base Revenue & Demand Response**	**SBC + FCM + RGGI + Other Funds + Carryover**	**EERF Funding Required for Each Sector**	**Low-Income Subsidization**	**EERF Funding Collected From Each Sector**
Residential	274,879,207	19,017,386	49,419,144	244,477,450	25,612,612	270,090,061
Low-Income	69,069,071	160,142	8,557,157	60,672,056	3,610,276	3,543,000
Commercial & Industrial	287,784,413	40,467,027	167,628,445	160,622,994	31,516,444	192,139,438
Grand Total	**631,732,691**	**59,644,555**	**225,604,746**	**465,772,500**	**60,739,331**	**465,772,500**

2017 Energy Efficiency Reconciliation Factor Funds						
Sector	**Total Program Administrator Budget**	**Lost Base Revenue & Demand Response**	**SBC + FCM + RGGI + Other Funds + Carryover**	**EERF Funding Required for Each Sector**	**Low-Income Subsidization**	**EERF Funding Collected From Each Sector**
Residential	283,258,433	16,297,400	84,885,954	214,669,878	26,085,760	240,755,638
Low-Income	69,547,452	2,737,495	10,233,441	62,051,506	3,776,250	3,420,870
Commercial & Industrial	302,517,956	47,122,737	189,503,323	160,137,370	32,544,876	192,682,245
Grand Total	**655,323,841**	**66,157,631**	**284,622,719**	**436,858,754**	**62,406,885**	**436,858,754**

2018 Energy Efficiency Reconciliation Factor Funds						
Sector	**Total Program Administrator Budget**	**Lost Base Revenue & Demand Response**	**SBC + FCM + RGGI + Other Funds + Carryover**	**EERF Funding Required for Each Sector**	**Low-Income Subsidization**	**EERF Funding Collected From Each Sector**
Residential	287,910,985	13,831,539	97,200,777	204,541,748	24,596,416	229,138,164
Low-Income	69,353,942	1,593,307	12,299,059	58,648,190	3,656,038	3,286,146
Commercial & Industrial	315,838,464	30,975,323	211,557,245	135,256,542	30,765,628	166,022,169
Grand Total	**673,103,392**	**46,400,169**	**321,057,081**	**398,446,480**	**59,018,081**	**398,446,480**

2016-2018 Energy Efficiency Reconciliation Factor Funds						
Sector	**Total Program Administrator Budget**	**Lost Base Revenue & Demand Response**	**SBC + FCM + RGGI + Other Funds + Carryover**	**EERF Funding Required for Each Sector**	**Low-Income Subsidization**	**EERF Funding Collected From Each Sector**
Residential	846,048,626	49,146,325	231,505,875	663,689,076	76,294,787	739,983,863
Low-Income	207,970,465	4,490,943	31,089,657	181,371,751	11,042,563	10,250,017
Commercial & Industrial	906,140,833	118,565,086	568,689,014	456,016,906	94,826,947	550,843,853
Grand Total	**1,960,159,924**	**172,202,355**	**831,284,546**	**1,301,077,733**	**182,164,297**	**1,301,077,733**

Notes:

For supporting information on the Total Program Administrator Budget, which includes Performance Incentives, see Table IV.C.1.

EERF Revenue Required = Total Program Administrator Budget + Lost Base Revenue - (SBC + FCM + RGGI + Other Funds + Carryover Funds)

For supporting information on the EERF calculation, refer to the Program Administrator's EERF exhibit.

Eversource (NSTAR) is the only electric Program Administrator that collects Lost Base Revenue (LBR). All other electric Program Administrators except for the Cape Light Compact have a revenue decoupling mechanism in place and do not estimate LBR. LBR is not applicable to the Cape Light Compact.

IV.C. Program Administrator Budgets

1. Summary Table

Statewide Electric

October 30, 2015

2016 Program Administrator Budget										
	Program Costs									
Program	Program Planning and Administration	Marketing and Advertising	Participant Incentive	Sales, Technical Assistance & Training	Evaluation and Market Research	Total Program Costs	Performance Incentive	Total Program Administrator Budget	Program Cost per Participant	Energy Benefit per Program Cost
A - Residential	**10,824,475**	**12,249,776**	**190,698,730**	**41,453,476**	**6,750,971**	**261,977,427**	**12,901,780**	**274,879,207**	**74.04**	**2.80**
A1 - Residential Whole House	5,988,661	3,911,411	109,143,092	31,802,103	4,882,913	155,728,180	7,123,405	162,851,585	134.93	2.54
A1a - Residential New Construction	541,523	186,172	5,053,731	797,011	265,230	6,843,668	796,609	7,640,277	1,331.97	5.84
A1b - Residential Multi-Family Retrofit	798,419	585,355	12,788,782	2,754,219	702,025	17,628,801	171,571	17,800,372	943.17	0.76
A1c - Residential Home Energy Services - Measures	3,632,782	1,584,044	85,364,010	12,607,796	3,491,723	106,680,355	5,836,379	112,516,734	7,541.34	3.02
A1d - Residential Home Energy Services - RCS	608,326	1,512,533	-	12,481,148	212,219	14,814,226	-	14,814,226	627.51	-
A1e - Residential Behavior/Feedback Program	407,610	43,307	5,936,569	3,161,929	211,716	9,761,130	318,846	10,079,976	8.93	2.14
A2 - Residential Products	2,866,848	5,738,032	60,954,131	5,793,754	1,868,058	77,220,824	5,778,375	82,999,198	32.39	4.38
A2a - Residential Heating & Cooling Equipment	704,244	370,196	9,546,180	1,211,104	267,507	12,099,231	279,247	12,378,478	428.52	1.55
A2b - Residential Consumer Products	379,901	1,769,215	2,007,501	2,327,818	241,154	6,725,589	179,969	6,905,558	181.62	1.94
A2c - Residential Lighting	1,782,702	3,598,621	49,400,451	2,254,832	1,359,397	58,396,004	5,319,158	63,715,162	25.18	5.25
A3 - Residential Hard-to-Measure	1,968,966	2,600,332	20,601,507	3,857,619	-	29,028,424	-	29,028,424		-
A3a - Residential Statewide Marketing	-	1,502,035	-	-	-	1,502,035	-	1,502,035		-
A3b - Residential Statewide Database	156,425	-	-	-	-	156,425	-	156,425		-
A3c - Residential DOER Assessment	1,093,101	-	-	-	-	1,093,101	-	1,093,101		-
A3d - Residential EEAC Consultants	-	-	-	-	-	-	-	-		
A3e - Residential Sponsorships & Subscriptions	459,427	-	-	-	-	459,427	-	459,427		-
A3f - Residential HEAT Loan	88,810	184,597	20,349,230	1,932,621	-	22,555,258	-	22,555,258		-
A3g - Residential Workforce Development	-	-	-	207,879	-	207,879	-	207,879		-
A3h - Residential R&D and Demonstration	-	23,500	252,277	350,028	-	625,805	-	625,805		-
A3i - Residential Education	171,204	890,200	-	1,367,091	-	2,428,495	-	2,428,495		-
B - Low-Income	**3,539,113**	**943,081**	**50,470,660**	**10,621,645**	**1,952,342**	**67,526,840**	**1,542,230**	**69,069,071**	**2,121.53**	**1.25**
B1 - Low-Income Whole House	2,358,279	662,686	50,470,660	10,621,645	1,952,342	66,065,611	1,542,230	67,607,842	2,075.62	1.28
B1a - Low-Income Single Family Retrofit	1,249,933	384,020	26,042,291	5,292,740	815,712	33,784,696	1,056,133	34,840,828	3,305.74	1.60
B1b - Low-Income Multi-Family Retrofit	1,108,346	278,666	24,428,369	5,328,905	1,136,630	32,280,916	486,097	32,767,013	1,493.84	0.94
B2 - Low-Income Hard-to-Measure	1,180,834	280,395	-	-	-	1,461,229	-	1,461,229		-
B2a - Low-Income Statewide Marketing	-	280,395	-	-	-	280,395	-	280,395		-
B2b - Low-Income Statewide Database	30,367	-	-	-	-	30,367	-	30,367		-
B2c - Low-Income DOER Assessment	363,611	-	-	-	-	363,611	-	363,611		-
B2d - Low-Income Energy Affordability Network	666,205	-	-	-	-	666,205	-	666,205		-
B2e - Low-Income Sponsorships & Subscriptions	120,651	-	-	-	-	120,651	-	120,651		-
C - Commercial & Industrial	**19,887,209**	**4,459,509**	**198,639,588**	**38,310,904**	**7,979,276**	**269,276,486**	**18,507,927**	**287,784,413**	**11,834.28**	**3.43**
C1 - C&I New Construction	5,487,483	839,552	37,962,390	11,140,163	1,710,723	57,140,311	4,527,926	61,668,237	50,847.05	4.35
C1a - C&I New Buildings & Major Renovations	3,820,793	625,531	20,972,029	8,311,409	1,229,048	34,958,810	2,377,351	37,336,161	57,339.79	3.75
C1b - C&I Initial Purchase & End of Useful Life	1,666,690	214,021	16,990,361	2,828,754	481,675	22,181,501	2,150,575	24,332,076	43,147.08	5.29
C2 - C&I Retrofit	11,365,506	2,268,406	160,487,198	26,659,741	6,268,553	207,049,405	13,980,001	221,029,406	9,572.25	3.27
C2a - C&I Existing Building Retrofit	7,022,698	1,149,445	86,092,026	15,319,042	3,036,105	112,619,315	9,000,463	121,619,778	58,539.33	3.60
C2b - C&I Small Business	2,659,732	790,433	46,142,059	7,709,461	1,717,732	59,019,417	2,359,820	61,379,237	12,730.84	2.16
C2c - C&I Multifamily Retrofit	529,167	224,579	7,961,934	1,968,242	400,962	11,084,885	141,398	11,226,282	20,797.16	0.84
C2d - C&I Upstream Lighting	1,153,909	103,949	20,291,179	1,662,996	1,113,754	24,325,788	2,478,320	26,804,109	1,673.32	5.51
C3 - C&I Hard-to-Measure	3,034,220	1,351,550	190,000	511,000	-	5,086,770	-	5,086,770		-
C3a - C&I Statewide Marketing	-	1,201,550	-	-	-	1,201,550	-	1,201,550		-
C3b - C&I Statewide Database	122,259	-	-	-	-	122,259	-	122,259		-
C3c - C&I DOER Assessment	1,872,535	-	-	-	-	1,872,535	-	1,872,535		-
C3d - C&I EEAC Consultants	-	-	-	-	-	-	-	-		
C3e - C&I Sponsorships & Subscriptions	1,039,426	-	-	-	-	1,039,426	-	1,039,426		-
C3f - C&I Workforce Development	-	150,000	150,000	276,000	-	576,000	-	576,000		-
C3g - C&I R&D and Demonstration	-	-	40,000	235,000	-	275,000	-	275,000		-
Grand Total	**34,250,797**	**17,652,365**	**439,808,978**	**90,386,025**	**16,682,589**	**598,780,754**	**32,951,937**	**631,732,691**	**166.65**	**2.91**

2017 Program Administrator Budget										
	Program Costs									
Program	Program Planning and Administration	Marketing and Advertising	Participant Incentive	Sales, Technical Assistance & Training	Evaluation and Market Research	Total Program Costs	Performance Incentive	Total Program Administrator Budget	Program Cost per Participant	Energy Benefit per Program Cost
A - Residential	**10,861,809**	**12,961,430**	**196,765,648**	**43,045,804**	**6,780,326**	**270,415,016**	**12,843,417**	**283,258,433**	**75.64**	**2.63**
A1 - Residential Whole House	6,101,433	4,035,616	114,084,143	33,084,831	4,884,410	162,190,433	7,333,037	169,523,470	140.02	2.47
A1a - Residential New Construction	572,478	187,686	5,231,447	817,065	257,745	7,066,422	830,538	7,896,960	1,376.40	5.71
A1b - Residential Multi-Family Retrofit	793,105	579,787	13,093,289	2,880,254	692,683	18,039,118	171,404	18,210,522	929.04	0.73
A1c - Residential Home Energy Services - Measures	3,707,084	1,648,616	89,818,974	13,117,671	3,507,972	111,800,317	6,034,862	117,835,179	7,665.36	2.92
A1d - Residential Home Energy Services - RCS	631,723	1,576,222	-	13,208,178	216,879	15,633,002	-	15,633,002	635.28	-
A1e - Residential Behavior/Feedback Program	397,044	43,305	5,940,432	3,061,663	209,130	9,651,574	296,232	9,947,806	8.82	2.02
A2 - Residential Products	2,779,540	6,128,442	61,128,733	5,997,101	1,895,916	77,929,733	5,510,380	83,440,112	32.25	4.00
A2a - Residential Heating & Cooling Equipment	708,401	431,524	9,823,511	1,327,750	274,507	12,565,693	291,476	12,857,169	440.21	1.51
A2b - Residential Consumer Products	391,856	1,978,094	2,084,103	2,350,833	236,192	7,041,078	183,784	7,224,862	188.15	1.84
A2c - Residential Lighting	1,679,283	3,718,825	49,221,118	2,318,517	1,385,218	58,322,961	5,035,120	63,358,081	24.81	4.79
A3 - Residential Hard-to-Measure	1,980,835	2,797,372	21,552,773	3,963,871	-	30,294,851	-	30,294,851		-
A3a - Residential Statewide Marketing	-	1,516,009	-	-	-	1,516,009	-	1,516,009		-
A3b - Residential Statewide Database	156,424	-	-	-	-	156,424	-	156,424		-
A3c - Residential DOER Assessment	1,098,399	-	-	-	-	1,098,399	-	1,098,399		-
A3d - Residential EEAC Consultants	-	-	-	-	-	-	-	-		
A3e - Residential Sponsorships & Subscriptions	464,415	-	-	-	-	464,415	-	464,415		-
A3f - Residential HEAT Loan	84,164	184,467	21,132,587	1,982,747	-	23,383,965	-	23,383,965		-
A3g - Residential Workforce Development	-	-	-	197,879	-	197,879	-	197,879		-
A3h - Residential R&D and Demonstration	-	39,695	420,186	407,068	-	866,949	-	866,949		-
A3i - Residential Education	177,434	1,057,200	-	1,376,178	-	2,610,812	-	2,610,812		-
B - Low-Income	**3,523,889**	**954,499**	**51,007,595**	**10,577,522**	**1,915,995**	**67,979,499**	**1,567,953**	**69,547,452**	**2,125.07**	**1.24**
B1 - Low-Income Whole House	2,332,911	672,293	51,007,595	10,577,522	1,915,995	66,506,316	1,567,953	68,074,269	2,079.02	1.27
B1a - Low-Income Single Family Retrofit	1,254,630	395,820	26,838,952	5,306,225	817,490	34,613,116	1,104,876	35,717,992	3,360.50	1.60
B1b - Low-Income Multi-Family Retrofit	1,078,281	276,473	24,168,643	5,271,298	1,098,505	31,893,200	463,077	32,356,277	1,470.46	0.91
B2 - Low-Income Hard-to-Measure	1,190,978	282,206	-	-	-	1,473,183	-	1,473,183		-
B2a - Low-Income Statewide Marketing	-	282,206	-	-	-	282,206	-	282,206		-
B2b - Low-Income Statewide Database	30,367	-	-	-	-	30,367	-	30,367		-
B2c - Low-Income DOER Assessment	367,348	-	-	-	-	367,348	-	367,348		-
B2d - Low-Income Energy Affordability Network	671,670	-	-	-	-	671,670	-	671,670		-
B2e - Low-Income Sponsorships & Subscriptions	121,592	-	-	-	-	121,592	-	121,592		-
C - Commercial & Industrial	**20,887,745**	**4,442,119**	**210,200,597**	**39,477,559**	**7,838,021**	**282,846,041**	**19,671,915**	**302,517,956**	**11,366.51**	**3.46**
C1 - C&I New Construction	5,767,658	588,066	40,358,185	11,434,392	1,784,303	59,932,605	4,986,446	64,919,051	51,015.35	4.38
C1a - C&I New Buildings & Major Renovations	4,032,451	481,886	22,202,450	9,336,428	1,271,809	37,325,024	2,625,728	39,950,752	58,492.48	3.79
C1b - C&I Initial Purchase & End of Useful Life	1,735,207	106,180	18,155,735	2,097,964	512,494	22,607,581	2,360,719	24,968,299	42,124.97	5.36
C2 - C&I Retrofit	12,053,456	2,507,955	169,594,911	27,605,667	6,053,718	217,815,707	14,685,469	232,501,176	9,186.90	3.29
C2a - C&I Existing Building Retrofit	7,386,990	1,375,332	90,150,053	16,561,918	3,098,895	118,573,187	9,566,308	128,139,495	61,597.06	3.77
C2b - C&I Small Business	2,898,623	810,659	48,192,594	7,934,199	1,807,023	61,643,098	2,403,246	64,046,344	12,621.33	2.11
C2c - C&I Multifamily Retrofit	537,338	128,161	8,077,136	1,950,406	403,643	11,096,684	142,157	11,238,841	20,473.59	0.83
C2d - C&I Upstream Lighting	1,230,504	193,804	23,175,128	1,159,144	744,157	26,502,738	2,573,758	29,076,496	1,620.14	4.92
C3 - C&I Hard-to-Measure	3,066,631	1,346,098	247,500	437,500	-	5,097,729	-	5,097,729		-
C3a - C&I Statewide Marketing	-	1,211,098	-	-	-	1,211,098	-	1,211,098		-
C3b - C&I Statewide Database	122,537	-	-	-	-	122,537	-	122,537		-
C3c - C&I DOER Assessment	1,879,025	-	-	-	-	1,879,025	-	1,879,025		-
C3d - C&I EEAC Consultants	-	-	-	-	-	-	-	-		
C3e - C&I Sponsorships & Subscriptions	1,065,069	-	-	-	-	1,065,069	-	1,065,069		-
C3f - C&I Workforce Development	-	135,000	177,500	197,500	-	510,000	-	510,000		-
C3g - C&I R&D and Demonstration	-	-	70,000	240,000	-	310,000	-	310,000		-
Grand Total	**35,273,442**	**18,358,048**	**457,973,840**	**93,100,884**	**16,534,342**	**621,240,557**	**34,083,285**	**655,323,841**	**171.06**	**2.86**

IV.C. Program Administrator Budgets

1. Summary Table

Statewide Electric
October 30, 2015

DPU 15-160 - 15-169
Exh. 1, Appendix C
H.O.s Leupold and Hale

2018 Program Administrator Budget										
	Program Costs									
Program	Program Planning and Administration	Marketing and Advertising	Participant Incentive	Sales, Technical Assistance & Training	Evaluation and Market Research	Total Program Costs	Performance Incentive	Total Program Administrator Budget	Program Cost per Participant	Energy Benefit per Program Cost
A - Residential	**10,971,003**	**13,080,148**	**199,582,220**	**44,903,681**	**6,710,475**	**275,247,527**	**12,663,459**	**287,910,985**	**77.61**	**2.48**
A1 - Residential Whole House	6,297,835	4,109,005	118,920,056	34,615,317	4,858,575	168,800,789	7,514,196	176,314,985	145.78	2.39
A1a - Residential New Construction	601,546	192,324	5,381,967	829,464	254,418	7,259,719	895,861	8,155,580	1,413.22	5.88
A1b - Residential Multi-Family Retrofit	801,198	580,351	13,458,618	3,019,794	685,937	18,545,898	171,608	18,717,506	919.07	0.72
A1c - Residential Home Energy Services - Measures	3,851,166	1,689,767	94,133,408	13,651,843	3,496,351	116,822,536	6,232,200	123,054,735	7,826.95	2.84
A1d - Residential Home Energy Services - RCS	640,522	1,603,003	-	13,889,541	216,449	16,349,515	-	16,349,515	651.17	-
A1e - Residential Behavior/Feedback Program	403,403	43,561	5,946,064	3,224,674	205,420	9,823,121	214,527	10,037,648	8.99	1.56
A2 - Residential Products	2,668,351	6,311,833	58,423,946	6,235,532	1,851,900	75,491,562	5,149,263	80,640,825	31.60	3.72
A2a - Residential Heating & Cooling Equipment	719,576	431,741	10,112,698	1,473,792	279,340	13,017,148	307,728	13,324,876	451.04	1.48
A2b - Residential Consumer Products	400,904	2,064,273	1,979,174	2,343,737	229,540	7,017,628	186,619	7,204,247	209.06	1.79
A2c - Residential Lighting	1,547,871	3,815,819	46,332,073	2,418,003	1,343,020	55,456,786	4,654,916	60,111,702	23.84	4.49
A3 - Residential Hard-to-Measure	2,004,816	2,659,310	22,238,218	4,052,832	-	30,955,176	-	30,955,176		-
A3a - Residential Statewide Marketing	-	1,525,560	-	-	-	1,525,560	-	1,525,560		-
A3b - Residential Statewide Database	156,425	-	-	-	-	156,425	-	156,425		-
A3c - Residential DOER Assessment	1,102,765	-	-	-	-	1,102,765	-	1,102,765		-
A3d - Residential EEAC Consultants	-	-	-	-	-	-	-	-		
A3e - Residential Sponsorships & Subscriptions	479,222	-	-	-	-	479,222	-	479,222		-
A3f - Residential HEAT Loan	86,377	190,250	21,979,407	2,068,500	-	24,324,533	-	24,324,533		-
A3g - Residential Workforce Development	-	-	-	197,879	-	197,879	-	197,879		-
A3h - Residential R&D and Demonstration	-	42,500	258,811	347,245	-	648,556	-	648,556		-
A3i - Residential Education	180,028	901,000	-	1,439,208	-	2,520,236	-	2,520,236		-
B - Low-Income	**3,521,180**	**961,330**	**50,618,067**	**10,780,495**	**1,849,704**	**67,730,777**	**1,623,166**	**69,353,942**	**2,106.76**	**1.25**
B1 - Low-Income Whole House	2,325,324	677,803	50,618,067	10,780,495	1,849,704	66,251,394	1,623,166	67,874,559	2,060.74	1.28
B1a - Low-Income Single Family Retrofit	1,284,062	400,730	27,334,714	5,461,458	808,824	35,289,787	1,142,842	36,432,629	3,399.79	1.59
B1b - Low-Income Multi-Family Retrofit	1,041,262	277,073	23,283,353	5,319,038	1,040,881	30,961,606	480,324	31,441,930	1,422.26	0.93
B2 - Low-Income Hard-to-Measure	1,195,856	283,527	-	-	-	1,479,383	-	1,479,383		-
B2a - Low-Income Statewide Marketing	-	283,527	-	-	-	283,527	-	283,527		-
B2b - Low-Income Statewide Database	30,367	-	-	-	-	30,367	-	30,367		-
B2c - Low-Income DOER Assessment	370,123	-	-	-	-	370,123	-	370,123		-
B2d - Low-Income Energy Affordability Network	669,873	-	-	-	-	669,873	-	669,873		-
B2e - Low-Income Sponsorships & Subscriptions	125,494	-	-	-	-	125,494	-	125,494		-
C - Commercial & Industrial	**20,360,519**	**4,506,809**	**221,571,203**	**40,119,339**	**8,018,857**	**294,576,727**	**21,261,737**	**315,838,464**	**11,735.33**	**3.61**
C1 - C&I New Construction	5,505,106	593,230	43,196,802	11,515,093	1,830,298	62,640,529	5,391,710	68,032,239	51,430.22	4.42
C1a - C&I New Buildings & Major Renovations	3,831,359	481,460	23,745,830	8,498,528	1,261,787	37,818,964	2,870,830	40,689,793	56,199.73	3.99
C1b - C&I Initial Purchase & End of Useful Life	1,673,747	111,769	19,450,972	3,016,565	568,512	24,821,565	2,520,881	27,342,446	45,541.43	5.07
C2 - C&I Retrofit	11,758,712	2,560,828	178,176,901	28,199,747	6,188,559	226,884,746	15,870,027	242,754,773	9,499.55	3.47
C2a - C&I Existing Building Retrofit	7,073,520	1,420,318	94,785,346	16,229,536	3,187,727	122,696,447	10,413,276	133,109,723	64,451.76	4.12
C2b - C&I Small Business	2,971,802	812,397	50,455,214	8,116,044	1,814,270	64,169,726	2,476,920	66,646,646	12,368.93	2.09
C2c - C&I Multifamily Retrofit	510,303	123,872	8,242,765	2,149,505	405,618	11,432,063	144,343	11,576,406	20,710.26	0.80
C2d - C&I Upstream Lighting	1,203,088	204,241	24,693,575	1,704,661	780,945	28,586,510	2,835,487	31,421,997	1,760.25	4.84
C3 - C&I Hard-to-Measure	3,096,701	1,352,751	197,500	404,500	-	5,051,452	-	5,051,452		-
C3a - C&I Statewide Marketing	-	1,217,751	-	-	-	1,217,751	-	1,217,751		-
C3b - C&I Statewide Database	122,259	-	-	-	-	122,259	-	122,259		-
C3c - C&I DOER Assessment	1,888,300	-	-	-	-	1,888,300	-	1,888,300		-
C3d - C&I EEAC Consultants	-	-	-	-	-	-	-	-		
C3e - C&I Sponsorships & Subscriptions	1,086,142	-	-	-	-	1,086,142	-	1,086,142		-
C3f - C&I Workforce Development	-	135,000	127,500	164,500	-	427,000	-	427,000		-
C3g - C&I R&D and Demonstration	-	-	70,000	240,000	-	310,000	-	310,000		-
Grand Total	**34,852,701**	**18,548,287**	**471,771,490**	**95,803,516**	**16,579,037**	**637,555,030**	**35,548,361**	**673,103,392**	**176.90**	**2.87**

2016-2018 Program Administrator Budget										
	Program Costs									
Program	Program Planning and Administration	Marketing and Advertising	Participant Incentive	Sales, Technical Assistance & Training	Evaluation and Market Research	Total Program Costs	Performance Incentive	Total Program Administrator Budget	Program Cost per Participant	Energy Benefit per Program Cost
A - Residential	**32,657,287**	**38,291,354**	**587,046,598**	**129,402,960**	**20,241,772**	**807,639,970**	**38,408,655**	**846,048,626**	**75.76**	**2.64**
A1 - Residential Whole House	18,387,930	12,056,033	342,147,291	99,502,251	14,625,898	486,719,402	21,970,638	508,690,040	140.25	2.46
A1a - Residential New Construction	1,715,547	566,182	15,667,145	2,443,541	777,393	21,169,808	2,523,008	23,692,816	1,373.86	5.81
A1b - Residential Multi-Family Retrofit	2,392,722	1,745,493	39,340,690	8,654,268	2,080,644	54,213,817	514,583	54,728,401	930.12	0.74
A1c - Residential Home Energy Services - Measures	11,191,032	4,922,427	269,316,392	39,377,310	10,496,046	335,303,208	18,103,441	353,406,649	7,680.42	2.92
A1d - Residential Home Energy Services - RCS	1,880,571	4,691,758	-	39,578,867	645,548	46,796,743	-	46,796,743	638.22	-
A1e - Residential Behavior/Feedback Program	1,208,057	130,172	17,823,064	9,448,265	626,266	29,235,825	829,606	30,065,431	8.91	1.91
A2 - Residential Products	8,314,739	18,178,308	180,506,810	18,026,387	5,615,874	230,642,118	16,438,018	247,080,136	32.08	4.03
A2a - Residential Heating & Cooling Equipment	2,132,221	1,233,461	29,482,390	4,012,646	821,354	37,682,072	878,451	38,560,523	440.01	1.51
A2b - Residential Consumer Products	1,172,662	5,811,582	6,070,778	7,022,389	706,885	20,784,295	550,372	21,334,668	192.41	1.86
A2c - Residential Lighting	5,009,856	11,133,265	144,953,642	6,991,352	4,087,635	172,175,751	15,009,194	187,184,945	24.61	4.85
A3 - Residential Hard-to-Measure	5,954,617	8,057,014	64,392,497	11,874,322	-	90,278,450	-	90,278,450		-
A3a - Residential Statewide Marketing	-	4,543,604	-	-	-	4,543,604	-	4,543,604		-
A3b - Residential Statewide Database	469,273	-	-	-	-	469,273	-	469,273		-
A3c - Residential DOER Assessment	3,294,265	-	-	-	-	3,294,265	-	3,294,265		-
A3d - Residential EEAC Consultants	-	-	-	-	-	-	-	-		
A3e - Residential Sponsorships & Subscriptions	1,403,063	-	-	-	-	1,403,063	-	1,403,063		-
A3f - Residential HEAT Loan	259,351	559,314	63,461,223	5,983,868	-	70,263,756	-	70,263,756		-
A3g - Residential Workforce Development	-	-	-	603,636	-	603,636	-	603,636		-
A3h - Residential R&D and Demonstration	-	105,695	931,274	1,104,341	-	2,141,310	-	2,141,310		-
A3i - Residential Education	528,666	2,848,400	-	4,182,477	-	7,559,543	-	7,559,543		-
B - Low-Income	**10,584,182**	**2,858,909**	**152,096,322**	**31,979,662**	**5,718,041**	**203,237,116**	**4,733,348**	**207,970,465**	**2,117.76**	**1.25**
B1 - Low-Income Whole House	7,016,514	2,012,782	152,096,322	31,979,662	5,718,041	198,823,321	4,733,348	203,556,669	2,071.77	1.28
B1a - Low-Income Single Family Retrofit	3,788,625	1,180,570	80,215,957	16,060,422	2,442,025	103,687,599	3,303,850	106,991,449	3,355.59	1.59
B1b - Low-Income Multi-Family Retrofit	3,227,889	832,212	71,880,365	15,919,241	3,276,016	95,135,722	1,429,498	96,565,220	1,462.10	0.93
B2 - Low-Income Hard-to-Measure	3,567,668	846,127	-	-	-	4,413,795	-	4,413,795		-
B2a - Low-Income Statewide Marketing	-	846,127	-	-	-	846,127	-	846,127		-
B2b - Low-Income Statewide Database	91,101	-	-	-	-	91,101	-	91,101		-
B2c - Low-Income DOER Assessment	1,101,082	-	-	-	-	1,101,082	-	1,101,082		-
B2d - Low-Income Energy Affordability Network	2,007,748	-	-	-	-	2,007,748	-	2,007,748		-
B2e - Low-Income Sponsorships & Subscriptions	367,737	-	-	-	-	367,737	-	367,737		-
C - Commercial & Industrial	**61,135,472**	**13,408,436**	**630,411,388**	**117,907,802**	**23,836,155**	**846,699,254**	**59,441,579**	**906,140,833**	**11,640.11**	**3.50**
C1 - C&I New Construction	16,760,247	2,020,848	121,517,377	34,089,648	5,325,325	179,713,445	14,906,083	194,619,527	51,105.26	4.38
C1a - C&I New Buildings & Major Renovations	11,684,603	1,588,877	66,920,309	26,146,365	3,762,644	110,102,798	7,873,908	117,976,706	57,323.32	3.85
C1b - C&I Initial Purchase & End of Useful Life	5,075,644	431,971	54,597,068	7,943,283	1,562,680	69,610,646	7,032,175	76,642,821	43,621.11	5.23
C2 - C&I Retrofit	35,177,674	7,337,189	508,259,011	82,465,154	18,510,831	651,749,858	44,535,497	696,285,355	9,415.18	3.34
C2a - C&I Existing Building Retrofit	21,483,207	3,945,095	271,027,425	48,110,496	9,322,726	353,888,949	28,980,046	382,868,996	61,519.17	3.84
C2b - C&I Small Business	8,530,157	2,413,488	144,789,868	23,759,704	5,339,024	184,832,241	7,239,986	192,072,227	12,566.82	2.12
C2c - C&I Multifamily Retrofit	1,576,808	476,612	24,281,836	6,068,153	1,210,223	33,613,632	427,898	34,041,530	20,659.88	0.82
C2d - C&I Upstream Lighting	3,587,501	501,994	68,159,883	4,526,801	2,638,857	79,415,036	7,887,566	87,302,602	1,684.81	5.07
C3 - C&I Hard-to-Measure	9,197,552	4,050,399	635,000	1,353,000	-	15,235,951	-	15,235,951		-
C3a - C&I Statewide Marketing	-	3,630,399	-	-	-	3,630,399	-	3,630,399		-
C3b - C&I Statewide Database	367,055	-	-	-	-	367,055	-	367,055		-
C3c - C&I DOER Assessment	5,639,860	-	-	-	-	5,639,860	-	5,639,860		-
C3d - C&I EEAC Consultants	-	-	-	-	-	-	-	-		
C3e - C&I Sponsorships & Subscriptions	3,190,637	-	-	-	-	3,190,637	-	3,190,637		-
C3f - C&I Workforce Development	-	420,000	455,000	638,000	-	1,513,000	-	1,513,000		-
C3g - C&I R&D and Demonstration	-	-	180,000	715,000	-	895,000	-	895,000		-
Grand Total	**104,376,941**	**54,558,699**	**1,369,554,308**	**279,290,425**	**49,795,968**	**1,857,576,341**	**102,583,583**	**1,960,159,924**	**171.54**	**2.88**

Notes:
Budgets for each year in 2016-2018 are represented in nominal dollars (2016$, 2017$, 2018$).
Refer to common definitions for allocation of costs.
The electric Program Administrators do not budget for the EEAC Consultant fees, as these costs are paid by the DOER using RGGI proceeds.

2016 Demand Response Budgets

Sector	Program Planning and Administration	Marketing and Advertising	Participant Incentive	Sales, Technical Assistance & Training	Evaluation and Market Research	Total Program Costs
Residential	$ 187,375	$ 214,500	$ 602,132	$ 1,935,913	$ 110,904	$ 3,050,824
Low-Income	$ -	$ -	$ -	$ -	$ -	$ -
Commercial & Industrial	$ 198,104	$ 32,000	$ 100,400	$ 660,104	$ 38,881	$ 1,029,489
Grand Total	**$ 385,478**	**$ 246,500**	**$ 702,532**	**$ 2,596,017**	**$ 149,785**	**$ 4,080,313**

2017 Demand Response Budgets

Sector	Program Planning and Administration	Marketing and Advertising	Participant Incentive	Sales, Technical Assistance & Training	Evaluation and Market Research	Total Program Costs
Residential	$ 214,411	$ 214,500	$ 1,508,954	$ 2,842,901	$ 181,590	$ 4,962,356
Low-Income	$ -	$ -	$ -	$ -	$ -	$ -
Commercial & Industrial	$ 206,617	$ 58,250	$ 3,140,800	$ 3,552,480	$ 277,255	$ 7,235,401
Grand Total	**$ 421,028**	**$ 272,750**	**$ 4,649,754**	**$ 6,395,381**	**$ 458,845**	**$ 12,197,757**

2018 Demand Response Budgets

Sector	Program Planning and Administration	Marketing and Advertising	Participant Incentive	Sales, Technical Assistance & Training	Evaluation and Market Research	Total Program Costs
Residential	$ 238,601	$ 214,500	$ 2,716,440	$ 3,811,744	$ 266,662	$ 7,247,948
Low-Income	$ -	$ -	$ -	$ -	$ -	$ -
Commercial & Industrial	$ 366,163	$ 58,250	$ 3,296,325	$ 3,550,707	$ 444,494	$ 7,715,939
Grand Total	**$ 604,764**	**$ 272,750**	**$ 6,012,765**	**$ 7,362,451**	**$ 711,156**	**$ 14,963,887**

2016-2018 Demand Response Budgets

Sector	Program Planning and Administration	Marketing and Advertising	Participant Incentive	Sales, Technical Assistance & Training	Evaluation and Market Research	Total Program Costs
Residential	$ 640,387	$ 643,500	$ 4,827,526	$ 8,590,559	$ 559,157	$ 15,261,129
Low-Income	$ -	$ -	$ -	$ -	$ -	$ -
Commercial & Industrial	$ 770,883	$ 148,500	$ 6,537,525	$ 7,763,291	$ 760,629	$ 15,980,828
Grand Total	**$ 1,411,270**	**$ 792,000**	**$ 11,365,051**	**$ 16,353,850**	**$ 1,319,786**	**$ 31,241,957**

IV.C. Program Administrator Budgets

2.2 PA Budget Comparison Table - Three Year Plan vs. Previous Years

Statewide Electric

October 30, 2015

Residential Programs

PA Budget Categories	Program Administrator Budget ($)									Budget Categories as a Percent of Total Program Administrator Budget (%)								
	2013		2014		2015		2016	2017	2018	2013		2014		2015		2016	2017	2018
	Planned	Evaluated	Planned	Evaluated	Planned	YTD	Planned	Planned	Planned	Planned	Evaluated	Planned	Evaluated	Planned	YTD	Planned	Planned	Planned
Program Planning and Administration	6,262,573	4,859,412	6,404,675	6,247,631	6,301,335	2,931,183	10,824,475	10,861,809	10,971,003	4%	3%	4%	3%	4%	3%	4%	4%	4%
Marketing and Advertising	10,645,060	9,834,099	11,037,957	9,747,780	11,447,840	3,692,962	12,249,776	12,961,430	13,080,148	7%	5%	6%	4%	6%	4%	4%	5%	5%
Participant Incentive	102,828,309	129,789,042	109,802,725	152,947,799	116,763,207	72,326,792	190,698,730	196,765,648	199,582,220	64%	70%	64%	70%	65%	77%	69%	69%	69%
Sales, Technical Assistance & Training	29,001,030	29,424,693	30,258,759	32,802,256	31,186,517	13,032,700	41,453,476	43,045,804	44,903,681	18%	16%	18%	15%	17%	14%	15%	15%	16%
Evaluation and Market Research	5,045,519	2,120,911	5,348,284	5,023,699	5,624,094	2,241,236	6,750,971	6,780,326	6,710,475	3%	1%	3%	2%	3%	2%	2%	2%	2%
Performance Incentive	8,019,226	10,178,016	7,482,518	12,066,866	7,599,548	-	12,901,780	12,843,417	12,663,459	5%	5%	4%	6%	4%	0%	5%	5%	4%
Total Program Administrator Budget	**161,801,717**	**186,206,174**	**170,334,917**	**218,836,031**	**178,922,542**	**94,224,872**	**274,879,207**	**283,258,433**	**287,910,985**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Low-Income Programs

PA Budget Categories	Program Administrator Budget ($)									Budget Categories as a Percent of Total Program Administrator Budget (%)								
	2013		2014		2015		2016	2017	2018	2013		2014		2015		2016	2017	2018
	Planned	Evaluated	Planned	Evaluated	Planned	YTD	Planned	Planned	Planned	Planned	Evaluated	Planned	Evaluated	Planned	YTD	Planned	Planned	Planned
Program Planning and Administration	3,233,979	2,017,700	3,234,052	2,395,220	3,238,859	883,620	3,539,113	3,523,889	3,521,180	6%	4%	6%	4%	6%	3%	5%	5%	5%
Marketing and Advertising	616,728	421,131	666,259	387,505	1,088,461	193,742	943,081	954,499	961,330	1%	1%	1%	1%	2%	1%	1%	1%	1%
Participant Incentive	39,131,176	39,276,517	39,695,582	46,043,326	40,927,999	20,830,012	50,470,660	51,007,595	50,618,067	70%	75%	71%	77%	70%	80%	73%	73%	73%
Sales, Technical Assistance & Training	9,398,821	8,027,354	9,497,982	8,589,755	9,648,454	3,818,445	10,621,645	10,577,522	10,780,495	17%	15%	17%	14%	17%	15%	15%	15%	16%
Evaluation and Market Research	1,756,128	691,809	1,829,828	922,593	2,009,354	221,840	1,952,342	1,915,995	1,849,704	3%	1%	3%	2%	3%	1%	3%	3%	3%
Performance Incentive	2,055,985	1,826,851	1,170,850	1,397,115	1,142,024	-	1,542,230	1,567,953	1,623,166	4%	3%	2%	2%	2%	0%	2%	2%	2%
Total Program Administrator Budget	**56,192,819**	**52,261,363**	**56,094,553**	**59,735,514**	**58,055,150**	**25,947,659**	**69,069,071**	**69,547,452**	**69,353,942**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Commercial & Industrial Programs

PA Budget Categories	Program Administrator Budget ($)									Budget Categories as a Percent of Total Program Administrator Budget (%)								
	2013		2014		2015		2016	2017	2018	2013		2014		2015		2016	2017	2018
	Planned	Evaluated	Planned	Evaluated	Planned	YTD	Planned	Planned	Planned	Planned	Evaluated	Planned	Evaluated	Planned	YTD	Planned	Planned	Planned
Program Planning and Administration	18,472,620	12,799,491	18,461,358	15,389,411	18,240,082	5,130,774	19,887,209	20,887,745	20,360,519	6%	6%	6%	6%	6%	7%	7%	7%	6%
Marketing and Advertising	6,370,803	2,313,849	6,376,091	2,748,562	6,021,586	1,277,201	4,459,509	4,442,119	4,506,809	2%	1%	2%	1%	2%	2%	2%	1%	1%
Participant Incentive	209,443,520	152,689,814	213,119,818	183,537,365	225,320,980	51,019,824	198,639,588	210,200,597	221,571,203	71%	72%	72%	72%	73%	72%	69%	69%	70%
Sales, Technical Assistance & Training	30,970,658	25,698,805	31,561,831	30,939,473	32,374,532	10,425,461	38,310,904	39,477,559	40,119,339	11%	12%	11%	12%	10%	15%	13%	13%	13%
Evaluation and Market Research	8,685,908	2,787,285	8,723,076	6,120,514	8,901,146	2,757,854	7,979,276	7,838,021	8,018,857	3%	1%	3%	2%	3%	4%	3%	3%	3%
Performance Incentive	19,046,479	15,992,028	18,301,210	17,193,295	18,500,688	-	18,507,927	19,671,915	21,261,737	7%	8%	6%	7%	6%	0%	6%	7%	7%
Total Program Administrator Budget	**292,989,988**	**212,281,272**	**296,543,384**	**255,928,620**	**309,359,014**	**70,611,115**	**287,784,413**	**302,517,956**	**315,838,464**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Total Programs

PA Budget Categories	Program Administrator Budget ($)									Budget Categories as a Percent of Total Program Administrator Budget (%)								
	2013		2014		2015		2016	2017	2018	2013		2014		2015		2016	2017	2018
	Planned	Evaluated	Planned	Evaluated	Planned	YTD	Planned	Planned	Planned	Planned	Evaluated	Planned	Evaluated	Planned	YTD	Planned	Planned	Planned
Program Planning and Administration	27,969,172	19,676,603	28,100,084	24,032,263	27,780,276	8,945,576	34,250,797	35,273,442	34,852,701	5%	4%	5%	4%	5%	5%	5%	5%	5%
Marketing and Advertising	17,632,591	12,569,080	18,080,307	12,883,847	18,557,886	5,163,905	17,652,365	18,358,048	18,548,287	3%	3%	3%	2%	3%	3%	3%	3%	3%
Participant Incentive	351,403,005	321,755,373	362,618,125	382,528,490	383,012,186	144,176,628	439,808,978	457,973,840	471,771,490	69%	71%	69%	72%	70%	76%	70%	70%	70%
Sales, Technical Assistance & Training	69,370,509	63,150,852	71,318,572	72,331,484	73,209,503	27,276,607	90,386,025	93,100,884	95,803,516	14%	14%	14%	14%	13%	14%	14%	14%	14%
Evaluation and Market Research	15,487,555	5,600,005	15,901,188	12,066,807	16,534,594	5,220,930	16,682,589	16,534,342	16,579,037	3%	1%	3%	2%	3%	3%	3%	3%	2%
Performance Incentive	29,121,691	27,996,896	26,954,578	30,657,275	27,242,260	-	32,951,937	34,083,285	35,548,361	6%	6%	5%	6%	5%	0%	5%	5%	5%
Total Program Administrator Budget	**510,984,524**	**450,748,809**	**522,972,854**	**534,500,165**	**546,336,705**	**190,783,646**	**631,732,691**	**655,323,841**	**673,103,392**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Notes:

2013-2015 planned values are from the Program Administrators' 2013-2015 Three-Year Plans, in nominal dollars (2013$, 2014$, 2015$).

2013 evaluated values are from the Program Administrator's 2013 Plan Year Report, D.P.U. , in 2013$.

2014 evaluated values are from the Program Administrator's 2014 Plan Year Report, D.P.U. , in 2014$.

2015 YTD values are estimated actual cost through August 2015, in 2015$.

For supporting information on the 2016-2018 values, see Table IV.C.1. Budgets for each year in 2016-2018 are represented in nominal dollars (2016$, 2017$, 2018$).

The Program Administrators have better aligned cost allocations across Program Administrators for the 2016-2018 Three-Year Plan, consistent with the Department's directives in the 2013-2015 Three-Year Plan Order (January 31, 2013). As a result, historical budget categories may not be directly comparable for each Program Administrator.

IV.D. Cost-Effectiveness

1. Summary Table

Statewide Electric

October 30, 2015

DPU 15-160 - 15-169
Exh. 1, Appendix C
H.O.s Leupold and Hale

2016 Total Resource Cost Test (2016$)

Program	Benefit-Cost Ratio	Net Benefits	Total TRC Test Benefits	Costs: Total Program Costs	Costs: Performance Incentive	Costs: Participant Costs	Costs: Total TRC Test Costs
A - Residential	**2.37**	**482,849,312**	**834,455,777**	**261,977,427**	**12,901,780**	**74,618,141**	**351,606,465**
A1 - Residential Whole House	2.33	269,613,607	472,941,695	155,728,180	7,123,405	39,088,744	203,328,088
A1a - Residential New Construction	2.77	32,083,354	50,217,617	6,843,668	796,609	10,435,271	18,134,264
A1b - Residential Multi-Family Retrofit	0.98	-317,135	16,448,605	17,628,801	171,571	(1,234,424)	16,765,740
A1c - Residential Home Energy Services - Measures	2.69	241,956,067	385,368,954	106,680,355	5,836,379	29,887,897	143,412,888
A1d - Residential Home Energy Services - RCS	0.00	-14,814,226	0	14,814,226	-	-	14,814,226
A1e - Residential Behavior/Feedback Program	2.05	10,705,547	20,906,518	9,761,130	318,846	-	10,200,971
A2 - Residential Products	3.03	242,264,129	361,514,082	77,220,824	5,778,375	35,529,397	119,249,953
A2a - Residential Heating & Cooling Equipment	1.00	-6,018	19,936,858	12,099,231	279,247	7,462,652	19,942,876
A2b - Residential Consumer Products	1.48	4,252,606	13,034,665	6,725,589	179,969	1,813,672	8,782,059
A2c - Residential Lighting	3.63	238,017,540	328,542,559	58,396,004	5,319,158	26,253,073	90,525,018
A3 - Residential Hard-to-Measure	0.00	-29,028,424	0	29,028,424	-	-	29,028,424
B - Low-Income	**1.65**	**44,971,461**	**114,662,979**	**67,526,840**	**1,542,230**	**-**	**69,691,518**
B1 - Low-Income Whole House	1.68	46,432,690	114,662,979	66,065,611	1,542,230	-	68,230,289
B1a - Low-Income Single Family Retrofit	2.01	35,562,736	70,725,472	33,784,696	1,056,133	-	35,162,737
B1b - Low-Income Multi-Family Retrofit	1.33	10,869,954	43,937,507	32,280,916	486,097	-	33,067,553
B2 - Low-Income Hard-to-Measure	0.00	-1,461,229	0	1,461,229	-	-	1,461,229
C - Commercial & Industrial	**2.58**	**669,443,313**	**1,092,059,160**	**269,276,486**	**18,507,927**	**132,662,031**	**422,615,847**
C1 - C&I New Construction	3.35	174,350,376	248,403,756	57,140,311	4,527,926	11,910,938	74,053,380
C1a - C&I New Buildings & Major Renovations	2.97	86,966,775	131,169,184	34,958,810	2,377,351	6,635,560	44,202,409
C1b - C&I Initial Purchase & End of Useful Life	3.93	87,383,601	117,234,572	22,181,501	2,150,575	5,275,378	29,850,971
C2 - C&I Retrofit	2.46	500,179,708	843,655,404	207,049,405	13,980,001	120,751,093	343,475,697
C2a - C&I Existing Building Retrofit	2.47	308,073,918	517,945,413	112,619,315	9,000,463	87,249,932	209,871,495
C2b - C&I Small Business	2.12	82,921,856	157,201,190	59,019,417	2,359,820	12,517,720	74,279,334
C2c - C&I Multifamily Retrofit	1.08	953,353	12,177,417	11,084,885	141,398	(126,019)	11,224,064
C2d - C&I Upstream Lighting	3.25	108,230,580	156,331,384	24,325,788	2,478,320	21,109,460	48,100,804
C3 - C&I Hard-to-Measure	0.00	-5,086,770	0	5,086,770	-	-	5,086,770
Grand Total	**2.42**	**1,197,264,086**	**2,041,177,916**	**598,780,754**	**32,951,937**	**207,280,172**	**843,913,830**

2017 Total Resource Cost Test (2016$)

Program	Benefit-Cost Ratio	Net Benefits	Total TRC Test Benefits	Costs: Total Program Costs	Costs: Performance Incentive	Costs: Participant Costs	Costs: Total TRC Test Costs
A - Residential	**2.33**	**463,904,924**	**811,614,592**	**263,716,614**	**12,525,275**	**69,349,201**	**347,709,668**
A1 - Residential Whole House	2.29	269,448,219	478,021,386	158,172,843	7,151,391	41,854,949	208,573,167
A1a - Residential New Construction	2.81	32,810,488	50,915,395	6,891,381	809,965	10,344,583	18,104,907
A1b - Residential Multi-Family Retrofit	0.98	-367,387	16,386,989	17,592,275	167,158	(1,205,745)	16,754,376
A1c - Residential Home Energy Services - Measures	2.63	242,530,487	391,175,683	109,030,931	5,885,374	32,716,112	148,645,197
A1d - Residential Home Energy Services - RCS	0.00	-15,245,760	0	15,245,760	-	-	15,245,760
A1e - Residential Behavior/Feedback Program	1.99	9,720,390	19,543,319	9,412,497	288,894	-	9,822,928
A2 - Residential Products	3.04	224,001,128	333,593,206	75,999,349	5,373,883	27,494,251	109,592,078
A2a - Residential Heating & Cooling Equipment	1.01	195,652	20,142,120	12,254,430	284,256	7,305,579	19,946,468
A2b - Residential Consumer Products	1.46	4,107,901	12,986,866	6,866,665	179,231	1,769,958	8,878,966
A2c - Residential Lighting	3.72	219,697,575	300,464,219	56,878,253	4,910,396	18,418,714	80,766,644
A3 - Residential Hard-to-Measure	0.00	-29,544,423	0	29,544,423	-	-	29,544,423
B - Low-Income	**1.68**	**46,219,226**	**114,669,170**	**66,295,591**	**1,529,113**	**-**	**68,449,944**
B1 - Low-Income Whole House	1.71	47,655,917	114,669,170	64,858,900	1,529,113	-	67,013,253
B1a - Low-Income Single Family Retrofit	2.06	37,236,098	72,392,678	33,755,721	1,077,507	-	35,156,580
B1b - Low-Income Multi-Family Retrofit	1.33	10,419,819	42,276,492	31,103,179	451,606	-	31,856,673
B2 - Low-Income Hard-to-Measure	0.00	-1,436,691	0	1,436,691	-	-	1,436,691
C - Commercial & Industrial	**2.59**	**699,551,919**	**1,138,448,337**	**275,839,712**	**19,184,626**	**141,692,944**	**438,896,418**
C1 - C&I New Construction	3.47	186,908,767	262,523,585	58,448,025	4,862,928	11,827,532	75,614,818
C1a - C&I New Buildings & Major Renovations	3.06	95,150,172	141,386,152	36,400,453	2,560,686	7,043,118	46,235,980
C1b - C&I Initial Purchase & End of Useful Life	4.12	91,758,595	121,137,433	22,047,572	2,302,242	4,784,415	29,378,838
C2 - C&I Retrofit	2.44	517,614,606	875,924,752	212,420,233	14,321,698	129,865,412	358,310,146
C2a - C&I Existing Building Retrofit	2.49	329,186,287	550,154,897	115,636,032	9,329,342	94,996,956	220,968,610
C2b - C&I Small Business	2.13	85,184,307	160,559,397	60,116,148	2,343,716	12,531,134	75,375,090
C2c - C&I Multifamily Retrofit	1.11	1,164,178	12,113,190	10,821,810	138,636	(135,790)	10,949,011
C2d - C&I Upstream Lighting	3.00	102,079,835	153,097,269	25,846,243	2,510,004	22,473,112	51,017,434
C3 - C&I Hard-to-Measure	0.00	-4,971,454	0	4,971,454	-	-	4,971,454
Grand Total	**2.41**	**1,209,676,070**	**2,064,732,100**	**605,851,918**	**33,239,014**	**211,042,145**	**855,056,030**

IV.D. Cost-Effectiveness

1. Summary Table

Statewide Electric

October 30, 2015

2018 Total Resource Cost Test (2016$)

Program	Benefit-Cost Ratio	Net Benefits	Total TRC Test Benefits	Costs			
				Total Program Costs	Performance Incentive	Participant Costs	Total TRC Test Costs
A - Residential	**2.30**	**442,970,196**	**782,600,088**	**261,780,202**	**12,043,860**	**63,677,747**	**339,629,892**
A1 - Residential Whole House	2.28	270,592,460	481,428,613	160,541,696	7,146,541	41,747,679	210,836,153
A1a - Residential New Construction	2.95	35,251,974	53,285,069	6,904,515	852,028	10,217,308	18,033,094
A1b - Residential Multi-Family Retrofit	0.99	-185,719	16,622,223	17,638,484	163,211	(1,195,342)	16,807,941
A1c - Residential Home Energy Services - Measures	2.63	245,374,333	396,151,277	111,106,637	5,927,270	32,725,713	150,776,943
A1d - Residential Home Energy Services - RCS	0.00	-15,549,565	0	15,549,565	-	-	15,549,565
A1e - Residential Behavior/Feedback Program	1.59	5,701,436	15,370,045	9,342,495	204,031	-	9,668,609
A2 - Residential Products	3.03	201,818,335	301,171,474	71,797,907	4,897,320	21,930,068	99,353,139
A2a - Residential Heating & Cooling Equipment	1.03	604,698	20,532,466	12,380,244	292,671	7,152,191	19,927,768
A2b - Residential Consumer Products	1.48	4,055,781	12,588,742	6,674,269	177,488	1,617,810	8,532,961
A2c - Residential Lighting	3.78	197,157,856	268,050,267	52,743,394	4,427,160	13,160,067	70,892,411
A3 - Residential Hard-to-Measure	0.00	-29,440,599	0	29,440,599	-	-	29,440,599
B - Low-Income	**1.73**	**48,939,090**	**115,527,725**	**64,416,842**	**1,543,747**	**-**	**66,588,634**
B1 - Low-Income Whole House	1.77	50,346,090	115,527,725	63,009,842	1,543,747	-	65,181,634
B1a - Low-Income Single Family Retrofit	2.10	38,553,817	73,528,671	33,563,127	1,086,925	-	34,974,855
B1b - Low-Income Multi-Family Retrofit	1.39	11,792,273	41,999,053	29,446,715	456,822	-	30,206,780
B2 - Low-Income Hard-to-Measure	0.00	-1,407,000	0	1,407,000	-	-	1,407,000
C - Commercial & Industrial	**2.63**	**749,534,134**	**1,210,592,308**	**280,163,662**	**20,221,442**	**158,484,159**	**461,058,174**
C1 - C&I New Construction	3.56	198,960,359	276,730,098	59,575,650	5,127,905	12,587,716	77,769,739
C1a - C&I New Buildings & Major Renovations	3.24	104,260,444	150,790,480	35,968,556	2,730,365	7,598,352	46,530,036
C1b - C&I Initial Purchase & End of Useful Life	4.03	94,699,916	125,939,618	23,607,094	2,397,539	4,989,363	31,239,703
C2 - C&I Retrofit	2.47	555,378,069	933,862,210	215,783,718	15,093,537	145,896,444	378,484,141
C2a - C&I Existing Building Retrofit	2.48	356,262,536	597,110,120	116,693,149	9,903,775	113,239,866	240,847,584
C2b - C&I Small Business	2.17	89,679,955	166,112,458	61,030,027	2,355,729	12,660,932	76,432,503
C2c - C&I Multifamily Retrofit	1.10	1,071,412	12,058,445	10,872,715	137,280	(147,875)	10,987,034
C2d - C&I Upstream Lighting	3.16	108,364,166	158,581,186	27,187,828	2,696,753	20,143,521	50,217,020
C3 - C&I Hard-to-Measure	0.00	-4,804,295	0	4,804,295	-	-	4,804,295
Grand Total	**2.43**	**1,241,443,420**	**2,108,720,120**	**606,360,707**	**33,809,049**	**222,161,906**	**867,276,701**

2016-2018 Total Resource Cost Test (2016$)

Program	Benefit-Cost Ratio	Net Benefits	Total TRC Test Benefits	Costs			
				Total Program Costs	Performance Incentive	Participant Costs	Total TRC Test Costs
A - Residential	**2.34**	**1,389,724,432**	**2,428,670,457**	**787,474,244**	**37,470,915**	**207,645,089**	**1,038,946,025**
A1 - Residential Whole House	2.30	809,654,286	1,432,391,695	474,442,718	21,421,338	122,691,373	622,737,409
A1a - Residential New Construction	2.85	100,145,816	154,418,081	20,639,563	2,458,602	30,997,162	54,272,265
A1b - Residential Multi-Family Retrofit	0.98	-870,240	49,457,817	52,859,559	501,941	(3,635,511)	50,328,057
A1c - Residential Home Energy Services - Measures	2.65	729,860,887	1,172,695,915	326,817,924	17,649,023	95,329,722	442,835,028
A1d - Residential Home Energy Services - RCS	0.00	-45,609,551	0	45,609,551	-	-	45,609,551
A1e - Residential Behavior/Feedback Program	1.88	26,127,374	55,819,882	28,516,122	811,771	-	29,692,508
A2 - Residential Products	3.04	668,083,592	996,278,762	225,018,080	16,049,578	84,953,716	328,195,170
A2a - Residential Heating & Cooling Equipment	1.01	794,333	60,611,444	36,733,906	856,174	21,920,422	59,817,112
A2b - Residential Consumer Products	1.47	12,416,288	38,610,273	20,266,523	536,689	5,201,440	26,193,985
A2c - Residential Lighting	3.70	654,872,971	897,057,045	168,017,651	14,656,714	57,831,854	242,184,074
A3 - Residential Hard-to-Measure	0.00	-88,013,446	0	88,013,446	-	-	88,013,446
B - Low-Income	**1.68**	**140,129,777**	**344,859,874**	**198,239,274**	**4,615,090**	**-**	**204,730,097**
B1 - Low-Income Whole House	1.72	144,434,697	344,859,874	193,934,354	4,615,090	-	200,425,177
B1a - Low-Income Single Family Retrofit	2.06	111,352,651	216,646,822	101,103,543	3,220,565	-	105,294,171
B1b - Low-Income Multi-Family Retrofit	1.35	33,082,046	128,213,052	92,830,811	1,394,526	-	95,131,006
B2 - Low-Income Hard-to-Measure	0.00	-4,304,920	0	4,304,920	-	-	4,304,920
C - Commercial & Industrial	**2.60**	**2,118,529,366**	**3,441,099,805**	**825,279,861**	**57,913,994**	**432,839,134**	**1,322,570,439**
C1 - C&I New Construction	3.46	560,219,502	787,657,439	175,163,986	14,518,758	36,326,186	227,437,938
C1a - C&I New Buildings & Major Renovations	3.09	286,377,391	423,345,816	107,327,819	7,668,402	21,277,030	136,968,425
C1b - C&I Initial Purchase & End of Useful Life	4.03	273,842,111	364,311,623	67,836,167	6,850,356	15,049,156	90,469,512
C2 - C&I Retrofit	2.46	1,573,172,383	2,653,442,366	635,253,356	43,395,236	396,512,948	1,080,269,983
C2a - C&I Existing Building Retrofit	2.48	993,522,740	1,665,210,430	344,948,496	28,233,580	295,486,753	671,687,689
C2b - C&I Small Business	2.14	257,786,118	483,873,045	180,165,591	7,059,265	37,709,787	226,086,927
C2c - C&I Multifamily Retrofit	1.10	3,188,943	36,349,052	32,779,409	417,314	(409,684)	33,160,109
C2d - C&I Upstream Lighting	3.13	318,674,581	468,009,839	77,359,859	7,685,077	63,726,093	149,335,258
C3 - C&I Hard-to-Measure	0.00	-14,862,518	0	14,862,518	-	-	14,862,518
Grand Total	**2.42**	**3,648,383,576**	**6,214,630,136**	**1,810,993,378**	**100,000,000**	**640,484,223**	**2,566,246,561**

Notes:

The Benefit-Cost Ratio is the Total TRC Test Benefits divided by the Total TRC Test Costs.
The Net Benefits are the Total TRC Test Benefits minus the Total TRC Test Costs.
For supporting information on the Total TRC Test Benefits, see Table IV.D.3.1.i.
For supporting information on the Total Program Costs, see Table IV.C.1.
For supporting information on the Performance Incentive, refer to the Performance Incentive Model.
The Total TRC Costs are the sum of the Total Program Costs, Performance Incentives, and Participant Costs.

IV.D Cost-Effectiveness

2.3 Cost Comparison Table - Three-Year Plan vs. Previous Years

Statewide Electric
October 30, 2015

TRC Costs Categories	TRC Costs						TRC Cost Categories as a Percent of Total TRC Costs (%)					
	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018
Residential												
PA Budget	186,206,173	213,077,166	169,438,328	274,879,207	276,241,889	273,824,063	73%	66%	78%	78%	79%	81%
Participant Cost	67,415,323	108,761,884	46,265,039	74,618,141	69,349,201	63,677,747	27%	34%	21%	21%	20%	19%
Residential Total TRC Costs	254,074,390	322,262,215	216,141,940	351,606,465	347,709,668	339,629,892	100%	100%	100%	100%	100%	100%
Low-Income												
PA Budget	52,261,363	58,142,371	54,988,695	69,069,071	67,824,704	65,960,589	99%	100%	97%	99%	99%	99%
Participant Cost	327,474	105,995	1,567,475	-	-	-	1%	0%	3%	0%	0%	0%
Low-Income Total TRC Costs	52,741,787	58,403,772	56,699,733	69,691,518	68,449,944	66,588,634	100%	100%	100%	100%	100%	100%
Commercial & Industrial												
PA Budget	212,281,272	249,213,985	292,989,131	287,784,413	295,024,338	300,385,104	65%	68%	69%	68%	67%	65%
Participant Cost	110,867,331	112,791,500	127,741,999	132,662,031	141,692,944	158,484,159	34%	31%	30%	31%	32%	34%
C&I Total TRC Costs	325,517,997	365,021,009	423,747,843	422,615,847	438,896,418	461,058,174	100%	100%	100%	100%	100%	100%
Grand Total												
PA Budget	450,748,808	520,433,523	517,416,154	631,732,691	639,090,932	640,169,756	71%	70%	74%	75%	75%	74%
Participant Cost	178,610,128	221,659,379	175,574,513	207,280,172	211,042,145	222,161,906	28%	30%	25%	25%	25%	26%
Grand Total TRC Costs	632,334,174	745,686,996	696,589,517	843,913,830	855,056,030	867,276,701	100%	100%	100%	100%	100%	100%

Notes:
2013 values are from the Program Administrator's 2013 Plan Year Report D.P.U. , in 2013$.
2014 values are from the Program Administrator's 2014 Plan Year Report, D.P.U. , in 2013$.
2015 values are from the Program Administrator's 2013-2015 Three-Year Plan, D.P.U. , in 2013$.
For supporting information on 2016-2018 TRC values, see Table IV.D.1. The 2016-2018 values are in 2016$.

IV.D Cost-Effectiveness

3.1.i. Benefits Summary Table

Statewide Electric
October 30, 2015

DPU 15-160 - 15-169
Exh. 1, Appendix C
H.O.s Leupold and Hale

2016 Benefits								
	Electric Benefits							
	Capacity					Electric Energy		
Program	Summer Generation	Transmission	Distribution	Capacity DRIPE	Total Capacity Benefits	Electric Energy	Electric Energy DRIPE	Total Electric Energy Benefits
A - Residential	**95,137,901**	**14,908,653**	**71,065,381**	**-**	**181,111,935**	**359,724,480**	**75,712,276**	**435,436,756**
A1 - Residential Whole House	38,847,142	6,465,651	28,904,384	-	74,217,177	92,896,458	22,663,147	115,559,605
A1a - Residential New Construction	11,393,129	2,095,573	7,969,134	-	21,457,837	9,666,024	1,107,560	10,773,584
A1b - Residential Multi-Family Retrofit	990,981	166,760	782,933	-	1,940,675	7,095,336	1,283,054	8,378,390
A1c - Residential Home Energy Services - Measures	25,543,434	3,822,030	18,072,243	-	47,437,707	66,259,024	12,830,204	79,089,228
A1d - Residential Home Energy Services - RCS	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	919,598	381,287	2,080,074	-	3,380,959	9,876,074	7,442,328	17,318,402
A2 - Residential Products	56,290,759	8,443,002	42,160,996	-	106,894,758	266,828,022	53,049,130	319,877,151
A2a - Residential Heating & Cooling Equipment	3,100,453	471,844	2,143,100	-	5,715,398	11,948,763	1,584,535	13,533,299
A2b - Residential Consumer Products	2,091,497	311,902	1,627,282	-	4,030,680	7,153,335	1,622,526	8,775,861
A2c - Residential Lighting	51,098,809	7,659,256	38,390,615	-	97,148,680	247,725,924	49,842,068	297,567,992
B - Low-Income	**6,678,404**	**900,438**	**4,707,272**	**-**	**12,286,113**	**26,304,817**	**5,383,354**	**31,688,170**
B1 - Low-Income Whole House	6,678,404	900,438	4,707,272	-	12,286,113	26,304,817	5,383,354	31,688,170
B1a - Low-Income Single Family Retrofit	4,638,569	630,032	3,220,579	-	8,489,179	11,548,277	2,218,749	13,767,026
B1b - Low-Income Multi-Family Retrofit	2,039,835	270,406	1,486,693	-	3,796,934	14,756,539	3,164,605	17,921,145
C - Commercial & Industrial	**161,881,344**	**25,445,706**	**118,468,021**	**-**	**305,795,071**	**581,586,450**	**98,231,085**	**679,817,535**
C1 - C&I New Construction	53,297,923	6,784,128	34,291,852	-	94,373,903	141,079,122	15,834,759	156,913,881
C1a - C&I New Buildings & Major Renovations	24,078,798	3,530,315	16,375,195	-	43,984,308	79,571,494	9,003,835	88,575,330
C1b - C&I Initial Purchase & End of Useful Life	29,219,125	3,253,813	17,916,657	-	50,389,595	61,507,627	6,830,924	68,338,551
C2 - C&I Retrofit	108,583,421	18,661,578	84,176,168	-	211,421,167	440,507,328	82,396,326	522,903,654
C2a - C&I Existing Building Retrofit	64,130,260	10,589,404	46,444,290	-	121,163,954	277,530,603	40,458,022	317,988,625
C2b - C&I Small Business	23,382,345	4,112,960	18,205,972	-	45,701,277	74,370,960	14,020,066	88,391,026
C2c - C&I Multifamily Retrofit	1,041,831	223,422	862,877	-	2,128,130	6,027,607	1,177,423	7,205,031
C2d - C&I Upstream Lighting	20,028,985	3,735,793	18,663,029	-	42,427,807	82,578,158	26,740,814	109,318,972
Grand Total	**263,697,649**	**41,254,797**	**194,240,673**	**-**	**499,193,119**	**967,615,746**	**179,326,715**	**1,146,942,461**

2017 Benefits								
	Electric Benefits							
	Capacity					Electric Energy		
Program	Summer Generation	Transmission	Distribution	Capacity DRIPE	Total Capacity Benefits	Electric Energy	Electric Energy DRIPE	Total Electric Energy Benefits
A - Residential	**104,040,958**	**14,237,753**	**68,898,404**	**-**	**187,177,116**	**347,543,946**	**42,192,166**	**389,736,111**
A1 - Residential Whole House	42,309,858	6,461,365	28,779,113	-	77,550,336	90,489,945	13,850,754	104,340,699
A1a - Residential New Construction	11,958,990	2,119,759	8,030,503	-	22,109,252	9,489,320	614,543	10,103,864
A1b - Residential Multi-Family Retrofit	1,110,191	164,672	775,609	-	2,050,471	7,151,459	753,013	7,904,471
A1c - Residential Home Energy Services - Measures	27,508,449	3,795,865	17,893,628	-	49,197,941	64,111,757	7,076,812	71,188,569
A1d - Residential Home Energy Services - RCS	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	1,732,228	381,070	2,079,374	-	4,192,672	9,737,409	5,406,386	15,143,795
A2 - Residential Products	61,731,100	7,776,388	40,119,291	-	109,626,779	257,054,000	28,341,412	285,395,413
A2a - Residential Heating & Cooling Equipment	3,371,414	479,256	2,175,686	-	6,026,356	12,394,407	959,709	13,354,117
A2b - Residential Consumer Products	2,459,098	327,395	1,693,700	-	4,480,194	7,294,856	944,551	8,239,407
A2c - Residential Lighting	55,900,588	6,969,737	36,249,905	-	99,120,230	237,364,737	26,437,152	263,801,889
B - Low-Income	**7,342,668**	**887,038**	**4,667,514**	**-**	**12,897,220**	**25,614,415**	**3,025,300**	**28,639,715**
B1 - Low-Income Whole House	7,342,668	887,038	4,667,514	-	12,897,220	25,614,415	3,025,300	28,639,715
B1a - Low-Income Single Family Retrofit	5,087,007	635,367	3,232,431	-	8,954,806	11,721,358	1,278,958	13,000,315
B1b - Low-Income Multi-Family Retrofit	2,255,660	251,671	1,435,082	-	3,942,414	13,893,057	1,746,342	15,639,400
C - Commercial & Industrial	**194,872,529**	**28,453,978**	**130,530,527**	**-**	**353,857,034**	**661,237,191**	**61,531,785**	**722,768,977**
C1 - C&I New Construction	60,403,196	6,888,612	36,190,446	-	103,482,254	150,313,468	9,880,114	160,193,582
C1a - C&I New Buildings & Major Renovations	28,238,409	3,696,493	17,849,698	-	49,784,601	87,131,602	5,720,579	92,852,181
C1b - C&I Initial Purchase & End of Useful Life	32,164,787	3,192,119	18,340,747	-	53,697,653	63,181,866	4,159,535	67,341,401
C2 - C&I Retrofit	134,469,332	21,565,366	94,340,082	-	250,374,780	510,923,723	51,651,671	562,575,394
C2a - C&I Existing Building Retrofit	81,462,154	13,244,174	55,437,863	-	150,144,191	341,064,920	26,955,965	368,020,885
C2b - C&I Small Business	26,685,300	4,302,743	18,855,947	-	49,843,990	77,362,715	8,429,599	85,792,314
C2c - C&I Multifamily Retrofit	1,156,953	224,431	870,128	-	2,251,511	6,296,024	721,290	7,017,313
C2d - C&I Upstream Lighting	25,164,926	3,794,018	19,176,144	-	48,135,087	86,200,064	15,544,818	101,744,882
Grand Total	**306,256,155**	**43,578,769**	**204,096,445**	**-**	**553,931,369**	**1,034,395,552**	**106,749,251**	**1,141,144,803**

IV.D Cost-Effectiveness

3.1.i. Benefits Summary Table

DPU 15-160 - 15-169
Exh. 1, Appendix C
H.O.s Leupold and Hale

Statewide Electric
October 30, 2015

Program	2016 Benefits									
	Natural Gas Benefits			Deliverable Fuel Benefits		Other Benefits				
	Natural Gas	Natural Gas DRIPE	Total Gas Benefits	Oil	Propane	Water	Total Energy Benefits	Non-Energy Impacts	Total TRC Test Benefits	Total Energy Benefits per Participant
A - Residential	**(24,311,959)**	**(5,195,684)**	**(29,507,643)**	**133,703,824**	**7,842,851**	**5,784,545**	**734,372,268**	**100,083,509**	**834,455,777**	**207.54**
A1 - Residential Whole House	5,607,899	539,643	6,147,541	176,312,165	18,248,706	5,649,514	396,134,709	76,806,986	472,941,695	343.24
A1a - Residential New Construction	305,654	26,461	332,116	1,565,199	5,859,506	-	39,988,241	10,229,376	50,217,617	7,782.84
A1b - Residential Multi-Family Retrofit	1,745	403	2,148	2,730,918	4,211	311,937	13,368,279	3,080,327	16,448,605	715.23
A1c - Residential Home Energy Services - Measures	5,245,979	502,983	5,748,962	171,943,235	12,367,778	5,284,760	321,871,671	63,497,283	385,368,954	22,753.43
A1d - Residential Home Energy Services - RCS	-	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	54,520	9,796	64,316	72,813	17,211	52,817	20,906,518	-	20,906,518	19.14
A2 - Residential Products	(29,919,858)	(5,735,327)	(35,655,184)	(42,608,341)	(10,405,855)	135,031	338,237,559	23,276,523	361,514,082	141.85
A2a - Residential Heating & Cooling Equipment	(411,484)	(44,012)	(455,496)	-	-	-	18,793,200	1,143,658	19,936,858	665.60
A2b - Residential Consumer Products	30,406	7,552	37,958	20,625	34,509	135,031	13,034,665	-	13,034,665	352.00
A2c - Residential Lighting	(29,538,780)	(5,698,867)	(35,237,647)	(42,628,967)	(10,440,364)	-	306,409,694	22,132,865	328,542,559	132.12
B - Low-Income	**1,670**	**449**	**2,120**	**38,890,167**	**1,170,854**	**271,175**	**84,308,599**	**30,354,380**	**114,662,979**	**2,648.77**
B1 - Low-Income Whole House	1,670	449	2,120	38,890,167	1,170,854	271,175	84,308,599	30,354,380	114,662,979	2,648.77
B1a - Low-Income Single Family Retrofit	1,670	449	2,120	30,417,473	1,163,398	90,220	53,929,416	16,796,056	70,725,472	5,276.85
B1b - Low-Income Multi-Family Retrofit	-	-	-	8,472,693	7,456	180,955	30,379,183	13,558,324	43,937,507	1,405.84
C - Commercial & Industrial	**(33,121,748)**	**(4,823,515)**	**(37,945,262)**	**(23,623,869)**	**285,717**	**397,408**	**924,726,599**	**167,332,561**	**1,092,059,160**	**40,640.29**
C1 - C&I New Construction	(726,319)	(60,972)	(787,292)	(2,096,737)	-	-	248,403,756	-	248,403,756	221,045.32
C1a - C&I New Buildings & Major Renovations	708,732	80,423	789,155	(2,179,609)	-	-	131,169,184	-	131,169,184	215,145.01
C1b - C&I Initial Purchase & End of Useful Life	(1,435,051)	(141,395)	(1,576,446)	82,872	-	-	117,234,572	-	117,234,572	228,042.69
C2 - C&I Retrofit	(32,395,428)	(4,762,543)	(37,157,971)	(21,527,132)	285,717	397,408	676,322,843	167,332,561	843,655,404	31,267.57
C2a - C&I Existing Building Retrofit	(23,975,164)	(2,676,974)	(26,652,138)	(7,517,138)	68,381	383,250	405,434,934	112,510,479	517,945,413	210,744.38
C2b - C&I Small Business	(5,264,703)	(1,049,304)	(6,314,007)	(505,225)	212,637	-	127,485,708	29,715,482	157,201,190	27,499.43
C2c - C&I Multifamily Retrofit	(147,782)	(37,714)	(185,496)	111,813	4,699	14,158	9,278,334	2,899,083	12,177,417	17,407.76
C2d - C&I Upstream Lighting	(3,007,779)	(998,551)	(4,006,331)	(13,616,581)	-	-	134,123,867	22,207,517	156,331,384	9,226.12
Grand Total	**(57,432,036)**	**(10,018,750)**	**(67,450,786)**	**148,970,121**	**9,299,422**	**6,453,128**	**1,743,407,466**	**297,770,450**	**2,041,177,916**	**485.21**

Program	2017 Benefits									
	Natural Gas Benefits			Deliverable Fuel Benefits		Other Benefits				
	Natural Gas	Natural Gas DRIPE	Total Gas Benefits	Oil	Propane	Water	Total Energy Benefits	Non-Energy Impacts	Total TRC Test Benefits	Total Energy Benefits per Participant
A - Residential	**(23,026,153)**	**(2,790,117)**	**(25,816,270)**	**144,216,552**	**9,792,349**	**6,140,363**	**711,246,221**	**100,368,372**	**811,614,592**	**198.96**
A1 - Residential Whole House	5,968,623	367,391	6,336,013	185,778,920	19,900,364	5,980,990	399,887,323	78,134,063	478,021,386	345.24
A1a - Residential New Construction	318,914	18,055	336,969	1,743,653	6,040,152	-	40,333,890	10,581,505	50,915,395	7,856.23
A1b - Residential Multi-Family Retrofit	1,787	239	2,027	2,941,507	4,519	322,520	13,225,515	3,161,474	16,386,989	681.13
A1c - Residential Home Energy Services - Measures	5,592,204	343,212	5,935,416	181,018,956	13,838,064	5,605,652	326,784,599	64,391,084	391,175,683	22,405.31
A1d - Residential Home Energy Services - RCS	-	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	55,718	5,885	61,602	74,804	17,628	52,817	19,543,319	-	19,543,319	17.85
A2 - Residential Products	(28,994,776)	(3,157,508)	(32,152,284)	(41,562,368)	(10,108,015)	159,373	311,358,898	22,234,308	333,593,206	128.85
A2a - Residential Heating & Cooling Equipment	(405,162)	(27,322)	(432,484)	-	-	-	18,947,989	1,194,132	20,142,120	663.80
A2b - Residential Consumer Products	37,298	5,262	42,560	22,793	42,540	159,373	12,986,866	-	12,986,866	347.04
A2c - Residential Lighting	(28,626,912)	(3,135,448)	(31,762,360)	(41,585,161)	(10,150,556)	-	279,424,043	21,040,176	300,464,219	118.88
B - Low-Income	**1,714**	**264**	**1,978**	**41,294,272**	**1,156,537**	**278,966**	**84,268,687**	**30,400,483**	**114,669,170**	**2,634.28**
B1 - Low-Income Whole House	1,714	264	1,978	41,294,272	1,156,537	278,966	84,268,687	30,400,483	114,669,170	2,634.28
B1a - Low-Income Single Family Retrofit	1,714	264	1,978	32,035,970	1,156,537	90,220	55,239,824	17,152,854	72,392,678	5,363.09
B1b - Low-Income Multi-Family Retrofit	-	-	-	9,258,303	-	188,747	29,028,863	13,247,629	42,276,492	1,338.40
C - Commercial & Industrial	**(68,395,140)**	**(5,535,339)**	**(73,930,479)**	**(25,251,976)**	**466,784**	**446,088**	**978,356,428**	**160,091,909**	**1,138,448,337**	**39,316.43**
C1 - C&I New Construction	891,685	76,772	968,457	(2,120,709)	-	-	262,523,585	-	262,523,585	223,463.22
C1a - C&I New Buildings & Major Renovations	888,134	66,634	954,768	(2,205,397)	-	-	141,386,152	-	141,386,152	221,567.87
C1b - C&I Initial Purchase & End of Useful Life	3,551	10,139	13,690	84,689	-	-	121,137,433	-	121,137,433	225,716.82
C2 - C&I Retrofit	(69,286,825)	(5,612,111)	(74,898,937)	(23,131,267)	466,784	446,088	715,832,843	160,091,909	875,924,752	30,191.98
C2a - C&I Existing Building Retrofit	(60,170,007)	(4,321,238)	(64,491,245)	(7,734,106)	78,511	433,428	446,451,665	103,703,231	550,154,897	231,925.18
C2b - C&I Small Business	(5,559,159)	(656,959)	(6,216,118)	73,181	383,180	-	129,876,548	30,682,849	160,559,397	26,592.02
C2c - C&I Multifamily Retrofit	(154,580)	(22,824)	(177,404)	94,985	5,093	12,660	9,204,158	2,909,032	12,113,190	16,981.84
C2d - C&I Upstream Lighting	(3,403,079)	(611,091)	(4,014,170)	(15,565,327)	-	-	130,300,472	22,796,797	153,097,269	7,965.38
Grand Total	**(91,419,580)**	**(8,325,192)**	**(99,744,772)**	**160,258,849**	**11,415,670**	**6,865,417**	**1,773,871,336**	**290,860,764**	**2,064,732,100**	**488.45**

IV.D Cost-Effectiveness

3.1.i. Benefits Summary Table

Statewide Electric
October 30, 2015

DPU 15-160 - 15-169
Exh. 1, Appendix C
H.O.s Leupold and Hale

2018 Benefits								
	Electric Benefits							
	Capacity					Electric Energy		
Program	Summer Generation	Transmission	Distribution	Capacity DRIPE	Total Capacity Benefits	Electric Energy	Electric Energy DRIPE	Total Electric Energy Benefits
A - Residential	**105,359,166**	**13,325,107**	**64,957,930**	**-**	**183,642,203**	**329,545,553**	**17,735,242**	**347,280,795**
A1 - Residential Whole House	44,135,707	6,399,819	28,531,950	-	79,067,475	89,114,296	5,999,218	95,113,514
A1a - Residential New Construction	12,623,931	2,132,269	8,164,322	-	22,920,522	11,187,574	340,117	11,527,690
A1b - Residential Multi-Family Retrofit	1,202,436	162,563	770,401	-	2,135,401	7,343,618	370,218	7,713,837
A1c - Residential Home Energy Services - Measures	28,477,959	3,724,231	17,518,882	-	49,721,072	61,836,183	3,163,337	64,999,520
A1d - Residential Home Energy Services - RCS	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	1,831,380	380,756	2,078,344	-	4,290,480	8,746,921	2,125,546	10,872,467
A2 - Residential Products	61,223,459	6,925,289	36,425,980	-	104,574,728	240,431,257	11,736,024	252,167,281
A2a - Residential Heating & Cooling Equipment	3,588,592	487,408	2,211,670	-	6,287,670	12,910,363	503,637	13,414,001
A2b - Residential Consumer Products	2,657,189	324,131	1,681,584	-	4,662,905	7,213,089	414,497	7,627,586
A2c - Residential Lighting	54,977,678	6,113,749	32,532,727	-	93,624,154	220,307,804	10,817,890	231,125,694
B - Low-Income	**7,880,412**	**890,496**	**4,680,018**	**-**	**13,450,926**	**26,275,229**	**1,446,869**	**27,722,098**
B1 - Low-Income Whole House	7,880,412	890,496	4,680,018	-	13,450,926	26,275,229	1,446,869	27,722,098
B1a - Low-Income Single Family Retrofit	5,403,330	639,790	3,234,745	-	9,277,865	11,911,831	604,070	12,515,901
B1b - Low-Income Multi-Family Retrofit	2,477,082	250,707	1,445,273	-	4,173,062	14,363,398	842,799	15,206,197
C - Commercial & Industrial	**230,703,543**	**31,976,419**	**145,262,776**	**-**	**407,942,739**	**773,077,600**	**32,190,385**	**805,267,984**
C1 - C&I New Construction	65,221,731	7,032,962	37,312,261	-	109,566,955	162,703,018	5,155,227	167,858,246
C1a - C&I New Buildings & Major Renovations	30,545,994	3,769,173	18,379,966	-	52,695,133	96,178,778	3,038,301	99,217,079
C1b - C&I Initial Purchase & End of Useful Life	34,675,737	3,263,789	18,932,296	-	56,871,822	66,524,240	2,116,927	68,641,167
C2 - C&I Retrofit	165,481,812	24,943,457	107,950,515	-	298,375,784	610,374,581	27,035,157	637,409,739
C2a - C&I Existing Building Retrofit	102,669,057	16,266,657	66,741,663	-	185,677,377	427,129,069	15,550,361	442,679,430
C2b - C&I Small Business	29,276,341	4,451,999	19,434,513	-	53,162,854	80,597,552	4,147,673	84,745,226
C2c - C&I Multifamily Retrofit	1,247,498	225,828	876,964	-	2,350,289	6,510,377	339,411	6,849,788
C2d - C&I Upstream Lighting	32,288,917	3,998,973	20,897,375	-	57,185,264	96,137,584	6,997,712	103,135,295
Grand Total	**343,943,121**	**46,192,023**	**214,900,724**	**-**	**605,035,868**	**1,128,898,382**	**51,372,495**	**1,180,270,877**

2016-2018 Benefits								
	Electric Benefits							
	Capacity					Electric Energy		
Program	Summer Generation	Transmission	Distribution	Capacity DRIPE	Total Capacity Benefits	Electric Energy	Electric Energy DRIPE	Total Electric Energy Benefits
A - Residential	**304,538,026**	**42,471,513**	**204,921,715**	**-**	**551,931,253**	**1,036,813,978**	**135,639,684**	**1,172,453,662**
A1 - Residential Whole House	125,292,707	19,326,834	86,215,447	-	230,834,988	272,500,699	42,513,118	315,013,818
A1a - Residential New Construction	35,976,050	6,347,601	24,163,959	-	66,487,610	30,342,918	2,062,220	32,405,138
A1b - Residential Multi-Family Retrofit	3,303,608	493,995	2,328,943	-	6,126,547	21,590,413	2,406,285	23,996,698
A1c - Residential Home Energy Services - Measures	81,529,842	11,342,125	53,484,753	-	146,356,720	192,206,965	23,070,353	215,277,317
A1d - Residential Home Energy Services - RCS	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	4,483,206	1,143,113	6,237,792	-	11,864,110	28,360,404	14,974,260	43,334,664
A2 - Residential Products	179,245,319	23,144,678	118,706,268	-	321,096,266	764,313,279	93,126,566	857,439,845
A2a - Residential Heating & Cooling Equipment	10,060,459	1,438,508	6,530,456	-	18,029,424	37,253,534	3,047,882	40,301,416
A2b - Residential Consumer Products	7,207,785	963,428	5,002,565	-	13,173,778	21,661,280	2,981,574	24,642,853
A2c - Residential Lighting	161,977,075	20,742,742	107,173,246	-	289,893,064	705,398,465	87,097,111	792,495,576
B - Low-Income	**21,901,483**	**2,677,973**	**14,054,804**	**-**	**38,634,259**	**78,194,461**	**9,855,522**	**88,049,983**
B1 - Low-Income Whole House	21,901,483	2,677,973	14,054,804	-	38,634,259	78,194,461	9,855,522	88,049,983
B1a - Low-Income Single Family Retrofit	15,128,906	1,905,188	9,687,756	-	26,721,849	35,181,466	4,101,776	39,283,242
B1b - Low-Income Multi-Family Retrofit	6,772,578	772,784	4,367,048	-	11,912,410	43,012,994	5,753,746	48,766,741
C - Commercial & Industrial	**587,457,416**	**85,876,103**	**394,261,324**	**-**	**1,067,594,843**	**2,015,901,241**	**191,953,255**	**2,207,854,496**
C1 - C&I New Construction	178,922,850	20,705,702	107,794,559	-	307,423,112	454,095,608	30,870,101	484,965,709
C1a - C&I New Buildings & Major Renovations	82,863,202	10,995,981	52,604,859	-	146,464,042	262,881,874	17,762,715	280,644,589
C1b - C&I Initial Purchase & End of Useful Life	96,059,649	9,709,721	55,189,700	-	160,959,070	191,213,734	13,107,386	204,321,120
C2 - C&I Retrofit	408,534,566	65,170,401	286,466,765	-	760,171,731	1,561,805,633	161,083,154	1,722,888,787
C2a - C&I Existing Building Retrofit	248,261,471	40,100,235	168,623,816	-	456,985,522	1,045,724,592	82,964,348	1,128,688,940
C2b - C&I Small Business	79,343,986	12,867,702	56,496,432	-	148,708,120	232,331,228	26,597,338	258,928,566
C2c - C&I Multifamily Retrofit	3,446,282	673,680	2,609,968	-	6,729,930	18,834,008	2,238,124	21,072,132
C2d - C&I Upstream Lighting	77,482,827	11,528,783	58,736,548	-	147,748,158	264,915,806	49,283,344	314,199,149
Grand Total	**913,896,925**	**131,025,588**	**613,237,843**	**-**	**1,658,160,356**	**3,130,909,680**	**337,448,461**	**3,468,358,141**

Notes:
Total Energy Benefits is the sum of electric benefits, natural gas benefits, deliverable fuel benefits, and other benefits.

IV.D Cost-Effectiveness

3.1.i. Benefits Summary Table

Statewide Electric
October 30, 2015

DPU 15-160 - 15-169
Exh. 1, Appendix C
H.O.s Leupold and Hale

	2018 Benefits									
	Natural Gas Benefits			Deliverable Fuel Benefits		Other Benefits				
Program	Natural Gas	Natural Gas DRIPE	Total Gas Benefits	Oil	Propane	Water	Total Energy Benefits	Non-Energy Impacts	Total TRC Test Benefits	Total Energy Benefits per Participant
A - Residential	**(20,275,681)**	**(1,419,155)**	**(21,694,836)**	**155,737,423**	**12,032,463**	**6,448,315**	**683,446,362**	**99,153,725**	**782,600,088**	**192.70**
A1 - Residential Whole House	6,392,195	269,785	6,661,980	194,241,863	21,322,838	6,262,756	402,670,425	78,758,188	481,428,613	347.76
A1a - Residential New Construction	324,569	12,909	337,478	1,773,852	6,132,867	-	42,692,409	10,592,660	53,285,069	8,310.77
A1b - Residential Multi-Family Retrofit	1,863	150	2,014	3,156,492	4,570	335,729	13,348,042	3,274,181	16,622,223	661.48
A1c - Residential Home Energy Services - Measures	6,009,418	253,087	6,262,505	189,235,104	15,167,518	5,874,210	331,259,930	64,891,347	396,151,277	22,193.97
A1d - Residential Home Energy Services - RCS	-	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	56,345	3,639	59,984	76,414	17,883	52,817	15,370,045	-	15,370,045	14.07
A2 - Residential Products	(26,667,876)	(1,688,940)	(28,356,816)	(38,504,440)	(9,290,375)	185,559	280,775,937	20,395,537	301,171,474	117.54
A2a - Residential Heating & Cooling Equipment	(397,579)	(18,002)	(415,581)	-	-	-	19,286,090	1,246,376	20,532,466	668.25
A2b - Residential Consumer Products	46,547	3,814	50,361	23,506	38,825	185,559	12,588,742	-	12,588,742	375.03
A2c - Residential Lighting	(26,316,844)	(1,674,753)	(27,991,596)	(38,527,946)	(9,329,200)	-	248,901,105	19,149,162	268,050,267	106.99
B - Low-Income	**1,735**	**158**	**1,893**	**42,200,065**	**1,302,587**	**278,966**	**84,956,536**	**30,571,188**	**115,527,725**	**2,642.56**
B1 - Low-Income Whole House	1,735	158	1,893	42,200,065	1,302,587	278,966	84,956,536	30,571,188	115,527,725	2,642.56
B1a - Low-Income Single Family Retrofit	1,735	158	1,893	33,008,835	1,302,587	90,220	56,197,301	17,331,371	73,528,671	5,414.00
B1b - Low-Income Multi-Family Retrofit	-	-	-	9,191,230	-	188,747	28,759,235	13,239,818	41,999,053	1,321.09
C - Commercial & Industrial	**(118,017,294)**	**(6,240,454)**	**(124,257,748)**	**(26,563,483)**	**816,640**	**496,616**	**1,063,702,747**	**146,889,561**	**1,210,592,308**	**42,375.71**
C1 - C&I New Construction	1,425,234	79,670	1,504,905	(2,200,007)	-	-	276,730,098	-	276,730,098	227,205.78
C1a - C&I New Buildings & Major Renovations	1,106,462	58,054	1,164,516	(2,286,248)	-	-	150,790,480	-	150,790,480	224,077.62
C1b - C&I Initial Purchase & End of Useful Life	318,772	21,617	340,389	86,241	-	-	125,939,618	-	125,939,618	231,068.03
C2 - C&I Retrofit	(119,442,529)	(6,320,124)	(125,762,653)	(24,363,477)	816,640	496,616	786,972,649	146,889,561	933,862,210	32,950.15
C2a - C&I Existing Building Retrofit	(109,874,043)	(5,525,259)	(115,399,302)	(8,046,864)	75,297	483,498	505,469,435	91,640,685	597,110,120	265,520.27
C2b - C&I Small Business	(5,572,263)	(411,861)	(5,984,124)	1,475,251	736,195	-	134,135,401	31,977,057	166,112,458	25,855.04
C2c - C&I Multifamily Retrofit	(159,476)	(14,075)	(173,551)	80,683	5,147	13,118	9,125,474	2,932,971	12,058,445	16,531.66
C2d - C&I Upstream Lighting	(3,836,746)	(368,929)	(4,205,675)	(17,872,546)	-	-	138,242,338	20,338,848	158,581,186	8,512.43
Grand Total	**(138,291,240)**	**(7,659,451)**	**(145,950,691)**	**171,374,005**	**14,151,689**	**7,223,897**	**1,832,105,646**	**276,614,475**	**2,108,720,120**	**508.36**

	2016-2018 Benefits									
	Natural Gas Benefits			Deliverable Fuel Benefits		Other Benefits				
Program	Natural Gas	Natural Gas DRIPE	Total Gas Benefits	Oil	Propane	Water	Total Energy Benefits	Non-Energy Impacts	Total TRC Test Benefits	Total Energy Benefits per Participant
A - Residential	**(67,613,794)**	**(9,404,956)**	**(77,018,749)**	**433,657,799**	**29,667,662**	**18,373,223**	**2,129,064,851**	**299,605,606**	**2,428,670,457**	**199.72**
A1 - Residential Whole House	17,968,717	1,176,818	19,145,535	556,332,948	59,471,909	17,893,260	1,198,692,457	233,699,238	1,432,391,695	345.41
A1a - Residential New Construction	949,138	57,425	1,006,562	5,082,704	18,032,525	-	123,014,540	31,403,541	154,418,081	7,983.29
A1b - Residential Multi-Family Retrofit	5,395	793	6,188	8,828,917	13,300	970,185	39,941,835	9,515,982	49,457,817	685.26
A1c - Residential Home Energy Services - Measures	16,847,601	1,099,282	17,946,882	542,197,296	41,373,361	16,764,623	979,916,200	192,779,715	1,172,695,915	22,445.86
A1d - Residential Home Energy Services - RCS	-	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	166,583	19,319	185,902	224,031	52,722	158,452	55,819,882	-	55,819,882	17.02
A2 - Residential Products	(85,582,510)	(10,581,774)	(96,164,285)	(122,675,149)	(29,804,246)	479,964	930,372,394	65,906,368	996,278,762	129.40
A2a - Residential Heating & Cooling Equipment	(1,214,225)	(89,335)	(1,303,560)	-	-	-	57,027,279	3,584,165	60,611,444	665.90
A2b - Residential Consumer Products	114,251	16,628	130,879	66,924	115,874	479,964	38,610,273	-	38,610,273	357.44
A2c - Residential Lighting	(84,482,536)	(10,509,067)	(94,991,604)	(122,742,073)	(29,920,120)	-	834,734,842	62,322,203	897,057,045	119.32
B - Low-Income	**5,119**	**871**	**5,990**	**122,384,504**	**3,629,977**	**829,108**	**253,533,822**	**91,326,051**	**344,859,874**	**2,641.86**
B1 - Low-Income Whole House	5,119	871	5,990	122,384,504	3,629,977	829,108	253,533,822	91,326,051	344,859,874	2,641.86
B1a - Low-Income Single Family Retrofit	5,119	871	5,990	95,462,278	3,622,522	270,659	165,366,541	51,280,281	216,646,822	5,351.67
B1b - Low-Income Multi-Family Retrofit	-	-	-	26,922,226	7,456	558,449	88,167,281	40,045,771	128,213,052	1,355.00
C - Commercial & Industrial	**(219,534,182)**	**(16,599,308)**	**(236,133,490)**	**(75,439,328)**	**1,569,141**	**1,340,112**	**2,966,785,774**	**474,314,031**	**3,441,099,805**	**40,786.27**
C1 - C&I New Construction	1,590,600	95,470	1,686,070	(6,417,452)	-	-	787,657,439	-	787,657,439	223,986.79
C1a - C&I New Buildings & Major Renovations	2,703,328	205,110	2,908,439	(6,671,254)	-	-	423,345,816	-	423,345,816	220,408.44
C1b - C&I Initial Purchase & End of Useful Life	(1,112,728)	(109,640)	(1,222,368)	253,801	-	-	364,311,623	-	364,311,623	228,293.77
C2 - C&I Retrofit	(221,124,782)	(16,694,778)	(237,819,560)	(69,021,876)	1,569,141	1,340,112	2,179,128,335	474,314,031	2,653,442,366	31,479.71
C2a - C&I Existing Building Retrofit	(194,019,214)	(12,523,471)	(206,542,685)	(23,298,108)	222,189	1,300,176	1,357,356,035	307,854,395	1,665,210,430	235,959.37
C2b - C&I Small Business	(16,396,125)	(2,118,124)	(18,514,248)	1,043,206	1,332,013	-	391,497,657	92,375,388	483,873,045	26,618.08
C2c - C&I Multifamily Retrofit	(461,839)	(74,613)	(536,451)	287,481	14,939	39,936	27,607,966	8,741,086	36,349,052	16,968.63
C2d - C&I Upstream Lighting	(10,247,605)	(1,978,571)	(12,226,175)	(47,054,455)	-	-	402,666,677	65,343,162	468,009,839	8,542.69
Grand Total	**(287,142,856)**	**(26,003,392)**	**(313,146,249)**	**480,602,975**	**34,866,781**	**20,542,443**	**5,349,384,448**	**865,245,688**	**6,214,630,136**	**494.00**

IV.D Cost-Effectiveness

3.1.iii. Benefits Comparison Table - Three Year Plan vs. Previous Years

Statewide Electric

October 30, 2015

DPU 15-160 - 15-169
Exh. 1, Appendix C
H.O.s Leupold and Hale

2013-2018 Benefits

Sector	Electric Benefits: Capacity					Electric Benefits: Electric Energy			Natural Gas Benefits			Deliverable Fuel Benefits		Other Benefits	Total Energy Benefits	Non-Energy Impacts	Total TRC Test Benefits
	Summer Generation	Transmission	Distribution	Capacity DRIPE	Total Capacity Benefits	Electric Energy	Electric Energy DRIPE	Total Electric Energy Benefits	Natural Gas	Natural Gas DRIPE	Total Gas Benefits	Oil	Propane	Water			
A - Residential	**385,426,516**	**70,265,436**	**325,694,919**	**54,601,129**	**835,988,000**	**1,667,208,588**	**376,066,916**	**2,043,275,504**	**(51,902,049)**	**(6,593,217)**	**(58,495,265)**	**1,104,445,085**	**96,201,599**	**33,718,136**	**4,055,133,059**	**1,037,396,335**	**5,092,529,394**
2013	19,372,448	9,553,045	41,942,235	21,583,914	92,451,642	226,890,580	74,657,857	301,548,437	5,470,715	-	5,470,715	219,620,222	24,257,601	4,035,070	647,383,686	249,267,785	896,651,471
2014	40,455,007	12,240,646	53,255,958	22,159,649	128,111,260	265,746,793	114,141,319	379,888,112	6,460,867	2,079,541	8,540,407	245,869,827	26,691,885	8,979,547	798,081,039	259,244,441	1,057,325,480
2015	21,061,035	6,000,232	25,575,011	10,857,566	63,493,845	137,757,237	51,628,056	189,385,293	3,780,163	732,199	4,512,362	205,297,238	15,584,450	2,330,295	480,603,482	229,278,504	709,881,986
2016	95,137,901	14,908,653	71,065,381	-	181,111,935	359,724,480	75,712,276	435,436,756	(24,311,959)	(5,195,684)	(29,507,643)	133,703,824	7,842,851	5,784,545	734,372,268	100,083,509	834,455,777
2017	104,040,958	14,237,753	68,898,404	-	187,177,116	347,543,946	42,192,166	389,736,111	(23,026,153)	(2,790,117)	(25,816,270)	144,216,552	9,792,349	6,140,363	711,246,221	100,368,372	811,614,592
2018	105,359,166	13,325,107	64,957,930	-	183,642,203	329,545,553	17,735,242	347,280,795	(20,275,681)	(1,419,155)	(21,694,836)	155,737,423	12,032,463	6,448,315	683,446,362	99,153,725	782,600,088
B - Low-Income	**31,705,812**	**5,611,756**	**26,886,169**	**6,109,813**	**70,313,550**	**152,959,826**	**36,037,196**	**188,997,023**	**2,541,489**	**418,011**	**2,959,500**	**249,054,461**	**6,083,028**	**3,208,185**	**520,615,747**	**197,057,363**	**717,673,110**
2013	2,327,070	973,820	4,295,384	2,491,059	10,087,333	25,241,835	7,891,557	33,133,391	764,408	-	764,408	46,318,787	985,703	793,545	92,083,166	30,143,459	122,226,625
2014	4,124,269	1,154,797	5,011,420	2,089,191	12,379,678	31,437,207	12,250,596	43,687,803	907,758	250,827	1,158,585	39,528,060	311,641	531,908	97,597,675	34,631,602	132,229,277
2015	3,352,989	805,167	3,524,562	1,529,562	9,212,280	18,086,324	6,039,521	24,125,845	864,204	166,313	1,030,517	40,823,110	1,155,707	1,053,624	77,401,083	40,956,251	118,357,335
2016	6,678,404	900,438	4,707,272	-	12,286,113	26,304,817	5,383,354	31,688,170	1,670	449	2,120	38,890,167	1,170,854	271,175	84,308,599	30,354,380	114,662,979
2017	7,342,668	887,038	4,667,514	-	12,897,220	25,614,415	3,025,300	28,639,715	1,714	264	1,978	41,294,272	1,156,537	278,966	84,268,687	30,400,483	114,669,170
2018	7,880,412	890,496	4,680,018	-	13,450,926	26,275,229	1,446,869	27,722,098	1,735	158	1,893	42,200,065	1,302,587	278,966	84,956,536	30,571,188	115,527,725
C - Commercial & Industrial	**939,789,557**	**180,066,856**	**808,155,719**	**208,150,281**	**2,136,162,413**	**4,318,545,924**	**907,923,373**	**5,226,469,297**	**(471,584,722)**	**(63,171,651)**	**(534,756,373)**	**(133,317,719)**	**2,461,109**	**2,742,456**	**6,699,761,184**	**1,024,563,418**	**7,724,324,602**
2013	77,563,294	29,863,794	131,297,671	88,248,030	326,972,788	760,129,970	201,649,622	961,779,592	(98,826,399)	-	(98,826,399)	(19,636,683)	360,382	136,907	1,170,786,588	153,921,441	1,324,708,029
2014	106,910,345	27,734,976	119,062,224	52,590,856	306,298,400	665,032,644	260,888,712	925,921,355	(23,685,141)	(14,275,007)	(37,960,148)	(18,430,180)	457,123	551,006	1,176,837,557	232,777,725	1,409,615,282
2015	167,858,503	36,591,983	163,534,500	67,311,396	435,296,381	877,482,070	253,431,784	1,130,913,854	(129,538,999)	(32,297,337)	(161,836,336)	(19,811,528)	74,464	714,430	1,385,351,265	163,550,221	1,548,901,486
2016	161,881,344	25,445,706	118,468,021	-	305,795,071	581,586,450	98,231,085	679,817,535	(33,121,748)	(4,823,515)	(37,945,262)	(23,623,869)	285,717	397,408	924,726,599	167,332,561	1,092,059,160
2017	194,872,529	28,453,978	130,530,527	-	353,857,034	661,237,191	61,531,785	722,768,977	(68,395,140)	(5,535,339)	(73,930,479)	(25,251,976)	466,784	446,088	978,356,428	160,091,909	1,138,448,337
2018	230,703,543	31,976,419	145,262,776	-	407,942,739	773,077,600	32,190,385	805,267,984	(118,017,294)	(6,240,454)	(124,257,748)	(26,563,483)	816,640	496,616	1,063,702,747	146,889,561	1,210,592,308
Grand Total	**1,356,921,885**	**255,944,048**	**1,160,736,807**	**268,861,223**	**3,042,463,963**	**6,138,714,339**	**1,320,027,485**	**7,458,741,824**	**(520,945,281)**	**(69,346,857)**	**(590,292,138)**	**1,220,181,827**	**104,745,736**	**39,668,777**	**11,275,509,989**	**2,259,017,117**	**13,534,527,106**
2013	99,262,812	40,390,659	177,535,289	112,323,003	429,511,763	1,012,262,384	284,199,036	1,296,461,420	(92,591,276)	-	(92,591,276)	246,302,326	25,603,686	4,965,522	1,910,253,441	433,332,685	2,343,586,125
2014	151,489,621	41,130,419	177,329,602	76,839,696	446,789,338	962,216,643	387,280,628	1,349,497,271	(16,316,517)	(11,944,639)	(28,261,156)	266,967,707	27,460,648	10,062,462	2,072,516,271	526,653,768	2,599,170,039
2015	192,272,527	43,397,382	192,634,073	79,698,524	508,002,505	1,033,325,631	311,099,361	1,344,424,992	(124,894,632)	(31,398,825)	(156,293,457)	226,308,820	16,814,621	4,098,350	1,943,355,831	433,784,976	2,377,140,806
2016	263,697,649	41,254,797	194,240,673	-	499,193,119	967,615,746	179,326,715	1,146,942,461	(57,432,036)	(10,018,750)	(67,450,786)	148,970,121	9,299,422	6,453,128	1,743,407,466	297,770,450	2,041,177,916
2017	306,256,155	43,578,769	204,096,445	-	553,931,369	1,034,395,552	106,749,251	1,141,144,803	(91,419,580)	(8,325,192)	(99,744,772)	160,258,849	11,415,670	6,865,417	1,773,871,336	290,860,764	2,064,732,100
2018	343,943,121	46,192,023	214,900,724	-	605,035,868	1,128,898,382	51,372,495	1,180,270,877	(138,291,240)	(7,659,451)	(145,950,691)	171,374,005	14,151,689	7,223,897	1,832,105,646	276,614,475	2,108,720,120

2013-2018 Benefits, Percent of Total TRC Test Benefits

Sector	Electric Benefits: Capacity					Electric Benefits: Electric Energy			Natural Gas Benefits			Deliverable Fuel Benefits		Other Benefits	Total Energy Benefits	Non-Energy Impacts	Total TRC Test Benefits
	Summer Generation	Transmission	Distribution	Capacity DRIPE	Total Capacity Benefits	Electric Energy	Electric Energy DRIPE	Total Electric Energy Benefits	Natural Gas	Natural Gas DRIPE	Total Gas Benefits	Oil	Propane	Water			
A - Residential	**7.6%**	**1.4%**	**6.4%**	**1.1%**	**16.4%**	**32.7%**	**7.4%**	**40.1%**	**-1.0%**	**-0.1%**	**-1.1%**	**21.7%**	**1.9%**	**0.7%**	**79.6%**	**20.4%**	**100%**
2013	2.2%	1.1%	4.7%	2.4%	10.3%	25.3%	8.3%	33.6%	0.6%	0.0%	0.6%	24.5%	2.7%	0.5%	72.2%	27.8%	100%
2014	3.8%	1.2%	5.0%	2.1%	12.1%	25.1%	10.8%	35.9%	0.6%	0.2%	0.8%	23.3%	2.5%	0.8%	75.5%	24.5%	100%
2015	3.0%	0.8%	3.6%	1.5%	8.9%	19.4%	7.3%	26.7%	0.5%	0.1%	0.6%	28.9%	2.2%	0.3%	67.7%	32.3%	100%
2016	11.4%	1.8%	8.5%	0.0%	21.7%	43.1%	9.1%	52.2%	-2.9%	-0.6%	-3.5%	16.0%	0.9%	0.7%	88.0%	12.0%	100%
2017	12.8%	1.8%	8.5%	0.0%	23.1%	42.8%	5.2%	48.0%	-2.8%	-0.3%	-3.2%	17.8%	1.2%	0.8%	87.6%	12.4%	100%
2018	13.5%	1.7%	8.3%	0.0%	23.5%	42.1%	2.3%	44.4%	-2.6%	-0.2%	-2.8%	19.9%	1.5%	0.8%	87.3%	12.7%	100%
B - Low-Income	**4.4%**	**0.8%**	**3.7%**	**0.9%**	**9.8%**	**21.3%**	**5.0%**	**26.3%**	**0.4%**	**0.1%**	**0.4%**	**34.7%**	**0.8%**	**0.4%**	**72.5%**	**27.5%**	**100%**
2013	1.9%	0.8%	3.5%	2.0%	8.3%	20.7%	6.5%	27.1%	0.6%	0.0%	0.6%	37.9%	0.8%	0.6%	75.3%	24.7%	100%
2014	3.1%	0.9%	3.8%	1.6%	9.4%	23.8%	9.3%	33.0%	0.7%	0.2%	0.9%	29.9%	0.2%	0.4%	73.8%	26.2%	100%
2015	2.8%	0.7%	3.0%	1.3%	7.8%	15.3%	5.1%	20.4%	0.7%	0.1%	0.9%	34.5%	1.0%	0.9%	65.4%	34.6%	100%
2016	5.8%	0.8%	4.1%	0.0%	10.7%	22.9%	4.7%	27.6%	0.0%	0.0%	0.0%	33.9%	1.0%	0.2%	73.5%	26.5%	100%
2017	6.4%	0.8%	4.1%	0.0%	11.2%	22.3%	2.6%	25.0%	0.0%	0.0%	0.0%	36.0%	1.0%	0.2%	73.5%	26.5%	100%
2018	6.8%	0.8%	4.1%	0.0%	11.6%	22.7%	1.3%	24.0%	0.0%	0.0%	0.0%	36.5%	1.1%	0.2%	73.5%	26.5%	100%
C - Commercial & Industrial	**12.2%**	**2.3%**	**10.5%**	**2.7%**	**27.7%**	**55.9%**	**11.8%**	**67.7%**	**-6.1%**	**-0.8%**	**-6.9%**	**-1.7%**	**0.0%**	**0.0%**	**86.7%**	**13.3%**	**100%**
2013	5.9%	2.3%	9.9%	6.7%	24.7%	57.4%	15.2%	72.6%	-7.5%	0.0%	-7.5%	-1.5%	0.0%	0.0%	88.4%	11.6%	100%
2014	7.6%	2.0%	8.4%	3.7%	21.7%	47.2%	18.5%	65.7%	-1.7%	-1.0%	-2.7%	-1.3%	0.0%	0.0%	83.5%	16.5%	100%
2015	10.8%	2.4%	10.6%	4.3%	28.1%	56.7%	16.4%	73.0%	-8.4%	-2.1%	-10.4%	-1.3%	0.0%	0.0%	89.4%	10.6%	100%
2016	14.8%	2.3%	10.8%	0.0%	28.0%	53.3%	9.0%	62.3%	-3.0%	-0.4%	-3.5%	-2.2%	0.0%	0.0%	84.7%	15.3%	100%
2017	17.1%	2.5%	11.5%	0.0%	31.1%	58.1%	5.4%	63.5%	-6.0%	-0.5%	-6.5%	-2.2%	0.0%	0.0%	85.9%	14.1%	100%
2018	19.1%	2.6%	12.0%	0.0%	33.7%	63.9%	2.7%	66.5%	-9.7%	-0.5%	-10.3%	-2.2%	0.1%	0.0%	87.9%	12.1%	100%
Grand Total	**10.0%**	**1.9%**	**8.6%**	**2.0%**	**22.5%**	**45.4%**	**9.8%**	**55.1%**	**-3.8%**	**-0.5%**	**-4.4%**	**9.0%**	**0.8%**	**0.3%**	**83.3%**	**16.7%**	**100%**
2013	4.2%	1.7%	7.6%	4.8%	18.3%	43.2%	12.1%	55.3%	-4.0%	0.0%	-4.0%	10.5%	1.1%	0.2%	81.5%	18.5%	100%
2014	5.8%	1.6%	6.8%	3.0%	17.2%	37.0%	14.9%	51.9%	-0.6%	-0.5%	-1.1%	10.3%	1.1%	0.4%	79.7%	20.3%	100%
2015	8.1%	1.8%	8.1%	3.4%	21.4%	43.5%	13.1%	56.6%	-5.3%	-1.3%	-6.6%	9.5%	0.7%	0.2%	81.8%	18.2%	100%
2016	12.9%	2.0%	9.5%	0.0%	24.5%	47.4%	8.8%	56.2%	-2.8%	-0.5%	-3.3%	7.3%	0.5%	0.3%	85.4%	14.6%	100%
2017	14.8%	2.1%	9.9%	0.0%	26.8%	50.1%	5.2%	55.3%	-4.4%	-0.4%	-4.8%	7.8%	0.6%	0.3%	85.9%	14.1%	100%
2018	16.3%	2.2%	10.2%	0.0%	28.7%	53.5%	2.4%	56.0%	-6.6%	-0.4%	-6.9%	8.1%	0.7%	0.3%	86.9%	13.1%	100%

Notes:

2013 values are from the Program Administrator's 2013 Plan Year Report D.P.U. , in 2013$.

2014 values are from the Program Administrator's 2014 Plan Year Report, D.P.U. , in 2013$.

2015 values are from the Program Administrator's 2013-2015 Three-Year Plan, D.P.U. , in 2013$.

For supporting information on the 2016-2018 values, see Table IV.D.3.1.i. The 2016-2018 values are in 2016$.

IV.D. Cost-Effectiveness DPU 15-160 - 15-169

3.2.i. Savings Summary Table Exh. 1, Appendix C

Statewide Electric H.O.s Leupold and Hale

October 30, 2015

2016 Net Savings

Program	# of Participants	Electric Savings				Natural Gas Savings		Deliverable Fuel Savings				Other Savings	
		Annual Capacity (kW)		Electric Energy (MWh)		(Therms)		Oil (MMBTU)		Propane (MMBTU)		Water (Gallons)	
		Summer	Winter	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime
A - Residential	**3,538,503**	**83,902**	**107,188**	**627,236**	**4,691,711**	**(3,790,452)**	**(30,112,489)**	**212,313**	**6,405,536**	**(16,435)**	**398,708**	**67,260,472**	**544,240,704**
A1 - Residential Whole House	1,154,109	38,538	49,164	238,676	1,208,125	324,318	6,540,647	460,949	8,604,954	49,909	964,678	65,452,311	531,583,577
A1a - Residential New Construction	5,138	3,100	1,221	7,800	115,122	15,240	353,757	3,019	74,670	12,508	307,350	-	-
A1b - Residential Multi-Family Retrofit	18,691	838	2,467	9,336	92,156	281	2,260	6,912	132,661	13	224	4,177,045	29,239,312
A1c - Residential Home Energy Services - Measures	14,146	14,502	17,945	92,713	870,978	302,037	6,117,030	450,640	8,393,843	37,294	656,168	60,776,935	497,360,945
A1d - Residential Home Energy Services - RCS	23,608	-	-	-	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	1,092,526	20,098	27,531	128,828	129,868	6,760	67,600	378	3,781	94	936	498,332	4,983,320
A2 - Residential Products	2,384,394	45,365	58,024	388,560	3,483,586	(4,114,770)	(36,653,136)	(248,636)	(2,199,418)	(66,344)	(565,970)	1,808,161	12,657,127
A2a - Residential Heating & Cooling Equipment	28,235	1,428	2,443	11,277	154,033	(27,181)	(489,251)	-	-	-	-	-	-
A2b - Residential Consumer Products	37,030	1,837	1,452	12,484	102,984	5,459	38,211	157	1,101	272	1,906	1,808,161	12,657,127
A2c - Residential Lighting	2,319,129	42,100	54,129	364,799	3,226,568	(4,093,048)	(36,202,095)	(248,793)	(2,200,520)	(66,616)	(567,876)	-	-
B - Low-Income	**31,829**	**4,588**	**9,312**	**40,615**	**354,457**	**317**	**2,220**	**93,803**	**1,896,772**	**3,255**	**62,041**	**3,631,218**	**25,418,526**
B1 - Low-Income Whole House	31,829	4,588	9,312	40,615	354,457	317	2,220	93,803	1,896,772	3,255	62,041	3,631,218	25,418,526
B1a - Low-Income Single Family Retrofit	10,220	2,818	2,806	16,195	156,042	317	2,220	75,130	1,487,963	3,233	61,645	1,208,103	8,456,718
B1b - Low-Income Multi-Family Retrofit	21,609	1,770	6,506	24,420	198,415	-	-	18,673	408,809	22	396	2,423,115	16,961,808
C - Commercial & Industrial	**22,754**	**102,132**	**88,312**	**703,733**	**7,766,005**	**(3,036,614)**	**(42,893,792)**	**(184,554)**	**(1,357,708)**	**1,688**	**15,579**	**6,729,206**	**78,952,353**
C1 - C&I New Construction	1,124	19,970	15,259	109,468	1,777,845	(32,114)	(888,102)	(7,825)	(114,788)	-	-	-	-
C1a - C&I New Buildings & Major Renovations	610	9,353	6,541	61,888	1,001,948	46,769	906,949	(8,088)	(119,261)	-	-	-	-
C1b - C&I Initial Purchase & End of Useful Life	514	10,618	8,717	47,580	775,897	(78,884)	(1,795,051)	263	4,473	-	-	-	-
C2 - C&I Retrofit	21,630	82,162	73,054	594,265	5,988,161	(3,004,499)	(42,005,690)	(176,729)	(1,242,919)	1,688	15,579	6,729,206	78,952,353
C2a - C&I Existing Building Retrofit	1,924	32,404	34,660	286,462	3,708,375	(1,552,355)	(30,586,239)	(30,770)	(415,003)	331	3,697	6,433,001	77,619,433
C2b - C&I Small Business	4,636	16,202	12,612	100,475	1,027,894	(703,516)	(7,090,941)	(2,242)	(28,221)	1,344	11,633	-	-
C2c - C&I Multifamily Retrofit	533	680	1,949	9,133	85,744	(26,404)	(200,209)	(3,225)	2,717	13	249	296,204	1,332,920
C2d - C&I Upstream Lighting	14,537	32,875	23,833	198,194	1,166,148	(722,224)	(4,128,301)	(140,492)	(802,412)	-	-	-	-
Grand Total	**3,593,086**	**190,623**	**204,813**	**1,371,584**	**12,812,173**	**(6,826,749)**	**(73,004,061)**	**121,563**	**6,944,600**	**(11,492)**	**476,327**	**77,620,896**	**648,611,583**

2017 Net Savings

Program	# of Participants	Electric Savings				Natural Gas Savings		Deliverable Fuel Savings				Other Savings	
		Annual Capacity (kW)		Electric Energy (MWh)		(Therms)		Oil (MMBTU)		Propane (MMBTU)		Water (Gallons)	
		Summer	Winter	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime
A - Residential	**3,574,796**	**79,363**	**101,197**	**583,876**	**4,475,104**	**(3,348,889)**	**(27,868,974)**	**253,563**	**6,807,138**	**(5,899)**	**500,712**	**71,086,821**	**577,780,551**
A1 - Residential Whole House	1,158,303	38,022	48,343	232,983	1,160,037	338,395	6,833,053	476,325	8,889,353	53,869	1,036,083	68,952,708	562,841,760
A1a - Residential New Construction	5,134	3,066	1,128	7,186	109,235	15,604	362,480	3,301	81,691	12,723	312,538	-	-
A1b - Residential Multi-Family Retrofit	19,417	833	2,476	9,310	91,805	281	2,260	7,322	140,156	14	236	4,318,764	30,231,345
A1c - Residential Home Energy Services - Measures	14,585	14,024	17,206	87,652	829,161	315,750	6,400,713	465,324	8,663,724	41,039	722,373	64,135,613	527,627,095
A1d - Residential Home Energy Services - RCS	24,608	-	-	-	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	1,094,559	20,099	27,533	128,835	129,836	6,760	67,600	378	3,781	94	936	498,332	4,983,320
A2 - Residential Products	2,416,493	41,341	52,855	350,893	3,315,067	(3,687,285)	(34,702,027)	(222,762)	(2,082,215)	(59,768)	(535,371)	2,134,113	14,938,792
A2a - Residential Heating & Cooling Equipment	28,545	1,444	2,536	11,398	156,227	(26,256)	(472,606)	-	-	-	-	-	-
A2b - Residential Consumer Products	37,422	1,903	1,470	12,618	104,012	6,537	45,756	168	1,178	326	2,279	2,134,113	14,938,792
A2c - Residential Lighting	2,350,526	37,994	48,850	326,878	3,054,829	(3,667,566)	(34,275,177)	(222,930)	(2,083,393)	(60,094)	(537,650)	-	-
B - Low-Income	**31,989**	**4,447**	**9,011**	**39,222**	**340,960**	**317**	**2,220**	**97,453**	**1,974,865**	**3,139**	**60,319**	**3,735,552**	**26,148,862**
B1 - Low-Income Whole House	31,989	4,447	9,011	39,222	340,960	317	2,220	97,453	1,974,865	3,139	60,319	3,735,552	26,148,862
B1a - Low-Income Single Family Retrofit	10,300	2,793	2,782	15,979	156,050	317	2,220	77,574	1,536,871	3,139	60,319	1,208,103	8,456,718
B1b - Low-Income Multi-Family Retrofit	21,689	1,654	6,229	23,243	184,909	-	-	19,879	437,994	-	-	2,527,449	17,692,144
C - Commercial & Industrial	**24,884**	**108,148**	**94,742**	**749,394**	**8,577,037**	**(5,213,204)**	**(85,890,325)**	**(187,507)**	**(1,403,391)**	**2,951**	**24,873**	**7,531,485**	**96,948,470**
C1 - C&I New Construction	1,175	21,339	16,310	113,707	1,839,351	73,038	1,148,038	(7,721)	(113,440)	-	-	-	-
C1a - C&I New Buildings & Major Renovations	638	10,223	7,238	65,449	1,063,125	59,429	1,116,545	(7,984)	(117,913)	-	-	-	-
C1b - C&I Initial Purchase & End of Useful Life	537	11,116	9,072	48,258	776,226	13,609	31,493	263	4,473	-	-	-	-
C2 - C&I Retrofit	23,709	86,808	78,432	635,687	6,737,686	(5,286,242)	(87,038,363)	(179,786)	(1,289,951)	2,951	24,873	7,531,485	96,948,470
C2a - C&I Existing Building Retrofit	1,925	36,028	38,939	319,804	4,372,189	(3,777,800)	(74,998,789)	(31,326)	(417,081)	318	4,139	7,266,628	95,756,613
C2b - C&I Small Business	4,884	16,766	13,086	103,376	1,055,205	(722,599)	(7,312,805)	2,589	5,124	2,619	20,469	-	-
C2c - C&I Multifamily Retrofit	542	687	1,967	9,217	85,442	(27,031)	(204,134)	(3,343)	2,111	14	265	264,857	1,191,857
C2d - C&I Upstream Lighting	16,358	33,327	24,440	203,290	1,224,850	(758,813)	(4,522,636)	(147,707)	(880,105)	-	-	-	-
Grand Total	**3,631,669**	**191,958**	**204,950**	**1,372,492**	**13,393,101**	**(8,561,777)**	**(113,757,079)**	**163,508**	**7,378,612**	**191**	**585,904**	**82,353,858**	**700,877,883**

IV.D. Cost-Effectiveness

3.2.i. Savings Summary Table

Statewide Electric

October 30, 2015

2018 Net Savings													
		Electric Savings				Natural Gas Savings		Deliverable Fuel Savings				Other Savings	
Program	# of Participants	Annual Capacity (kW)		Electric Energy (MWh)		(Therms)		Oil (MMBTU)		Propane (MMBTU)		Water (Gallons)	
		Summer	Winter	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime
A - Residential	**3,546,733**	**73,013**	**92,953**	**528,881**	**4,152,991**	**(2,784,865)**	**(24,257,736)**	**301,145**	**7,256,055**	**6,760**	**614,179**	**74,538,873**	**606,780,547**
A1 - Residential Whole House	1,157,912	37,395	47,435	227,383	1,128,310	358,748	7,220,042	490,520	9,140,584	57,797	1,098,770	72,054,105	589,387,176
A1a - Residential New Construction	5,137	3,092	1,138	7,519	124,045	15,660	363,778	3,305	81,800	12,793	314,236	-	-
A1b - Residential Multi-Family Retrofit	20,179	820	2,502	9,269	92,454	290	2,328	7,749	147,941	14	236	4,495,637	31,469,456
A1c - Residential Home Energy Services - Measures	14,926	13,384	16,260	81,754	782,024	336,038	6,786,336	479,087	8,907,062	44,896	783,362	67,060,137	552,934,400
A1d - Residential Home Energy Services - RCS	25,108	-	-	-	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	1,092,562	20,100	27,534	128,841	129,787	6,760	67,600	378	3,781	94	936	498,332	4,983,320
A2 - Residential Products	2,388,821	35,617	45,518	301,498	3,024,681	(3,143,613)	(31,477,778)	(189,375)	(1,884,529)	(51,036)	(484,591)	2,484,767	17,393,372
A2a - Residential Heating & Cooling Equipment	28,860	1,463	2,633	11,531	158,577	(25,412)	(457,416)	-	-	-	-	-	-
A2b - Residential Consumer Products	33,567	1,851	1,351	12,043	101,128	8,067	56,466	169	1,185	292	2,044	2,484,767	17,393,372
A2c - Residential Lighting	2,326,394	32,304	41,534	277,924	2,764,976	(3,126,268)	(31,076,828)	(189,544)	(1,885,714)	(51,328)	(486,636)	-	-
B - Low-Income	**32,149**	**4,358**	**8,803**	**38,215**	**344,907**	**317**	**2,220**	**98,082**	**1,985,331**	**3,488**	**67,212**	**3,735,552**	**26,148,862**
B1 - Low-Income Whole House	32,149	4,358	8,803	38,215	344,907	317	2,220	98,082	1,985,331	3,488	67,212	3,735,552	26,148,862
B1a - Low-Income Single Family Retrofit	10,380	2,750	2,747	15,633	155,291	317	2,220	78,609	1,557,412	3,488	67,212	1,208,103	8,456,718
B1b - Low-Income Multi-Family Retrofit	21,769	1,608	6,056	22,582	189,615	-	-	19,473	427,919	-	-	2,527,449	17,692,144
C - Commercial & Industrial	**25,102**	**114,074**	**101,571**	**806,368**	**9,680,873**	**(8,245,786)**	**(145,689,951)**	**(178,912)**	**(1,435,586)**	**5,232**	**42,877**	**8,372,642**	**108,368,316**
C1 - C&I New Construction	1,218	22,112	17,146	118,999	1,926,745	108,727	1,792,275	(7,852)	(115,465)	-	-	-	-
C1a - C&I New Buildings & Major Renovations	673	10,611	7,689	69,752	1,135,370	74,887	1,372,898	(8,115)	(119,939)	-	-	-	-
C1b - C&I Initial Purchase & End of Useful Life	545	11,501	9,457	49,247	791,375	33,840	419,378	263	4,473	-	-	-	-
C2 - C&I Retrofit	23,884	91,962	84,425	687,368	7,754,128	(8,354,512)	(147,482,226)	(171,060)	(1,320,120)	5,232	42,877	8,372,642	108,368,316
C2a - C&I Existing Building Retrofit	1,904	40,939	44,526	369,555	5,243,704	(6,850,529)	(135,015,934)	(32,102)	(425,663)	317	3,923	8,098,200	107,133,326
C2b - C&I Small Business	5,188	17,380	13,646	106,905	1,082,555	(718,721)	(7,238,471)	12,004	81,243	4,902	38,688	-	-
C2c - C&I Multifamily Retrofit	552	695	2,007	9,354	86,373	(27,666)	(208,008)	(3,464)	1,497	14	265	274,442	1,234,989
C2d - C&I Upstream Lighting	16,240	32,948	24,245	201,554	1,341,496	(757,597)	(5,019,812)	(147,497)	(977,197)	-	-	-	-
Grand Total	**3,603,984**	**191,444**	**203,327**	**1,373,464**	**14,178,770**	**(11,030,333)**	**(169,945,466)**	**220,314**	**7,805,801**	**15,481**	**724,268**	**86,647,066**	**741,297,725**

2016-2018 Net Savings													
		Electric Savings				Natural Gas Savings		Deliverable Fuel Savings				Other Savings	
Program	# of Participants	Annual Capacity (kW)		Electric Energy (MWh)		(Therms)		Oil (MMBTU)		Propane (MMBTU)		Water (Gallons)	
		Summer	Winter	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime
A - Residential	**10,660,031**	**236,278**	**301,338**	**1,739,994**	**13,319,806**	**(9,924,206)**	**(82,239,198)**	**767,021**	**20,468,729**	**(15,574)**	**1,513,599**	**212,886,166**	**1,728,801,803**
A1 - Residential Whole House	3,470,324	113,955	144,941	699,042	3,496,472	1,021,462	20,593,742	1,427,794	26,634,892	161,575	3,099,531	206,459,125	1,683,812,512
A1a - Residential New Construction	15,409	9,258	3,487	22,505	348,402	46,504	1,080,014	9,625	238,162	38,024	934,125	-	-
A1b - Residential Multi-Family Retrofit	58,287	2,491	7,445	27,914	276,415	852	6,848	21,983	420,758	40	696	12,991,445	90,940,113
A1c - Residential Home Energy Services - Measures	43,657	41,910	51,411	262,119	2,482,164	953,826	19,304,080	1,395,051	25,964,629	123,229	2,161,903	191,972,684	1,577,922,440
A1d - Residential Home Energy Services - RCS	73,324	-	-	-	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	3,279,647	60,296	82,597	386,504	389,491	20,280	202,800	1,134	11,343	281	2,808	1,494,996	14,949,960
A2 - Residential Products	7,189,708	122,323	156,397	1,040,952	9,823,334	(10,945,668)	(102,832,940)	(660,773)	(6,166,162)	(177,149)	(1,585,932)	6,427,041	44,989,290
A2a - Residential Heating & Cooling Equipment	85,640	4,335	7,612	34,206	468,838	(78,849)	(1,419,273)	-	-	-	-	-	-
A2b - Residential Consumer Products	108,019	5,590	4,273	37,145	308,124	20,062	140,433	495	3,464	890	6,230	6,427,041	44,989,290
A2c - Residential Lighting	6,996,049	112,398	144,512	969,601	9,046,373	(10,886,882)	(101,554,100)	(661,268)	(6,169,626)	(178,039)	(1,592,162)	-	-
B - Low-Income	**95,968**	**13,393**	**27,126**	**118,051**	**1,040,323**	**952**	**6,661**	**289,338**	**5,856,968**	**9,882**	**189,572**	**11,102,321**	**77,716,250**
B1 - Low-Income Whole House	95,968	13,393	27,126	118,051	1,040,323	952	6,661	289,338	5,856,968	9,882	189,572	11,102,321	77,716,250
B1a - Low-Income Single Family Retrofit	30,900	8,362	8,335	47,807	467,383	952	6,661	231,313	4,582,247	9,860	189,176	3,624,308	25,370,155
B1b - Low-Income Multi-Family Retrofit	65,068	5,031	18,791	70,245	572,940	-	-	58,025	1,274,722	22	396	7,478,014	52,346,095
C - Commercial & Industrial	**72,740**	**324,353**	**284,626**	**2,259,494**	**26,023,915**	**(16,495,603)**	**(274,474,068)**	**(550,974)**	**(4,196,684)**	**9,871**	**83,329**	**22,633,332**	**284,269,139**
C1 - C&I New Construction	3,517	63,421	48,715	342,174	5,543,941	149,650	2,052,212	(23,398)	(343,693)	-	-	-	-
C1a - C&I New Buildings & Major Renovations	1,921	30,187	21,468	197,089	3,200,442	181,085	3,396,391	(24,188)	(357,113)	-	-	-	-
C1b - C&I Initial Purchase & End of Useful Life	1,596	33,234	27,246	145,085	2,343,499	(31,435)	(1,344,179)	789	13,420	-	-	-	-
C2 - C&I Retrofit	69,223	260,932	235,911	1,917,320	20,479,974	(16,645,254)	(276,526,280)	(527,575)	(3,852,991)	9,871	83,329	22,633,332	284,269,139
C2a - C&I Existing Building Retrofit	5,752	109,370	118,125	975,821	13,324,267	(12,180,683)	(240,600,963)	(94,198)	(1,257,746)	966	11,759	21,797,828	280,509,372
C2b - C&I Small Business	14,708	50,349	39,345	310,757	3,165,654	(2,144,836)	(21,642,218)	12,351	58,145	8,864	70,789	-	-
C2c - C&I Multifamily Retrofit	1,627	2,063	5,923	27,704	257,559	(81,101)	(612,351)	(10,032)	6,324	40	780	835,504	3,759,767
C2d - C&I Upstream Lighting	47,136	99,150	72,518	603,039	3,732,494	(2,238,634)	(13,670,748)	(435,696)	(2,659,715)	-	-	-	-
Grand Total	**10,828,739**	**574,025**	**613,090**	**4,117,539**	**40,384,044**	**(26,418,858)**	**(356,706,605)**	**505,385**	**22,129,013**	**4,179**	**1,786,500**	**246,621,819**	**2,090,787,191**

IV.D. Cost-Effectiveness

3.2.ii. Savings Comparison Table - Three Year Plan vs. Previous Years

DPU 15-160 - 15-169
Statewide Electric
Exh. 1, Appendix C
October 30, 2015
H.O.s Leupold and Hale

Sector	# of Participants	Electric Net Savings				Natural Gas Net Savings		Deliverable Fuel Net Savings				Other Net Savings	
		Annual Capacity (kW)		Electric Energy (MWh)		Therms		Oil (MMBTU)		Propane (MMBTU)		Water (Gallons)	
		Summer	Winter	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime
A - Residential	**19,392,380**	**426,469**	**548,583**	**3,054,807**	**21,899,997**	**(9,057,792)**	**(64,381,859)**	**2,075,680**	**22,854,418**	**89,021**	**1,806,135**	**393,955,543**	**1,781,185,734**
2013	2,655,894	57,306	78,723	414,357	2,803,962	275,082	5,587,843	448,401	821,765	31,781	34,700	51,759,234	15,181,878
2014	3,770,105	68,792	100,119	520,010	3,790,658	383,265	7,758,940	489,635	848,125	45,629	138,879	97,927,953	23,748,394
2015	2,306,349	64,093	68,404	380,446	1,985,572	208,068	4,510,556	370,624	715,799	27,184	118,958	31,382,190	13,453,660
2016	3,538,503	83,902	107,188	627,236	4,691,711	(3,790,452)	(30,112,489)	212,313	6,405,536	(16,435)	398,708	67,260,472	544,240,704
2017	3,574,796	79,363	101,197	583,876	4,475,104	(3,348,889)	(27,868,974)	253,563	6,807,138	(5,899)	500,712	71,086,821	577,780,551
2018	3,546,733	73,013	92,953	528,881	4,152,991	(2,784,865)	(24,257,736)	301,145	7,256,055	6,760	614,179	74,538,873	606,780,547
B - Low-Income	**195,286**	**27,608**	**54,608**	**225,239**	**2,064,781**	**134,679**	**2,828,057**	**533,631**	**6,352,995**	**13,736**	**256,089**	**42,806,449**	**92,605,650**
2013	35,793	3,887	8,166	34,522	315,878	38,500	688,301	92,096	139,720	1,352	22,342	10,178,820	3,270,736
2014	36,419	4,938	13,915	45,872	454,269	46,402	1,086,159	74,468	129,508	533	7,222	7,264,236	1,353,408
2015	27,106	5,391	5,401	26,794	254,311	48,825	1,046,936	77,729	226,798	1,970	36,953	14,261,072	10,265,256
2016	31,829	4,588	9,312	40,615	354,457	317	2,220	93,803	1,896,772	3,255	62,041	3,631,218	25,418,526
2017	31,989	4,447	9,011	39,222	340,960	317	2,220	97,453	1,974,865	3,139	60,319	3,735,552	26,148,862
2018	32,149	4,358	8,803	38,215	344,907	317	2,220	98,082	1,985,331	3,488	67,212	3,735,552	26,148,862
C - Commercial & Industrial	**137,025**	**638,623**	**582,832**	**4,567,606**	**55,839,925**	**(35,359,809)**	**(562,991,567)**	**(760,269)**	**(4,202,146)**	**12,359**	**112,793**	**44,776,820**	**284,269,139**
2013	30,717	100,404	86,504	667,562	8,882,062	(5,954,148)	(88,535,448)	(67,456)	50,106	923	9,939	1,660,563	-
2014	16,971	106,554	92,291	773,144	9,310,037	(3,003,851)	(32,706,126)	(81,799)	(72,660)	1,306	16,771	8,149,440	-
2015	16,597	107,312	119,411	867,405	11,623,911	(9,906,206)	(167,275,924)	(60,040)	17,092	259	2,754	12,333,485	-
2016	22,754	102,132	88,312	703,733	7,766,005	(3,036,614)	(42,893,792)	(184,554)	(1,357,708)	1,688	15,579	6,729,206	78,952,353
2017	24,884	108,148	94,742	749,394	8,577,037	(5,213,204)	(85,890,325)	(187,507)	(1,403,391)	2,951	24,873	7,531,485	96,948,470
2018	25,102	114,074	101,571	806,368	9,680,873	(8,245,786)	(145,689,951)	(178,912)	(1,435,586)	5,232	42,877	8,372,642	108,368,316
Grand Total	**19,724,690**	**1,092,700**	**1,186,024**	**7,847,652**	**79,804,703**	**(44,282,922)**	**(624,545,369)**	**1,849,042**	**25,005,267**	**115,116**	**2,175,017**	**481,538,812**	**2,158,060,522**
2013	2,722,404	161,596	173,393	1,116,442	12,001,902	(5,640,566)	(82,259,304)	473,041	1,011,591	34,056	66,981	63,598,618	18,452,614
2014	3,823,495	180,284	206,325	1,339,026	13,554,964	(2,574,185)	(23,861,028)	482,303	904,973	47,469	162,872	113,341,629	25,101,802
2015	2,350,052	176,796	193,216	1,274,645	13,863,794	(9,649,313)	(161,718,432)	388,313	959,690	29,412	158,665	57,976,746	23,718,916
2016	3,593,086	190,623	204,813	1,371,584	12,812,173	(6,826,749)	(73,004,061)	121,563	6,944,600	(11,492)	476,327	77,620,896	648,611,583
2017	3,631,669	191,958	204,950	1,372,492	13,393,101	(8,561,777)	(113,757,079)	163,508	7,378,612	191	585,904	82,353,858	700,877,883
2018	3,603,984	191,444	203,327	1,373,464	14,178,770	(11,030,333)	(169,945,466)	220,314	7,805,801	15,481	724,268	86,647,066	741,297,725

Notes:

2013 values are from the Program Administrator's 2013 Plan Year Report D.P.U. .

2014 values are from the Program Administrator's 2014 Plan Year Report, D.P.U. .

2015 values are from the Program Administrator's 2013-2015 Three-Year Plan, D.P.U. .

For supporting information on the 2016-2018 values, see Table IV.D.3.2.i.

The Progam Administrators have developed new participant definitions through the common assumptions working group for the 2016-2018 Three-Year Plan. Historical participant numbers may not be comparable.

IV.D. Cost-Effectiveness

3.3.iii. T&D Avoided Costs Comparison Table - Three Year Plan vs. Previous Years

Statewide Electric
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NSTAR & CLC Avoided Cost Factors ($/kW)		
Year	Distribution	Transmission
2013	$68.79	$21.00
2014	$70.32	$21.47
2015	$71.88	$21.94
2016	$122.34	$36.53
2017	$122.34	$36.53
2018	$122.34	$36.53

WMECO Avoided Cost Factors ($/kW)		
Year	Distribution	Transmission
2013	$76.08	$22.27
2014	$77.77	$22.76
2015	$79.49	$23.27
2016	$56.02	$0.00
2017	$56.02	$0.00
2018	$56.02	$0.00

National Grid Avoided Cost Factors ($/kW)		
Year	Distribution	Transmission
2013	$111.37	$20.62
2014	$111.37	$20.62
2015	$111.37	$20.62
2016	$82.57	$10.52
2017	$82.57	$10.52
2018	$82.57	$10.52

Unitil Avoided Cost Factors ($/kW)		
Year	Distribution	Transmission
2013	$171.15	$0.00
2014	$174.95	$0.00
2015	$178.84	$0.00
2016	$182.58	$0.00
2017	$182.58	$0.00
2018	$182.58	$0.00

Notes:
2013 values are from the Program Administrator's 2013 Plan Year Report D.P.U. , in 2013$.
2014 values are from the Program Administrator's 2014 Plan Year Report, D.P.U. , in 2013$.
2015 values are from the Program Administrator's 2013-2015 Three-Year Plan, D.P.U. , in 2013$.
For supporting information on the 2016-2018 values, refer to the Program Administrator's Benefit-Cost Screening Model. The 2016-2018 values are in 2016$.

IV.H. Performance Incentive

1. Summary Table

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2016 Performance Incentives				
Sector	**After-Tax Performance Incentives**	**% of Program Costs**	**Pre-Tax Performance Incentives**	**% of Program Costs**
Residential	7,819,374	3.0%	12,901,780	4.9%
Low-Income	932,738	1.4%	1,542,230	2.3%
Commercial & Industrial	11,199,531	4.2%	18,507,927	6.9%
Grand Total	**19,951,644**	**3.3%**	**32,951,937**	**5.5%**

2017 Performance Incentives				
Sector	**After-Tax Performance Incentives**	**% of Program Costs**	**Pre-Tax Performance Incentives**	**% of Program Costs**
Residential	7,782,160	2.9%	12,843,417	4.7%
Low-Income	948,186	1.4%	1,567,953	2.3%
Commercial & Industrial	11,907,451	4.2%	19,671,915	7.0%
Grand Total	**20,637,797**	**3.3%**	**34,083,285**	**5.5%**

2018 Performance Incentives				
Sector	**After-Tax Performance Incentives**	**% of Program Costs**	**Pre-Tax Performance Incentives**	**% of Program Costs**
Residential	7,672,454	2.8%	12,663,459	4.6%
Low-Income	981,610	1.4%	1,623,166	2.4%
Commercial & Industrial	12,871,775	4.4%	21,261,737	7.2%
Grand Total	**21,525,839**	**3.4%**	**35,548,361**	**5.6%**

2016-2018 Performance Incentives				
Sector	**After-Tax Performance Incentives**	**% of Program Costs**	**Pre-Tax Performance Incentives**	**% of Program Costs**
Residential	23,273,988	2.9%	38,408,655	4.8%
Low-Income	2,862,535	1.4%	4,733,348	2.3%
Commercial & Industrial	35,978,757	4.2%	59,441,579	7.0%
Grand Total	**62,115,280**	**3.3%**	**102,583,583**	**5.5%**

Notes:
Performance Incentives for each year in 2016-2018 are represented in nominal dollars (2016$, 2017$, 2018$).
For supporting information on the Performance Incentive, refer to the Performance Incentive Model.
Performance Incentives are not applicable to the Cape Light Compact.

V.B. Allocation of Funds

1. Low-Income Minimum

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2016 Sector Cost Allocation		
Sector	**Program Budget**	
	($)	**(% of Total)**
A - Residential	261,977,427	43.8%
B - Low-Income	67,526,840	11.3%
C - Commercial & Industrial	269,276,486	45.0%
Grand Total	**598,780,754**	**100%**

2017 Sector Cost Allocation		
Sector	**Program Budget**	
	($)	**(% of Total)**
A - Residential	270,415,016	43.5%
B - Low-Income	67,979,499	10.9%
C - Commercial & Industrial	282,846,041	45.5%
Grand Total	**621,240,557**	**100%**

2018 Sector Cost Allocation		
Sector	**Program Budget**	
	($)	**(% of Total)**
A - Residential	275,247,527	43.2%
B - Low-Income	67,730,777	10.6%
C - Commercial & Industrial	294,576,727	46.2%
Grand Total	**637,555,030**	**100%**

2016-2018 Sector Cost Allocation		
Sector	**Program Budget**	
	($)	**(% of Total)**
A - Residential	807,639,970	43.5%
B - Low-Income	203,237,116	10.9%
C - Commercial & Industrial	846,699,254	45.6%
Grand Total	**1,857,576,341**	**100%**

Notes:
General Laws c. 25, § 19(c) requires that at least 10 percent of the amount expended for electric energy efficiency programs and at least 20 percent of the amount expended for gas energy efficiency programs be spent on low-income programs.

V.D. Outsourced/Competitively Procured Services

1. Summary Table

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2016 Competitively Procured Services		
Sector & Cost Categories	**Costs ($)**	**Costs as a Percent of Total Sector Costs (%)**
A - Residential		
Total Cost of Services	73,584,921	100%
In-House Activities	9,742,798	13%
Outsourced Activities	63,842,123	87%
Competitively Procured	61,125,080	83%
Non-Competitively Procured	2,717,043	4%
B - Low-Income		
Total Cost of Services	17,171,042	100%
In-House Activities	2,050,289	12%
Outsourced Activities	15,120,754	88%
Competitively Procured	4,285,515	25%
Non-Competitively Procured	10,835,239	63%
C - Commercial & Industrial		
Total Cost of Services	71,345,000	100%
In-House Activities	24,791,687	35%
Outsourced Activities	46,553,313	65%
Competitively Procured	36,207,032	51%
Non-Competitively Procured	10,346,281	15%
Grand Total		
Total Cost of Services	162,100,963	100%
In-House Activities	36,584,773	23%
Outsourced Activities	125,516,190	77%
Competitively Procured	101,617,627	63%
Non-Competitively Procured	23,898,563	15%

2017 Competitively Procured Services		
Sector & Cost Categories	**Costs ($)**	**Costs as a Percent of Total Sector Costs (%)**
A - Residential		
Total Cost of Services	76,832,098	100%
In-House Activities	10,042,650	13%
Outsourced Activities	66,789,449	87%
Competitively Procured	64,020,734	83%
Non-Competitively Procured	2,768,715	4%
B - Low-Income		
Total Cost of Services	17,094,927	100%
In-House Activities	2,089,959	12%
Outsourced Activities	15,004,968	88%
Competitively Procured	4,328,287	25%
Non-Competitively Procured	10,676,681	62%
C - Commercial & Industrial		
Total Cost of Services	76,480,286	100%
In-House Activities	25,440,133	33%
Outsourced Activities	51,040,153	67%
Competitively Procured	39,420,919	52%
Non-Competitively Procured	11,619,234	15%
Grand Total		
Total Cost of Services	170,407,311	100%
In-House Activities	37,572,742	22%
Outsourced Activities	132,834,569	78%
Competitively Procured	107,769,939	63%
Non-Competitively Procured	25,064,630	15%

V.D. Outsourced/Competitively Procured Services

1. Summary Table

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2018 Competitively Procured Services		
Sector & Cost Categories	**Costs ($)**	**Costs as a Percent of Total Sector Costs (%)**
A - Residential		
Total Cost of Services	79,974,654	100%
In-House Activities	10,391,984	13%
Outsourced Activities	69,582,671	87%
Competitively Procured	66,749,602	83%
Non-Competitively Procured	2,833,068	4%
B - Low-Income		
Total Cost of Services	17,223,508	100%
In-House Activities	2,125,397	12%
Outsourced Activities	15,098,111	88%
Competitively Procured	4,388,112	25%
Non-Competitively Procured	10,709,999	62%
C - Commercial & Industrial		
Total Cost of Services	77,399,081	100%
In-House Activities	26,311,452	34%
Outsourced Activities	51,087,629	66%
Competitively Procured	39,130,020	51%
Non-Competitively Procured	11,957,610	15%
Grand Total		
Total Cost of Services	174,597,244	100%
In-House Activities	38,828,832	22%
Outsourced Activities	135,768,411	78%
Competitively Procured	110,267,734	63%
Non-Competitively Procured	25,500,677	15%

2016-2018 Competitively Procured Services		
Sector & Cost Categories	**Costs ($)**	**Costs as a Percent of Total Sector Costs (%)**
A - Residential		
Total Cost of Services	230,391,674	100%
In-House Activities	30,177,431	13%
Outsourced Activities	200,214,242	87%
Competitively Procured	191,895,416	83%
Non-Competitively Procured	8,318,827	4%
B - Low-Income		
Total Cost of Services	51,489,478	100%
In-House Activities	6,265,645	12%
Outsourced Activities	45,223,833	88%
Competitively Procured	13,001,913	25%
Non-Competitively Procured	32,221,919	63%
C - Commercial & Industrial		
Total Cost of Services	225,224,367	100%
In-House Activities	76,543,272	34%
Outsourced Activities	148,681,095	66%
Competitively Procured	114,757,971	51%
Non-Competitively Procured	33,923,124	15%
Grand Total		
Total Cost of Services	507,105,518	100%
In-House Activities	112,986,348	22%
Outsourced Activities	394,119,170	78%
Competitively Procured	319,655,300	63%
Non-Competitively Procured	74,463,870	15%

Notes:
General Laws c. 25, § 19(b) requires the Department to ensure that energy efficiency programs use competitive procurement processes to the fullest extent practicable.
Costs for the Competitively Procured Services analysis include Program Planning and Administration; Marketing and Advertising; Sales, Technical Assistance & Training; and Evaluation and Market Research.
Costs for each year in 2016-2018 are represented in nominal dollars (2016$, 2017$, 2018$).

V.D. Outsourced/Competitively Procured Services

3. Comparison Table - Three Year Plan vs. Previous Years

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Sector	Competitively Procured Services Costs ($)					Competitively Procured Services Costs as a Percent of Total Sector Costs (%)				
	Total Cost of Services	In-House Activities	Outsourced Activities			Total Cost of Services	In-House Activities	Outsourced Activities		
			Total Outsourced	Competitively Procured	Non-Competitively Procured			Total Outsourced	Competitively Procured	Non-Competitively Procured
A - Residential	**388,955,315**	**56,288,034**	**332,667,280**	**313,739,770**	**18,927,510**	**100%**	**14%**	**86%**	**81%**	**5%**
2013	50,954,182	8,221,200	42,732,982	39,244,905	3,488,078	100%	16%	84%	77%	7%
2014	53,049,674	8,666,942	44,382,732	40,837,540	3,545,192	100%	16%	84%	77%	7%
2015	54,559,785	9,222,462	45,337,323	41,761,910	3,575,414	100%	17%	83%	77%	7%
2016	73,584,921	9,742,798	63,842,123	61,125,080	2,717,043	100%	13%	87%	83%	4%
2017	76,832,098	10,042,650	66,789,449	64,020,734	2,768,715	100%	13%	87%	83%	4%
2018	79,974,654	10,391,984	69,582,671	66,749,602	2,833,068	100%	13%	87%	83%	4%
B - Low-Income	**97,695,743**	**12,888,244**	**84,807,498**	**31,773,491**	**53,034,007**	**100%**	**13%**	**87%**	**33%**	**54%**
2013	14,993,017	2,138,913	12,854,104	5,982,346	6,871,758	100%	14%	86%	40%	46%
2014	15,228,120	2,202,883	13,025,237	6,075,289	6,949,948	100%	14%	86%	40%	46%
2015	15,985,128	2,280,804	13,704,324	6,713,943	6,990,381	100%	14%	86%	42%	44%
2016	17,171,042	2,050,289	15,120,754	4,285,515	10,835,239	100%	12%	88%	25%	63%
2017	17,094,927	2,089,959	15,004,968	4,328,287	10,676,681	100%	12%	88%	25%	62%
2018	17,223,508	2,125,397	15,098,111	4,388,112	10,709,999	100%	12%	88%	25%	62%
C - Commercial & Industrial	**420,384,060**	**162,531,765**	**257,852,295**	**206,547,835**	**51,304,460**	**100%**	**39%**	**61%**	**49%**	**12%**
2013	64,499,989	27,258,258	37,241,730	31,492,283	5,749,448	100%	42%	58%	49%	9%
2014	65,122,357	28,353,730	36,768,627	30,975,836	5,792,791	100%	44%	56%	48%	9%
2015	65,537,347	30,376,505	35,160,842	29,321,745	5,839,097	100%	46%	54%	45%	9%
2016	71,345,000	24,791,687	46,553,313	36,207,032	10,346,281	100%	35%	65%	51%	15%
2017	76,480,286	25,440,133	51,040,153	39,420,919	11,619,234	100%	33%	67%	52%	15%
2018	77,399,081	26,311,452	51,087,629	39,130,020	11,957,610	100%	34%	66%	51%	15%
Grand Total	**907,035,117**	**231,708,044**	**675,327,074**	**552,061,097**	**123,265,977**	**100%**	**26%**	**74%**	**61%**	**14%**
2013	130,447,187	37,618,370	92,828,817	76,719,533	16,109,283	100%	29%	71%	59%	12%
2014	133,400,151	39,223,555	94,176,597	77,888,666	16,287,931	100%	29%	71%	58%	12%
2015	136,082,260	41,879,770	94,202,490	77,797,597	16,404,893	100%	31%	69%	57%	12%
2016	162,100,963	36,584,773	125,516,190	101,617,627	23,898,563	100%	23%	77%	63%	15%
2017	170,407,311	37,572,742	132,834,569	107,769,939	25,064,630	100%	22%	78%	63%	15%
2018	174,597,244	38,828,832	135,768,411	110,267,734	25,500,677	100%	22%	78%	63%	15%

Notes:
General Laws c. 25, § 19(b) requires the Department to ensure that energy efficiency programs use competitive procurement processes to the fullest extent practicable.
Costs for the Competitively Procured Services analysis include Program Planning and Administration; Marketing and Advertising; Sales, Technical Assistance & Training; and Evaluation and Market Research.
The 2013-2015 costs are from the Program Administrator's 2013-2015 Three-Year Plan, D.P.U. , in nominal dollars (2013$, 2014$, 2015$).
For supporting information on the 2016-2018 values, see Table V.D.1. Costs for each year in 2016-2018 are represented in nominal dollars (2016$, 2017$, 2018$).

VII. Appendix

GHG reductions are provided for information purposes only. They are not included in the TRC test.

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2016 Greenhouse Gas Reductions											
	Adjusted Gross Annual Savings			GHG Factors					Annual Emissions Reductions (Short Tons)		
				NOX	SO2	CO2					
Sector	Electric Energy (MWh)	Natural Gas (Therms)	Oil (MMBTU)	Electric Energy	Electric Energy	Electric Energy	Natural Gas	Oil	NOX	SO2	CO2
A - Residential	748,069	(5,091,157)	102,802	0.000193548	0.000172043	0.392473	0.00585	0.080693	144.8	128.7	272,109
B - Low-Income	40,615	317	93,803	0.000193548	0.000172043	0.392473	0.00585	0.080693	7.9	7.0	23,511
C - Commercial & Industrial	686,248	(2,910,740)	(153,969)	0.000193548	0.000172043	0.392473	0.00585	0.080693	132.8	118.1	239,882
Grand Total	**1,474,931**	**(8,001,580)**	**42,636**	**0.000193548**	**0.000172043**	**0.392473**	**0.00585**	**0.080693**	**285.5**	**253.8**	**535,502**

2017 Greenhouse Gas Reductions											
	Adjusted Gross Annual Savings			GHG Factors					Annual Emissions Reductions (Short Tons)		
				NOX	SO2	CO2					
Sector	Electric Energy (MWh)	Natural Gas (Therms)	Oil (MMBTU)	Electric Energy	Electric Energy	Electric Energy	Natural Gas	Oil	NOX	SO2	CO2
A - Residential	716,627	(4,754,733)	135,438	0.000193548	0.000172043	0.392473	0.00585	0.080693	138.7	123.3	264,370
B - Low-Income	39,222	317	97,453	0.000193548	0.000172043	0.392473	0.00585	0.080693	7.6	6.7	23,259
C - Commercial & Industrial	737,875	(5,132,559)	(162,155)	0.000193548	0.000172043	0.392473	0.00585	0.080693	142.8	126.9	246,486
Grand Total	**1,493,724**	**(9,886,975)**	**70,735**	**0.000193548**	**0.000172043**	**0.392473**	**0.00585**	**0.080693**	**289.1**	**257.0**	**534,115**

2018 Greenhouse Gas Reductions											
	Adjusted Gross Annual Savings			GHG Factors					Annual Emissions Reductions (Short Tons)		
				NOX	SO2	CO2					
Sector	Electric Energy (MWh)	Natural Gas (Therms)	Oil (MMBTU)	Electric Energy	Electric Energy	Electric Energy	Natural Gas	Oil	NOX	SO2	CO2
A - Residential	668,186	(4,238,388)	179,001	0.000193548	0.000172043	0.392473	0.00585	0.080693	129.3	115.0	251,894
B - Low-Income	38,215	317	98,082	0.000193548	0.000172043	0.392473	0.00585	0.080693	7.4	6.6	22,915
C - Commercial & Industrial	809,598	(8,270,298)	(165,593)	0.000193548	0.000172043	0.392473	0.00585	0.080693	156.7	139.3	256,002
Grand Total	**1,515,999**	**(12,508,368)**	**111,489**	**0.000193548**	**0.000172043**	**0.392473**	**0.00585**	**0.080693**	**293.4**	**260.8**	**530,811**

2016-2018 Greenhouse Gas Reductions											
	Adjusted Gross Annual Savings			GHG Factors					Annual Emissions Reductions (Short Tons)		
				NOX	SO2	CO2					
Sector	Electric Energy (MWh)	Natural Gas (Therms)	Oil (MMBTU)	Electric Energy	Electric Energy	Electric Energy	Natural Gas	Oil	NOX	SO2	CO2
A - Residential	2,132,881	(14,084,278)	417,240	0.000193548	0.000172043	0.392473	0.00585	0.080693	412.8	366.9	788,374
B - Low-Income	118,051	952	289,338	0.000193548	0.000172043	0.392473	0.00585	0.080693	22.8	20.3	69,685
C - Commercial & Industrial	2,233,721	(16,313,596)	(481,718)	0.000193548	0.000172043	0.392473	0.00585	0.080693	432.3	384.3	742,370
Grand Total	**4,484,654**	**(30,396,923)**	**224,860**	**0.000193548**	**0.000172043**	**0.392473**	**0.00585**	**0.080693**	**868.0**	**771.6**	**1,600,429**

Notes:

The Program Administrators are working with DEP to determine the best method for properly and precisely capturing the full impact of energy efficiency measures on GHG emissions. As part of this process, the Program Administrators have included this additional table on greenhouse gas reductions, based on continuing discussions with the DEP. These reductions are calculated using factors proposed by DEP, which are based on adjusted gross annual electric energy, natural gas, and oil savings. The Program Administrators look forward to discussing these proposed factors with DEP and are committed to ensuring that the full impact of energy efficiency measures on GHG emissions are captured.

VII. Appendix

B.2. Master EE Activities

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Sector	Benefits (2016$)						TRC Costs (2016$)			Cost-Effectiveness	
	Capacity	Electric Energy	Natural Gas	Deliverable Fuels & Other	Non-Energy Impacts	Total Benefits	PA Budget	Participant Costs	Total TRC Test Costs	B/C Ratio	Net Benefits
2016	**499,193,119**	**967,615,746**	**(67,450,786)**	**164,722,672**	**297,770,450**	**2,041,177,916**	**631,732,691**	**207,280,172**	**843,913,830**	**2.42**	**1,197,264,086**
A - Residential	181,111,935	359,724,480	(29,507,643)	147,331,220	100,083,509	834,455,777	274,879,207	74,618,141	351,606,465	2.37	482,849,312
B - Low-Income	12,286,113	26,304,817	2,120	40,332,195	30,354,380	114,662,979	69,069,071	-	69,691,518	1.65	44,971,461
C - Commercial & Industrial	305,795,071	581,586,450	(37,945,262)	(22,940,744)	167,332,561	1,092,059,160	287,784,413	132,662,031	422,615,847	2.58	669,443,313
2017	**553,931,369**	**1,034,395,552**	**(99,744,772)**	**178,539,936**	**290,860,764**	**2,064,732,100**	**639,090,932**	**211,042,145**	**855,056,030**	**2.41**	**1,209,676,070**
A - Residential	187,177,116	347,543,946	(25,816,270)	160,149,264	100,368,372	811,614,592	276,241,889	69,349,201	347,709,668	2.33	463,904,924
B - Low-Income	12,897,220	25,614,415	1,978	42,729,775	30,400,483	114,669,170	67,824,704	-	68,449,944	1.68	46,219,226
C - Commercial & Industrial	353,857,034	661,237,191	(73,930,479)	(24,339,103)	160,091,909	1,138,448,337	295,024,338	141,692,944	438,896,418	2.59	699,551,919
2018	**605,035,868**	**1,128,898,382**	**(145,950,691)**	**192,749,592**	**276,614,475**	**2,108,720,120**	**640,169,756**	**222,161,906**	**867,276,701**	**2.43**	**1,241,443,420**
A - Residential	183,642,203	329,545,553	(21,694,836)	174,218,201	99,153,725	782,600,088	273,824,063	63,677,747	339,629,892	2.30	442,970,196
B - Low-Income	13,450,926	26,275,229	1,893	43,781,619	30,571,188	115,527,725	65,960,589	-	66,588,634	1.73	48,939,090
C - Commercial & Industrial	407,942,739	773,077,600	(124,257,748)	(25,250,228)	146,889,561	1,210,592,308	300,385,104	158,484,159	461,058,174	2.63	749,534,134
Grand Total	**1,658,160,356**	**3,130,909,680**	**(313,146,249)**	**536,012,199**	**865,245,688**	**6,214,630,136**	**1,910,993,378**	**640,484,223**	**2,566,246,561**	**2.42**	**3,648,383,576**
A - Residential	551,931,253	1,036,813,978	(77,018,749)	481,698,685	299,605,606	2,428,670,457	824,945,159.03	207,645,089	1,038,946,025	2.34	1,389,724,432
B - Low-Income	38,634,259	78,194,461	5,990	126,843,589	91,326,051	344,859,874	202,854,364.01	-	204,730,097	1.69	140,129,777
C - Commercial & Industrial	1,067,594,843	2,015,901,241	(236,133,490)	(72,530,075)	474,314,031	3,441,099,805	883,193,855.32	432,839,134	1,322,570,439	2.60	2,118,529,366

Notes:
GHG reductions are provided for information purposes only. They are not included in the TRC test.

VII. Appendix

B.2. Master EE Activities

Statewide Electric

October 30, 2015

Sector	Annual Net Savings						Avg Measure Life	Summer Capacity Cost	Electric Energy Cost	Gas Costs	Participants	Annual Emissions Reductions (Short Tons)		
	Summer Capacity (kW)	Electric Energy (MWh)	Gas (Therms)	Oil (MMBTu)	Propane (MMBTu)	Water (Gallons)	(yrs.)	(TRC$/Annual kW)	(TRC$/Annual MWh)	(TRC$/Annual Therm)		NOX	SO2	CO2
2016	**190,623**	**1,371,584**	**(6,826,749)**	**121,563**	**(11,492)**	**77,620,896**	**9**	**4,427**	**615**	**(124)**	**3,593,086**	**285.5**	**253.8**	**535,502**
A - Residential	83,902	627,236	(3,790,452)	212,313	(16,435)	67,260,472	7	4,191	561	(93)	3,538,503	144.8	128.7	272,109
B - Low-Income	4,588	40,615	317	93,803	3,255	3,631,218	9	15,191	1,716	219,708	31,829	7.9	7.0	23,511
C - Commercial & Industrial	102,132	703,733	(3,036,614)	(184,554)	1,688	6,729,206	11	4,138	601	(139)	22,754	132.8	118.1	239,882
2017	**191,958**	**1,372,492**	**(8,561,777)**	**163,508**	**191**	**82,353,858**	**10**	**4,454**	**623**	**(100)**	**3,631,669**	**289.1**	**257.0**	**534,115**
A - Residential	79,363	583,876	(3,348,889)	253,563	(5,899)	71,086,821	8	4,381	596	(104)	3,574,796	138.7	123.3	264,370
B - Low-Income	4,447	39,222	317	97,453	3,139	3,735,552	9	15,392	1,745	215,794	31,989	7.6	6.7	23,259
C - Commercial & Industrial	108,148	749,394	(5,213,204)	(187,507)	2,951	7,531,485	11	4,058	586	(84)	24,884	142.8	126.9	246,486
2018	**191,444**	**1,373,464**	**(11,030,333)**	**220,314**	**15,481**	**86,647,066**	**10**	**4,530**	**631**	**(79)**	**3,603,984**	**293.4**	**260.8**	**530,811**
A - Residential	73,013	528,881	(2,784,865)	301,145	6,760	74,538,873	8	4,652	642	(122)	3,546,733	129.3	115.0	251,894
B - Low-Income	4,358	38,215	317	98,082	3,488	3,735,552	9	15,280	1,742	209,926	32,149	7.4	6.6	22,915
C - Commercial & Industrial	114,074	806,368	(8,245,786)	(178,912)	5,232	8,372,642	12	4,042	572	(56)	25,102	156.7	139.3	256,002
Grand Total	**574,025**	**4,117,539**	**(26,418,858)**	**505,385**	**4,179**	**246,621,819**	**10**	**4,471**	**623**	**(97)**	**10,828,739**	**868.0**	**771.6**	**1,600,429**
A - Residential	236,278	1,739,994	(9,924,206)	767,021	(15,574)	212,886,166	8	4,397	597	(105)	10,660,031	412.8	366.9	788,374
B - Low-Income	13,393	118,051	952	289,338	9,882	11,102,321	9	15,286	1,734	215,143	95,968	22.8	20.3	69,685
C - Commercial & Industrial	324,353	2,259,494	(16,495,603)	(550,974)	9,871	22,633,332	11	4,078	585	(80)	72,740	432.3	384.3	742,370

IV.I. Cost Recovery

1. Calculation of LBR

DPU 15-160 - 15-169

NSTAR Electric Company, d/b/a Eversource Energy

October 30, 2015

	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	Calculation of Lost Base Revenue, 2016							
	Program	**Base Year 2007 Savings (kWh)**	**2016 Annual Savings (kWh)**	**Incremental Savings from Measures Installed in 2009 - 2015 (kWh) (1)**	**Incremental Savings from Measures installed in 2016 (kWh) (1) (2)**	**Total Incremental Savings (kWh) (3)**	**LBR Rate ($/kWh) (4)**	**Lost Base Revenue ($) (5)**
1	**Residential (total)**	74,721,243	194,369,953	211,720,571	38,749,671	250,470,242	0.04526	$ 11,335,043
2	**Low Income (total)**	2,864,812	12,926,757	55,191,446	5,490,546	60,681,991	0.04511	2,737,495
3	**Commercial & Industrial (total)**	120,549,087	336,638,902	1,223,485,299	59,007,843	1,282,493,143	0.03110	39,887,335
4	**GRAND TOTAL**	**198,135,143**	**543,935,612**	**1,490,397,316**	**103,248,060**	**1,593,645,376**		**$ 53,959,874**

	Calculation of Lost Base Revenue, 2017 (8)									
	Program	**Base Year 2007 Savings (kWh)**	**2017 Annual Savings (kWh)**	**Incremental Savings from Measures Installed in 2009 - 2015 (kWh) (1)**	**Incremental Savings from Measures installed in 2016 (kWh) (1)**	**Incremental Savings from Measures installed in 2017 (kWh) (1) (2)**	**Total Incremental Savings (kWh) (6)**	**Adjusted Incremental Savings (kWh) (7)**	**LBR Rate ($/kWh) (4)**	**Lost Base Revenue ($) (8)**
5	**Residential (total)**	74,721,243	173,663,755	211,720,571	61,833,807	16,832,405	290,386,784	145,477,491	0.04526	$ 6,583,591
6	**Low Income (total)**	2,864,812	11,810,115	55,191,446	9,765,799	4,909,587	69,866,831	35,318,796	0.04511	1,593,307
7	**Commercial & Industrial (total)**	120,549,087	361,735,081	1,223,485,299	215,834,742	63,458,037	1,502,778,078	747,856,450	0.03110	23,259,384
8	**GRAND TOTAL**	**198,135,143**	**547,208,952**	**1,490,397,316**	**287,434,348**	**85,200,029**	**1,863,031,693**	**928,652,737**		**$ 31,436,282**

	Total Lost Base Revenue, 2016-2017 (9)			
	Program	**2016**	**2017**	**TOTAL**
13	**Residential (total)**	**$ 11,335,043**	**$ 6,583,591**	**$ 17,918,635**
14	**Low Income (total)**	**2,737,495**	**1,593,307**	**4,330,801**
15	**Commercial & Industrial (total)**	**39,887,335**	**23,259,384**	**63,146,720**
16	**GRAND TOTAL**	**$ 53,959,874**	**$ 31,436,282**	**$ 85,396,156**

Notes:

(1) Represents total incremental savings to the base year 2007 for each period, net of expired savings

(2) Monthly as Installed

(3) (D)+(E)

(4) LBR rates are in 2014 dollars, which will be reconciled in the EERF to the actual LBR rate for each year.

(5) (F)*(G)

(6) (D)+(E)+(F)

(7) (H)*(I)

(8) This amount representes the full annualized rate of LBR that would be collected in 2017, however the Company is only proposing to collect LBR until the time Department approved decoupled rates would go into effect.

(9) Amount adjusted for 6 months of savings, which assumes NSTAR Electric is operating under decoupled rates by July 1, 2017. If the Company is not operating under decoupled rates by July 1, 2017, the Company will collect LBR until the effective date of the decoupled rates consistent with the Department's rulings in D.P.U. 10-06-A through D.P.U. 10-09-A. LBR would equate to approximately $30m through the end of 2017, and $70m through the end of 2018.

Energy Efficiency Tables

D.P.U. 15-160 to D.P.U. 15-169
Exh. 1, Appendix C
H.O.s Gold and Sawyer

Statewide Gas
October 30, 2015

OVERVIEW

The following data tables provide a summary of the Program Administrator's benefits, costs, savings, and cost-effectiveness for 2013 through 2018. The 2013 through 2015 planned values are consistent with each Program Administrator's 2013-2015 Three-Year Plan. The 2013 and 2014 evaluated values are consistent with each Program Administrator's 2013 and 2014 Plan-Year Reports. The 2015 year-to-date data represents the most up-to-date estimated actual values available. Specifically, 2015 year-to-date costs and each Program Administrator's primary-fuel savings are estimated actuals through August 2015, while the 2015 year-to-date benefits and each Program Administrator's non-primary-fuel savings are estimated actuals through June 2015 consistent with the 2015 Second Quarterly Report. The 2016-2018 planned values are consistent with each Program Administrator's 2016-2018 Three-Year Plan.

The data included in these tables is based on other supporting models. The primary supporting models used by the Program Administrators are the Benefit-Cost Screening model, each Program Administrator's EES calculation support documents, and the Performance Incentive model. These exhibits should be referenced when looking for more detailed analyses, such as measure level detail and EES calculations. High-level summaries for each of these models are provided below, along with information on plan details that are not summarized in the following plan tables.

BENEFIT-COST SCREENING MODEL

The Benefit-Cost Screening model provides measure level savings and benefits. This model uses the avoided cost values from the 2015 Avoided Energy Supply Cost study prepared by Tabors Caramanis Rudkevich.

EES CALCULATIONS

Each Program Administrator's Energy Efficiency Surcharge analysis provides supporting information on the EES rates proposed for effect in 2016-2018, including how the rates are calculated for each customer sector, and how revenue is collected from each customer sector.

PERFORMANCE INCENTIVE MODEL

The Performance Incentive model filed as part of the Joint Statewide Three-Year Plan provides support for the performance incentive dollars proposed for collection by the Program Administrator. Note that performance incentives are not applicable to the Cape Light Compact.

EM&V ACTIVITIES

The Evaluation, Monitoring & Verification Section of the Joint Statewide Three-Year Plan describes in detail the EM&V activities planned for 2016-2018.

OTHER FUNDING

For the electric Program Administrators, "Other Funding" are those funds, private or public utility administered or otherwise, that may be available for energy efficiency or demand resources and do not include SBC Funds, FCM Revenue, or RGGI Proceeds. The electric Program Administrators assume no other funding sources for 2016-2018.

IV.D. Cost Effectiveness

Additional Filing Requirements

Statewide Gas

October 30, 2015

D.P.U. 15-160 to D.P.U. 15-169
Exh. 1, Appendix C
H.O.s Gold and Sawyer

2013 Evaluated Additional Filing Requirements

Program	Participants	Annual Savings			Total Energy Benefits	Total Costs		Savings per TRC Costs			Savings per Participant per TRC Costs			Total Energy Benefits		
		Electric Energy	Natural Gas	Oil		Program Costs	TRC Test Costs	Electric Energy	Natural Gas	Oil	Electric Energy	Natural Gas	Oil	per Program Costs	per TRC Costs	per Participant per TRC Costs
	(#)	(MWh)	(Therms)	(MMBTU)	($)	(Nominal $)	(2013$)	(kWh/$)	(Therms/$)	(MMBTU/$)	(kWh/#/$)	(Therms/#/$)	(MMBTU/#/$)	($/$)	($/$)	($/#/$)
A - Residential	**556,505**	**4,252**	**13,956,596**	**-**	**174,394,277**	**87,557,656**	**134,143,802**	**0.032**	**0.104**	**-**	**0.0000**	**0.000000**	**-**	**1.992**	**1.300**	**0.000**
A1 - Residential Whole House	525,881	4,169	10,668,110	-	121,722,180	61,142,007	81,329,400	0.051	0.131	-	0.0000	0.000000	-	1.991	1.497	0.000
Residential Multi-Family Retrofit	9,505	178	595,369	-	11,542,095	5,146,778	5,022,572	0.035	0.119	-	0.0000	0.000012	-	2.243	2.298	0.000
Residential Home Energy Services	40,677	2,479	3,741,337	-	81,138,380	45,763,893	60,252,572	0.041	0.062	-	0.0000	0.000002	-	1.773	1.347	0.000
Residential New Construction	2,889	1,512	985,961	-	24,579,106	7,447,613	13,208,781	0.114	0.075	-	0.0000	0.000026	-	3.300	1.861	0.001
Residential Behavior/Feedback	472,810	-	5,345,443	-	4,462,598	2,783,723	2,845,474	-	1.879	-	-	0.000004	-	1.603	1.568	0.000
A2 - Residential Products	30,624	83	3,288,486	-	52,672,097	24,213,308	50,609,180	0.002	0.065	-	0.0000	0.000002	-	2.175	1.041	0.000
Residential Heating & Water Heating	30,624	83	3,288,486	-	52,672,097	24,213,308	50,609,180	0.002	0.065	-	0.0000	0.000002	-	2.175	1.041	0.000
A3 - Residential Hard-to-Measure	-	-	-	-	-	2,202,341	2,205,222	-	-	-				-	-	
B - Low-Income	**10,373**	**998**	**2,042,010**	**-**	**43,921,590**	**34,538,151**	**35,682,714**	**0.028**	**0.057**	**-**	**0.0000**	**0.000006**	**-**	**1.272**	**1.231**	**0.000**
B1 - Low-Income Whole House	10,373	998	2,042,010	-	43,921,590	34,077,983	35,222,546	0.028	0.058	-	0.0000	0.000006	-	1.289	1.247	0.000
Low-Income Single Family Retrofit	3,139	998	783,946	-	20,333,116	16,699,065	17,155,902	0.058	0.046	-	0.0000	0.000015	-	1.218	1.185	0.000
Low-Income Multi-Family Retrofit	7,234	-	1,258,064	-	23,588,474	17,378,918	18,066,644	-	0.070	-	-	0.000010	-	1.357	1.306	0.000
B2 - Low-Income Hard-to-Measure	-	-	-	-	-	460,168	460,168	-	-	-				-	-	
C - Commercial & Industrial	**5,296**	**261**	**8,669,370**	**-**	**121,277,268**	**29,566,522**	**43,303,079**	**0.006**	**0.200**	**-**	**0.0000**	**0.000038**	**-**	**4.102**	**2.801**	**0.001**
C1 - C&I New Construction	1,082	22	2,796,731	-	52,764,165	10,773,376	15,675,062	0.001	0.178	-	0.0000	0.000165	-	4.898	3.366	0.003
C&I New Construction	1,082	22	2,796,731	-	52,764,165	10,773,376	15,675,062	0.001	0.178	-	0.0000	0.000165	-	4.898	3.366	0.003
C2 - C&I Retrofit	4,214	239	5,872,639	-	68,513,103	17,675,670	26,507,941	0.009	0.222	-	0.0000	0.000053	-	3.876	2.585	0.001
C&I Retrofit	3,195	239	5,635,981	-	64,013,513	17,216,085	25,932,772	0.009	0.217	-	0.0000	0.000068	-	3.718	2.468	0.001
C&I Direct Install	1,019	-	236,658	-	4,499,590	459,585	575,169	-	0.411	-	-	0.000404	-	9.791	7.823	0.008
C3 - C&I Hard-to-Measure	-	-	-	-	-	1,117,476	1,120,076	-	-	-				-	-	
Grand Total	**572,174**	**5,510**	**24,667,976**	**-**	**339,593,135**	**151,662,329**	**213,129,594**	**0.026**	**0.116**	**-**	**0.0000**	**0.000000**	**-**	**2.239**	**1.593**	**0.000**

2014 Evaluated Additional Filing Requirements

Program	Participants	Annual Savings			Total Energy Benefits	Total Costs		Savings per TRC Costs			Savings per Participant per TRC Costs			Total Energy Benefits		
		Electric Energy	Natural Gas	Oil		Program Costs	TRC Test Costs	Electric Energy	Natural Gas	Oil	Electric Energy	Natural Gas	Oil	per Program Costs	per TRC Costs	per Participant per TRC Costs
	(#)	(MWh)	(Therms)	(MMBTU)	($)	(Nominal $)	(2013$)	(kWh/$)	(Therms/$)	(MMBTU/$)	(kWh/#/$)	(Therms/#/$)	(MMBTU/#/$)	($/$)	($/$)	($/#/$)
A - Residential	**569,411**	**5,155**	**15,691,501**	**-**	**227,645,421**	**98,897,476**	**142,141,505**	**0.036**	**0.110**	**-**	**0.0000**	**0.000000**	**-**	**2.302**	**1.602**	**0.000**
A1 - Residential Whole House	536,483	4,827	12,906,488	-	172,151,953	72,158,275	94,753,406	0.051	0.136	-	0.0000	0.000000	-	2.386	1.817	0.000
Residential Multi-Family Retrofit	15,809	173	686,675	-	16,155,902	5,892,249	5,740,641	0.030	0.120	-	0.0000	0.000008	-	2.742	2.814	0.000
Residential Home Energy Services	42,513	3,110	4,556,232	-	113,215,311	53,731,865	69,321,975	0.045	0.066	-	0.0000	0.000002	-	2.107	1.633	0.000
Residential New Construction	4,713	1,544	1,262,602	-	34,818,601	9,054,389	16,204,132	0.095	0.078	-	0.0000	0.000017	-	3.845	2.149	0.000
Residential Behavior/Feedback	473,448	-	6,400,980	-	7,962,138	3,479,772	3,486,658	-	1.836	-	-	0.000004	-	2.288	2.284	0.000
A2 - Residential Products	32,928	328	2,785,013	-	55,493,468	23,862,403	44,581,453	0.007	0.062	-	0.0000	0.000002	-	2.326	1.245	0.000
Residential Heating & Water Heating	32,928	328	2,785,013	-	55,493,468	23,862,403	44,581,453	0.007	0.062	-	0.0000	0.000002	-	2.326	1.245	0.000
A3 - Residential Hard-to-Measure	-	-	-	-	-	2,876,798	2,806,646	-	-	-				-	-	
B - Low-Income	**10,891**	**676**	**2,628,673**	**-**	**61,523,240**	**38,284,014**	**38,438,807**	**0.018**	**0.068**	**-**	**0.0000**	**0.000006**	**-**	**1.607**	**1.601**	**0.000**
B1 - Low-Income Whole House	10,891	676	2,628,673	-	61,523,240	37,771,124	37,939,726	0.018	0.069	-	0.0000	0.000006	-	1.629	1.622	0.000
Low-Income Single Family Retrofit	2,668	676	667,176	-	18,593,399	15,365,369	15,277,756	0.044	0.044	-	0.0000	0.000016	-	1.210	1.217	0.000
Low-Income Multi-Family Retrofit	8,223	-	1,961,498	-	42,929,840	22,405,755	22,661,971	-	0.087	-	-	0.000011	-	1.916	1.894	0.000
B2 - Low-Income Hard-to-Measure	-	-	-	-	-	512,890	499,081	-	-	-				-	-	
C - Commercial & Industrial	**10,365**	**62**	**10,323,023**	**-**	**172,125,542**	**33,914,584**	**52,333,799**	**0.001**	**0.197**	**-**	**0.0000**	**0.000019**	**-**	**5.075**	**3.289**	**0.000**
C1 - C&I New Construction	1,000	7	2,571,619	-	52,301,955	11,022,302	16,244,574	0.000	0.158	-	0.0000	0.000158	-	4.745	3.220	0.003
C&I New Construction	1,000	7	2,571,619	-	52,301,955	11,022,302	16,244,574	0.000	0.158	-	0.0000	0.000158	-	4.745	3.220	0.003
C2 - C&I Retrofit	9,365	56	7,751,404	-	119,823,587	21,651,970	34,878,649	0.002	0.222	-	0.0000	0.000024	-	5.534	3.435	0.000
C&I Retrofit	8,638	56	7,577,044	-	116,055,502	21,011,892	34,066,563	0.002	0.222	-	0.0000	0.000026	-	5.523	3.407	0.000
C&I Direct Install	727	-	174,360	-	3,768,085	640,078	812,086	-	0.215	-	-	0.000295	-	5.887	4.640	0.006
C3 - C&I Hard-to-Measure	-	-	-	-	-	1,240,313	1,210,575	-	-	-				-	-	
Grand Total	**590,667**	**5,893**	**28,643,197**	**-**	**461,294,203**	**171,096,074**	**232,914,110**	**0.025**	**0.123**	**-**	**0.0000**	**0.000000**	**-**	**2.696**	**1.981**	**0.000**

IV.D. Cost Effectiveness
Additional Filing Requirements
Statewide Gas
October 30, 2015

D.P.U. 15-160 to D.P.U. 15-169
Exh. 1, Appendix C
H.O.s Gold and Sawyer

2015 YTD Additional Filing Requirements

Program	Participants	Annual Savings			Total Energy Benefits	Total Costs		Savings per TRC Costs			Savings per Participant per TRC Costs			Total Energy Benefits		
		Electric Energy	Natural Gas	Oil		Program Costs	TRC Test Costs	Electric Energy	Natural Gas	Oil	Electric Energy	Natural Gas	Oil	per Program Costs	per TRC Costs	per Participant per TRC Costs
	(#)	(MWh)	(Therms)	(MMBTU)	($)	(Nominal $)	(2013$)	(kWh/$)	(Therms/$)	(MMBTU/$)	(kWh/#/$)	(Therms/#/$)	(MMBTU/#/$)	($/$)	($/$)	($/#/$)
A - Residential	**539,592**	**2,286**	**9,342,890**	**-**	**104,935,939**	**60,217,545**	**57,021,348**	**0.040**	**0.164**	**-**	**0.0000**	**0.000000**	**-**	**1.743**	**1.840**	**0.000**
A1 - Residential Whole House	520,029	2,048	7,755,517	-	75,280,872	42,209,724	39,967,220	0.051	0.194	-	0.0000	0.000000	-	1.783	1.884	0.000
Residential Multi-Family Retrofit	6,278	173	267,217	-	5,557,296	3,434,181	3,251,340	0.053	0.082	-	0.0000	0.000013	-	1.618	1.709	0.000
Residential Home Energy Services	23,458	1,453	2,203,699	-	45,975,861	30,569,645	28,941,999	0.050	0.076	-	0.0000	0.000003	-	1.504	1.589	0.000
Residential New Construction	3,499	423	741,381	-	18,181,294	5,200,136	4,928,520	0.086	0.150	-	0.0000	0.000043	-	3.496	3.689	0.001
Residential Behavior/Feedback	486,794	-	4,543,221	-	5,566,421	3,005,762	2,845,361	-	1.597	-	-	0.000003	-	1.852	1.956	0.000
A2 - Residential Products	19,563	238	1,587,373	-	29,655,067	15,927,089	15,083,912	0.016	0.105	-	0.0000	0.000005	-	1.862	1.966	0.000
Residential Heating & Water Heating	19,563	238	1,587,373	-	29,655,067	15,927,089	15,083,912	0.016	0.105	-	0.0000	0.000005	-	1.862	1.966	0.000
A3 - Residential Hard-to-Measure	-	-	-	-	-	2,080,733	1,970,217	-	-	-				-	-	
B - Low-Income	**6,586**	**268**	**1,362,164**	**-**	**22,717,355**	**23,190,096**	**21,966,210**	**0.012**	**0.062**	**-**	**0.0000**	**0.000009**	**-**	**0.980**	**1.034**	**0.000**
B1 - Low-Income Whole House	6,586	268	1,362,164	-	22,717,355	22,714,513	21,515,915	0.012	0.063	-	0.0000	0.000010	-	1.000	1.056	0.000
Low-Income Single Family Retrofit	1,640	268	384,670	-	7,554,692	9,514,461	9,018,703	0.030	0.043	-	0.0000	0.000026	-	0.794	0.838	0.001
Low-Income Multi-Family Retrofit	4,946	-	977,494	-	15,162,663	13,200,052	12,497,211	-	0.078	-	-	0.000016	-	1.149	1.213	0.000
B2 - Low-Income Hard-to-Measure	-	-	-	-	-	475,583	450,295	-	-	-				-	-	
C - Commercial & Industrial	**2,266**	**160**	**4,078,923**	**-**	**38,059,194**	**18,998,788**	**17,997,008**	**0.009**	**0.227**	**-**	**0.0000**	**0.000100**	**-**	**2.003**	**2.115**	**0.001**
C1 - C&I New Construction	613	3	1,393,042	-	19,258,084	7,620,352	7,218,339	0.000	0.193	-	0.0000	0.000315	-	2.527	2.668	0.004
C&I New Construction	613	3	1,393,042	-	19,258,084	7,620,352	7,218,339	0.000	0.193	-	0.0000	0.000315	-	2.527	2.668	0.004
C2 - C&I Retrofit	1,653	157	2,685,881	-	18,801,110	10,286,664	9,744,549	0.016	0.276	-	0.0000	0.000167	-	1.828	1.929	0.001
C&I Retrofit	1,161	157	2,544,202	-	16,636,655	9,738,772	9,223,556	0.017	0.276	-	0.0000	0.000238	-	1.708	1.804	0.002
C&I Direct Install	492	-	141,679	-	2,164,455	547,893	520,993	-	0.272	-	-	0.000553	-	3.951	4.154	0.008
C3 - C&I Hard-to-Measure	-	-	-	-	-	1,091,772	1,034,121	-	-	-				-	-	
Grand Total	**548,444**	**2,714**	**14,783,977**	**-**	**165,712,488**	**102,406,429**	**96,984,567**	**0.028**	**0.152**	**-**	**0.0000**	**0.000000**	**-**	**1.618**	**1.709**	**0.000**

2013-2015 YTD Additional Filing Requirements

Program	Participants	Annual Savings			Total Energy Benefits	Total Costs		Savings per TRC Costs			Savings per Participant per TRC Costs			Total Energy Benefits		
		Electric Energy	Natural Gas	Oil		Program Costs	TRC Test Costs	Electric Energy	Natural Gas	Oil	Electric Energy	Natural Gas	Oil	per Program Costs	per TRC Costs	per Participant per TRC Costs
	(#)	(MWh)	(Therms)	(MMBTU)	($)	(Nominal $)	(2013$)	(kWh/$)	(Therms/$)	(MMBTU/$)	(kWh/#/$)	(Therms/#/$)	(MMBTU/#/$)	($/$)	($/$)	($/#/$)
A - Residential	**1,665,508**	**11,693**	**38,990,987**	**-**	**506,975,637**	**246,672,677**	**333,306,655**	**0.035**	**0.117**	**-**	**0.0000**	**0.000000**	**-**	**2.055**	**1.521**	**0.000**
A1 - Residential Whole House	1,582,393	11,044	31,330,115	-	369,155,005	175,510,006	216,050,025	0.051	0.145	-	0.0000	0.000000	-	2.103	1.709	0.000
Residential Multi-Family Retrofit	31,592	523	1,549,260	-	33,255,293	14,473,208	14,014,553	0.037	0.111	-	0.0000	0.000003	-	2.298	2.373	0.000
Residential Home Energy Services	106,648	7,041	10,501,268	-	240,329,553	130,065,403	158,516,546	0.044	0.066	-	0.0000	0.000001	-	1.848	1.516	0.000
Residential New Construction	11,101	3,479	2,989,943	-	77,579,001	21,702,138	34,341,434	0.101	0.087	-	0.0000	0.000008	-	3.575	2.259	0.000
Residential Behavior/Feedback	1,433,052	-	16,289,644	-	17,991,158	9,269,257	9,177,493	-	1.775	-	-	0.000001	-	1.941	1.960	0.000
A2 - Residential Products	83,115	649	7,660,872	-	137,820,632	64,002,800	110,274,545	0.006	0.069	-	0.0000	0.000001	-	2.153	1.250	0.000
Residential Heating & Water Heating	83,115	649	7,660,872	-	137,820,632	64,002,800	110,274,545	0.006	0.069	-	0.0000	0.000001	-	2.153	1.250	0.000
A3 - Residential Hard-to-Measure	-	-	-	-	-	7,159,871	6,982,085	-	-	-				-	-	
B - Low-Income	**27,850**	**1,941**	**6,032,848**	**-**	**128,162,185**	**96,012,260**	**96,087,730**	**0.020**	**0.063**	**-**	**0.0000**	**0.000002**	**-**	**1.335**	**1.334**	**0.000**
B1 - Low-Income Whole House	27,850	1,941	6,032,848	-	128,162,185	94,563,619	94,678,187	0.021	0.064	-	0.0000	0.000002	-	1.355	1.354	0.000
Low-Income Single Family Retrofit	7,447	1,941	1,835,792	-	46,481,208	41,578,895	41,452,361	0.047	0.044	-	0.0000	0.000006	-	1.118	1.121	0.000
Low-Income Multi-Family Retrofit	20,403	-	4,197,056	-	81,680,977	52,984,725	53,225,826	-	0.079	-	-	0.000004	-	1.542	1.535	0.000
B2 - Low-Income Hard-to-Measure	-	-	-	-	-	1,448,641	1,409,544	-	-	-				-	-	
C - Commercial & Industrial	**17,927**	**483**	**23,071,316**	**-**	**331,462,004**	**82,479,894**	**113,633,886**	**0.004**	**0.203**	**-**	**0.0000**	**0.000011**	**-**	**4.019**	**2.917**	**0.000**
C1 - C&I New Construction	2,695	32	6,761,392	-	124,324,204	29,416,030	39,137,975	0.001	0.173	-	0.0000	0.000064	-	4.226	3.177	0.001
C&I New Construction	2,695	32	6,761,392	-	124,324,204	29,416,030	39,137,975	0.001	0.173	-	0.0000	0.000064	-	4.226	3.177	0.001
C2 - C&I Retrofit	15,232	452	16,309,924	-	207,137,800	49,614,305	71,131,139	0.006	0.229	-	0.0000	0.000015	-	4.175	2.912	0.000
C&I Retrofit	12,994	452	15,757,227	-	196,705,670	47,966,748	69,222,891	0.007	0.228	-	0.0000	0.000018	-	4.101	2.842	0.000
C&I Direct Install	2,238	-	552,697	-	10,432,130	1,647,556	1,908,248	-	0.290	-	-	0.000129	-	6.332	5.467	0.002
C3 - C&I Hard-to-Measure	-	-	-	-	-	3,449,560	3,364,772	-	-	-				-	-	
Grand Total	**1,711,285**	**14,118**	**68,095,151**	**-**	**966,599,826**	**425,164,832**	**543,028,271**	**0.026**	**0.125**	**-**	**0.0000**	**0.000000**	**-**	**2.273**	**1.780**	**0.000**

IV.D. Cost Effectiveness

Additional Filing Requirements

Statewide Gas

October 30, 2015

D.P.U. 15-160 to D.P.U. 15-169

Exh. 1, Appendix C

H.O.s Gold and Sawyer

2016 Planned Additional Filing Requirements

Program	Participants	Annual Savings			Total Energy Benefits	Total Costs		Savings per TRC Costs			Savings per Participant per TRC Costs			Total Energy Benefits		
		Electric Energy	Natural Gas	Oil		Program Costs	TRC Test Costs	Electric Energy	Natural Gas	Oil	Electric Energy	Natural Gas	Oil	per Program Costs	per TRC Costs	per Participant per TRC Costs
	(#)	(MWh)	(Therms)	(MMBTU)	($)	(Nominal $)	(2016$)	(kWh/$)	(Therms/$)	(MMBTU/$)	(kWh/#/$)	(Therms/#/$)	(MMBTU/#/$)	($/$)	($/$)	($/#/$)
A - Residential	**612,250**	**9,174**	**15,104,655**	**-**	**220,667,845**	**128,380,576**	**186,055,759**	**0.049**	**0.081**	**-**	**0.0000**	**0.000000**	**-**	**1.719**	**1.186**	**0.000**
A1 - Residential Whole House	581,111	8,655	12,498,355	-	173,071,891	99,967,130	136,167,655	0.064	0.092	-	0.0000	0.000000	-	1.731	1.271	0.000
A1a - Residential New Construction	4,583	1,073	1,185,579	-	29,266,742	10,899,580	20,522,211	0.052	0.058	-	0.0000	0.000013	-	2.685	1.426	0.000
A1b - Residential Multi-Family Retrofit	9,146	124	365,893	-	8,232,009	7,267,591	7,015,624	0.018	0.052	-	0.0000	0.000006	-	1.133	1.173	0.000
A1c - Residential Home Energy Services - Measures	16,953	7,459	4,915,809	-	127,735,847	66,553,493	93,280,277	0.080	0.053	-	0.0000	0.000003	-	1.919	1.369	0.000
A1d - Residential Home Energy Services - RCS	44,711	-	-	-	-	11,771,690	11,771,690	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	505,718	-	6,031,074	-	7,837,292	3,474,775	3,577,853	-	1.686	-	-	0.000003	-	2.255	2.191	0.000
A2 - Residential Products	31,138	518	2,606,301	-	47,595,954	24,280,305	45,754,963	0.011	0.057	-	0.0000	0.000002	-	1.960	1.040	0.000
A2a - Residential Heating & Cooling Equipment	31,138	518	2,606,301	-	47,595,954	24,280,305	45,754,963	0.011	0.057	-	0.0000	0.000002	-	1.960	1.040	0.000
A3 - Residential Hard-to-Measure	-	-	-	-	-	4,133,142	4,133,142	-	-	-				-	-	
B - Low-Income	**10,596**	**750**	**2,054,911**	**-**	**43,474,027**	**44,552,694**	**45,539,870**	**0.016**	**0.045**	**-**	**0.0000**	**0.000004**	**-**	**0.976**	**0.955**	**0.000**
B1 - Low-Income Whole House	10,596	750	2,054,911	-	43,474,027	43,487,336	44,474,513	0.017	0.046	-	0.0000	0.000004	-	1.000	0.978	0.000
B1a - Low-Income Single Family Retrofit	2,840	750	760,160	-	19,053,640	21,944,921	22,290,280	0.034	0.034	-	0.0000	0.000012	-	0.868	0.855	0.000
B1b - Low-Income Multi-Family Retrofit	7,756	-	1,294,751	-	24,420,387	21,542,416	22,184,233	-	0.058	-	-	0.000008	-	1.134	1.101	0.000
B2 - Low-Income Hard-to-Measure	-	-	-	-	-	1,065,358	1,065,358	-	-	-				-	-	
C - Commercial & Industrial	**6,283**	**4**	**10,935,286**	**-**	**137,077,119**	**43,935,544**	**62,971,727**	**0.000**	**0.174**	**-**	**0.0000**	**0.000028**	**-**	**3.120**	**2.177**	**0.000**
C1 - C&I New Construction	1,688	4	3,825,609	-	60,837,811	16,429,220	21,830,689	0.000	0.175	-	0.0000	0.000104	-	3.703	2.787	0.002
C1a - C&I New Buildings & Major Renovations	330	1	2,701,169	-	41,677,003	9,923,558	13,340,082	0.000	0.202	-	0.0000	0.000614	-	4.200	3.124	0.009
C1b - C&I Initial Purchase & End of Useful Life	1,358	3	1,124,440	-	19,160,807	6,505,662	8,490,607	0.000	0.132	-	0.0000	0.000098	-	2.945	2.257	0.002
C2 - C&I Retrofit	4,595	-	7,109,677	-	76,239,308	26,206,676	39,841,391	-	0.178	-	-	0.000039	-	2.909	1.914	0.000
C2a - C&I Existing Building Retrofit	1,644	-	6,359,669	-	65,076,301	20,192,419	33,040,507	-	0.192	-	-	0.000117	-	3.223	1.970	0.001
C2b - C&I Small Business	1,623	-	384,661	-	5,730,926	1,947,147	2,289,023	-	0.168	-	-	0.000104	-	2.943	2.504	0.002
C2c - C&I Multifamily Retrofit	1,328	-	365,347	-	5,432,081	4,067,110	4,511,862	-	0.081	-	-	0.000061	-	1.336	1.204	0.001
C3 - C&I Hard-to-Measure	-	-	-	-	-	1,299,648	1,299,648	-	-	-				-	-	
Grand Total	**629,128**	**9,927**	**28,094,852**	**-**	**401,218,991**	**216,868,815**	**294,567,357**	**0.034**	**0.095**	**-**	**0.0000**	**0.000000**	**-**	**1.850**	**1.362**	**0.000**

2017 Planned Additional Filing Requirements

Program	Participants	Annual Savings			Total Energy Benefits	Total Costs		Savings per TRC Costs			Savings per Participant per TRC Costs			Total Energy Benefits		
		Electric Energy	Natural Gas	Oil		Program Costs	TRC Test Costs	Electric Energy	Natural Gas	Oil	Electric Energy	Natural Gas	Oil	per Program Costs	per TRC Costs	per Participant per TRC Costs
	(#)	(MWh)	(Therms)	(MMBTU)	($)	(Nominal $)	(2016$)	(kWh/$)	(Therms/$)	(MMBTU/$)	(kWh/#/$)	(Therms/#/$)	(MMBTU/#/$)	($/$)	($/$)	($/#/$)
A - Residential	**612,552**	**8,981**	**15,185,401**	**-**	**220,787,986**	**131,256,509**	**188,051,515**	**0.048**	**0.081**	**-**	**0.0000**	**0.000000**	**-**	**1.682**	**1.174**	**0.000**
A1 - Residential Whole House	581,550	8,445	12,535,935	-	172,902,391	102,392,260	138,586,350	0.061	0.090	-	0.0000	0.000000	-	1.689	1.248	0.000
A1a - Residential New Construction	4,215	1,003	1,140,061	-	28,058,235	10,520,034	19,155,299	0.052	0.060	-	0.0000	0.000014	-	2.667	1.465	0.000
A1b - Residential Multi-Family Retrofit	9,192	136	370,833	-	8,161,820	7,365,651	7,034,267	0.019	0.053	-	0.0000	0.000006	-	1.108	1.160	0.000
A1c - Residential Home Energy Services - Measures	17,080	7,306	5,067,505	-	129,895,361	68,893,232	97,081,195	0.075	0.052	-	0.0000	0.000003	-	1.885	1.338	0.000
A1d - Residential Home Energy Services - RCS	45,376	-	-	-	-	12,153,888	11,852,826	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	505,687	-	5,957,536	-	6,786,975	3,459,456	3,462,763	-	1.720	-	-	0.000003	-	1.962	1.960	0.000
A2 - Residential Products	31,002	536	2,649,466	-	47,885,595	24,534,241	45,242,417	0.012	0.059	-	0.0000	0.000002	-	1.952	1.058	0.000
A2a - Residential Heating & Cooling Equipment	31,002	536	2,649,466	-	47,885,595	24,534,241	45,242,417	0.012	0.059	-	0.0000	0.000002	-	1.952	1.058	0.000
A3 - Residential Hard-to-Measure	-	-	-	-	-	4,330,007	4,222,749	-	-	-				-	-	
B - Low-Income	**10,625**	**756**	**2,061,664**	**-**	**43,202,857**	**44,988,485**	**44,866,982**	**0.017**	**0.046**	**-**	**0.0000**	**0.000004**	**-**	**0.960**	**0.963**	**0.000**
B1 - Low-Income Whole House	10,625	756	2,061,664	-	43,202,857	43,912,929	43,818,069	0.017	0.047	-	0.0000	0.000004	-	0.984	0.986	0.000
B1a - Low-Income Single Family Retrofit	2,870	756	769,456	-	19,171,864	22,311,441	22,110,775	0.034	0.035	-	0.0000	0.000012	-	0.859	0.867	0.000
B1b - Low-Income Multi-Family Retrofit	7,755	-	1,292,208	-	24,030,993	21,601,488	21,707,293	-	0.060	-	-	0.000008	-	1.112	1.107	0.000
B2 - Low-Income Hard-to-Measure	-	-	-	-	-	1,075,556	1,048,913	-	-	-				-	-	
C - Commercial & Industrial	**6,523**	**4**	**11,257,314**	**-**	**136,060,674**	**44,893,412**	**63,234,170**	**0.000**	**0.178**	**-**	**0.0000**	**0.000027**	**-**	**3.031**	**2.152**	**0.000**
C1 - C&I New Construction	1,892	4	3,884,614	-	61,507,536	16,609,729	21,782,613	0.000	0.178	-	0.0000	0.000094	-	3.703	2.824	0.001
C1a - C&I New Buildings & Major Renovations	416	1	2,727,894	-	42,262,482	9,963,727	13,107,710	0.000	0.208	-	0.0000	0.000500	-	4.242	3.224	0.008
C1b - C&I Initial Purchase & End of Useful Life	1,476	3	1,156,720	-	19,245,054	6,646,001	8,674,903	0.000	0.133	-	0.0000	0.000090	-	2.896	2.218	0.002
C2 - C&I Retrofit	4,631	-	7,372,700	-	74,553,137	27,021,198	40,220,344	-	0.183	-	-	0.000040	-	2.759	1.854	0.000
C2a - C&I Existing Building Retrofit	1,649	-	6,589,409	-	63,393,847	20,874,869	33,434,877	-	0.197	-	-	0.000120	-	3.037	1.896	0.001
C2b - C&I Small Business	1,678	-	413,087	-	5,901,391	2,020,223	2,343,223	-	0.176	-	-	0.000105	-	2.921	2.518	0.002
C2c - C&I Multifamily Retrofit	1,303	-	370,204	-	5,257,899	4,126,105	4,442,245	-	0.083	-	-	0.000064	-	1.274	1.184	0.001
C3 - C&I Hard-to-Measure	-	-	-	-	-	1,262,486	1,231,213	-	-	-				-	-	
Grand Total	**629,700**	**9,741**	**28,504,379**	**-**	**400,051,517**	**221,138,405**	**296,152,668**	**0.033**	**0.096**	**-**	**0.0000**	**0.000000**	**-**	**1.809**	**1.351**	**0.000**

IV.D. Cost Effectiveness

D.P.U. 15-160 to D.P.U. 15-169

Additional Filing Requirements

Exh. 1, Appendix C

Statewide Gas

H.O.s Gold and Sawyer

October 30, 2015

2018 Planned Additional Filing Requirements

Program	Participants	Annual Savings			Total Energy Benefits	Total Costs		Savings per TRC Costs			Savings per Participant per TRC Costs			Total Energy Benefits		
		Electric Energy	Natural Gas	Oil		Program Costs	TRC Test Costs	Electric Energy	Natural Gas	Oil	Electric Energy	Natural Gas	Oil	per Program Costs	per TRC Costs	per Participant per TRC Costs
	(#)	(MWh)	(Therms)	(MMBTU)	($)	(Nominal $)	(2016$)	(kWh/$)	(Therms/$)	(MMBTU/$)	(kWh/#/$)	(Therms/#/$)	(MMBTU/#/$)	($/$)	($/$)	($/#/$)
A - Residential	**597,057**	**8,809**	**15,521,036**	**-**	**227,142,048**	**135,468,460**	**190,664,579**	**0.046**	**0.081**	**-**	**0.0000**	**0.000000**	**-**	**1.677**	**1.191**	**0.000**
A1 - Residential Whole House	582,667	8,255	12,812,246	-	178,355,539	105,716,560	141,176,885	0.058	0.091	-	0.0000	0.000000	-	1.687	1.263	0.000
A1a - Residential New Construction	4,271	961	1,289,022	-	30,804,687	10,630,741	19,084,278	0.050	0.068	-	0.0000	0.000016	-	2.898	1.614	0.000
A1b - Residential Multi-Family Retrofit	9,304	124	384,337	-	8,342,060	7,572,672	7,087,830	0.018	0.054	-	0.0000	0.000006	-	1.102	1.177	0.000
A1c - Residential Home Energy Services - Measures	17,345	7,170	5,233,742	-	133,331,301	71,359,459	99,564,866	0.072	0.053	-	0.0000	0.000003	-	1.868	1.339	0.000
A1d - Residential Home Energy Services - RCS	46,235	-	-	-	-	12,617,608	12,000,253	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	505,512	-	5,905,145	-	5,877,491	3,536,080	3,439,659	-	1.717	-	-	0.000003	-	1.662	1.709	0.000
A2 - Residential Products	14,391	554	2,708,789	-	48,786,509	25,362,873	45,313,413	0.012	0.060	-	0.0000	0.000004	-	1.924	1.077	0.000
A2a - Residential Heating & Cooling Equipment	14,391	554	2,708,789	-	48,786,509	25,362,873	45,313,413	0.012	0.060	-	0.0000	0.000004	-	1.924	1.077	0.000
A3 - Residential Hard-to-Measure	-	-	-	-	-	4,389,027	4,174,281	-	-	-				-	-	
B - Low-Income	**10,755**	**761**	**2,076,231**	**-**	**43,410,115**	**45,635,214**	**44,408,454**	**0.017**	**0.047**	**-**	**0.0000**	**0.000004**	**-**	**0.951**	**0.978**	**0.000**
B1 - Low-Income Whole House	10,755	761	2,076,231	-	43,410,115	44,547,408	43,373,872	0.018	0.048	-	0.0000	0.000004	-	0.974	1.001	0.000
B1a - Low-Income Single Family Retrofit	2,900	761	777,704	-	19,372,594	22,662,920	21,913,091	0.035	0.035	-	0.0000	0.000012	-	0.855	0.884	0.000
B1b - Low-Income Multi-Family Retrofit	7,855	-	1,298,527	-	24,037,522	21,884,489	21,460,781	-	0.061	-	-	0.000008	-	1.098	1.120	0.000
B2 - Low-Income Hard-to-Measure	-	-	-	-	-	1,087,806	1,034,582	-	-	-				-	-	
C - Commercial & Industrial	**6,670**	**3**	**11,613,120**	**-**	**137,329,473**	**46,442,384**	**64,652,523**	**0.000**	**0.180**	**-**	**0.0000**	**0.000027**	**-**	**2.957**	**2.124**	**0.000**
C1 - C&I New Construction	2,060	3	3,877,190	-	61,213,540	16,771,866	21,688,782	0.000	0.179	-	0.0000	0.000087	-	3.650	2.822	0.001
C1a - C&I New Buildings & Major Renovations	443	0	2,675,670	-	41,554,423	9,916,994	12,787,094	0.000	0.209	-	0.0000	0.000473	-	4.190	3.250	0.007
C1b - C&I Initial Purchase & End of Useful Life	1,617	3	1,201,520	-	19,659,118	6,854,873	8,901,688	0.000	0.135	-	0.0000	0.000083	-	2.868	2.208	0.001
C2 - C&I Retrofit	4,610	-	7,735,930	-	76,115,933	28,498,123	41,848,710	-	0.185	-	-	0.000040	-	2.671	1.819	0.000
C2a - C&I Existing Building Retrofit	1,603	-	6,937,934	-	64,895,608	22,246,838	35,069,439	-	0.198	-	-	0.000123	-	2.917	1.850	0.001
C2b - C&I Small Business	1,701	-	421,489	-	5,922,778	2,027,966	2,310,011	-	0.182	-	-	0.000107	-	2.921	2.564	0.002
C2c - C&I Multifamily Retrofit	1,306	-	376,507	-	5,297,547	4,223,319	4,469,261	-	0.084	-	-	0.000065	-	1.254	1.185	0.001
C3 - C&I Hard-to-Measure	-	-	-	-	-	1,172,394	1,115,031	-	-	-				-	-	
Grand Total	**614,482**	**9,574**	**29,210,387**	**-**	**407,881,637**	**227,546,058**	**299,725,557**	**0.032**	**0.097**	**-**	**0.0000**	**0.000000**	**-**	**1.793**	**1.361**	**0.000**

2016-2018 Planned Additional Filing Requirements

Program	Participants	Annual Savings			Total Energy Benefits	Total Costs		Savings per TRC Costs			Savings per Participant per TRC Costs			Total Energy Benefits		
		Electric Energy	Natural Gas	Oil		Program Costs	TRC Test Costs	Electric Energy	Natural Gas	Oil	Electric Energy	Natural Gas	Oil	per Program Costs	per TRC Costs	per Participant per TRC Costs
	(#)	(MWh)	(Therms)	(MMBTU)	($)	(Nominal $)	(2013$)	(kWh/$)	(Therms/$)	(MMBTU/$)	(kWh/#/$)	(Therms/#/$)	(MMBTU/#/$)	($/$)	($/$)	($/#/$)
A - Residential	**1,821,859**	**26,965**	**45,811,092**	**-**	**668,597,880**	**395,105,545**	**564,771,854**	**0.048**	**0.081**	**-**	**0.0000**	**0.000000**	**-**	**1.692**	**1.184**	**0.000**
A1 - Residential Whole House	1,745,328	25,356	37,846,536	-	524,329,821	308,075,950	415,930,890	0.061	0.091	-	0.0000	0.000000	-	1.702	1.261	0.000
A1a - Residential New Construction	13,069	3,037	3,614,661	-	88,129,664	32,050,355	58,761,788	0.052	0.062	-	0.0000	0.000005	-	2.750	1.500	0.000
A1b - Residential Multi-Family Retrofit	27,642	385	1,121,062	-	24,735,889	22,205,914	21,137,721	0.018	0.053	-	0.0000	0.000002	-	1.114	1.170	0.000
A1c - Residential Home Energy Services - Measures	51,378	21,935	15,217,056	-	390,962,509	206,806,184	289,926,337	0.076	0.052	-	0.0000	0.000001	-	1.890	1.348	0.000
A1d - Residential Home Energy Services - RCS	136,322	-	-	-	-	36,543,185	35,624,769	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	1,516,917	-	17,893,756	-	20,501,758	10,470,312	10,480,275	-	1.707	-	-	0.000001	-	1.958	1.956	0.000
A2 - Residential Products	76,531	1,608	7,964,556	-	144,268,059	74,177,419	136,310,793	0.012	0.058	-	0.0000	0.000001	-	1.945	1.058	0.000
A2a - Residential Heating & Cooling Equipment	76,531	1,608	7,964,556	-	144,268,059	74,177,419	136,310,793	0.012	0.058	-	0.0000	0.000001	-	1.945	1.058	0.000
A3 - Residential Hard-to-Measure	-	-	-	-	-	12,852,176	12,530,172	-	-	-				-	-	
B - Low-Income	**31,976**	**2,267**	**6,192,807**	**-**	**130,086,999**	**135,176,393**	**134,815,307**	**0.017**	**0.046**	**-**	**0.0000**	**0.000001**	**-**	**0.962**	**0.965**	**0.000**
B1 - Low-Income Whole House	31,976	2,267	6,192,807	-	130,086,999	131,947,674	131,666,454	0.017	0.047	-	0.0000	0.000001	-	0.986	0.988	0.000
B1a - Low-Income Single Family Retrofit	8,610	2,267	2,307,320	-	57,598,098	66,919,281	66,314,147	0.034	0.035	-	0.0000	0.000004	-	0.861	0.869	0.000
B1b - Low-Income Multi-Family Retrofit	23,366	-	3,885,487	-	72,488,901	65,028,392	65,352,307	-	0.059	-	-	0.000003	-	1.115	1.109	0.000
B2 - Low-Income Hard-to-Measure	-	-	-	-	-	3,228,720	3,148,853	-	-	-				-	-	
C - Commercial & Industrial	**19,475**	**11**	**33,805,720**	**-**	**410,467,265**	**135,271,340**	**190,858,420**	**0.000**	**0.177**	**-**	**0.0000**	**0.000009**	**-**	**3.034**	**2.151**	**0.000**
C1 - C&I New Construction	5,640	11	11,587,413	-	183,558,888	49,810,815	65,302,083	0.000	0.177	-	0.0000	0.000031	-	3.685	2.811	0.000
C1a - C&I New Buildings & Major Renovations	1,189	2	8,104,733	-	125,493,908	29,804,279	39,234,886	0.000	0.207	-	0.0000	0.000174	-	4.211	3.199	0.003
C1b - C&I Initial Purchase & End of Useful Life	4,451	9	3,482,679	-	58,064,980	20,006,536	26,067,197	0.000	0.134	-	0.0000	0.000030	-	2.902	2.228	0.001
C2 - C&I Retrofit	13,836	-	22,218,307	-	226,908,378	81,725,997	121,910,445	-	0.182	-	-	0.000013	-	2.776	1.861	0.000
C2a - C&I Existing Building Retrofit	4,896	-	19,887,012	-	193,365,756	63,314,126	101,544,822	-	0.196	-	-	0.000040	-	3.054	1.904	0.000
C2b - C&I Small Business	5,003	-	1,219,237	-	17,555,095	5,995,337	6,942,256	-	0.176	-	-	0.000035	-	2.928	2.529	0.001
C2c - C&I Multifamily Retrofit	3,937	-	1,112,058	-	15,987,527	12,416,534	13,423,367	-	0.083	-	-	0.000021	-	1.288	1.191	0.000
C3 - C&I Hard-to-Measure	-	-	-	-	-	3,734,528	3,645,892	-	-	-				-	-	
Grand Total	**1,873,310**	**29,243**	**85,809,618**	**-**	**1,209,152,144**	**665,553,278**	**890,445,581**	**0.033**	**0.096**	**-**	**0.0000**	**0.000000**	**-**	**1.817**	**1.358**	**0.000**

Notes:

On September 29, 2015, the Department of Public Utilities issued a Hearing Officer Memorandum from Jeffrey Leupold identifying additional information that the Program Administrators must include in their respective 2016-2018 plan filings (revised October 2, 2015). The above tables provide the information requested in 2.a through 2.e of that Memorandum. Note that 2.c, Resource Benefits Per Program Costs, is also provided on the Budget Summary table (Table IV.C.1).

Note that performance incentives and participant costs are not available for 2015 at this time. Therefore, the 2015 YTD table analyzes the Program Administrator's costs in 2013$, rather than the TRC Costs in 2013$.

IV.B. Gas PA Funding Sources

1. Summary Table

D.P.U. 15-160 to D.P.U. 15-169
Statewide Gas
Exh. 1, Appendix C
October 30, 2015
H.O.s Gold and Sawyer

2016 Gas Ratepayer Funds				
Sector	**Total Program Costs**	**Performance Incentives**	**Lost Base Revenues**	**Total Ratepayer Funds**
A - Residential	128,380,576	3,150,870		131,531,447
B - Low-Income	44,552,694	808,692		45,361,386
C - Commercial & Industrial	43,935,544	2,009,099		45,944,644
Grand Total	**216,868,815**	**5,968,662**	**-**	**222,837,477**

2017 Gas Ratepayer Funds				
Sector	**Total Program Costs**	**Performance Incentives**	**Lost Base Revenues**	**Total Ratepayer Funds**
A - Residential	131,256,509	3,221,225		134,477,734
B - Low-Income	44,988,485	834,280		45,822,765
C - Commercial & Industrial	44,893,412	2,048,479		46,941,890
Grand Total	**221,138,405**	**6,103,984**	**-**	**227,242,389**

2018 Gas Ratepayer Funds				
Sector	**Total Program Costs**	**Performance Incentives**	**Lost Base Revenues**	**Total Ratepayer Funds**
A - Residential	135,468,460	3,400,695		138,869,155
B - Low-Income	45,635,214	868,487		46,503,701
C - Commercial & Industrial	46,442,384	2,122,085		48,564,469
Grand Total	**227,546,058**	**6,391,266**	**-**	**233,937,325**

2016-2018 Gas Ratepayer Funds				
Sector	**Total Program Costs**	**Performance Incentives**	**Lost Base Revenues**	**Total Ratepayer Funds**
A - Residential	395,105,545	9,772,790	-	404,878,335
B - Low-Income	135,176,393	2,511,460	-	137,687,853
C - Commercial & Industrial	135,271,340	6,179,663	-	141,451,003
Grand Total	**665,553,278**	**18,463,913**	**-**	**684,017,191**

Notes:
Ratepayer funds for each year in 2016-2018 are represented in nominal dollars (2016$, 2017$, 2018$).
Berkshire Gas is the only gas Program Administrator that will collect Lost Base Revenue (LBR) during the 2016-2018 term, assuming the Department approves NSTAR Gas Company d/b/a/ Eversource Energy's petition for a decoupling plan in D.P.U. 14-15. All other gas Program Administrators have a revenue decoupling mechanism in place and do not estimate LBR.

IV.C. Program Administrator Budgets

1. Summary Table

Statewide Gas

October 30, 2015

2016 Program Administrator Budget										
Program	Program Costs						Performance Incentive	Total Program Administrator Budget	Program Cost per Participant	Energy Benefit per Program Cost
	Program Planning and Administration	Marketing and Advertising	Participant Incentive	Sales, Technical Assistance & Training	Evaluation and Market Research	Total Program Costs				
A - Residential	**5,152,941**	**4,343,646**	**91,664,661**	**23,279,576**	**3,939,753**	**128,380,576**	**3,150,870**	**131,531,447**	**209.69**	**1.72**
A1 - Residential Whole House	3,246,873	2,114,258	70,040,731	21,500,150	3,065,118	99,967,130	2,626,832	102,593,962	172.03	1.73
A1a - Residential New Construction	430,367	110,619	9,165,382	829,688	363,524	10,899,580	509,271	11,408,851	2,378.26	2.69
A1b - Residential Multi-Family Retrofit	291,518	177,122	5,555,723	965,365	277,863	7,267,591	140,930	7,408,521	794.62	1.13
A1c - Residential Home Energy Services - Measures	1,975,982	1,005,391	52,964,620	8,616,194	1,991,306	66,553,493	1,891,947	68,445,440	3,925.81	1.92
A1d - Residential Home Energy Services - RCS	378,317	802,621	-	10,274,401	316,351	11,771,690	-	11,771,690	263.28	-
A1e - Residential Behavior/Feedback Program	170,689	18,505	2,355,005	814,503	116,074	3,474,775	84,685	3,559,460	6.87	2.26
A2 - Residential Products	878,123	1,045,543	20,308,994	1,173,010	874,635	24,280,305	524,039	24,804,343	779.75	1.96
A2a - Residential Heating & Cooling Equipment	878,123	1,045,543	20,308,994	1,173,010	874,635	24,280,305	524,039	24,804,343	779.75	1.96
A3 - Residential Hard-to-Measure	1,027,944	1,183,845	1,314,936	606,416	-	4,133,142	-	4,133,142		-
A3a - Residential Statewide Marketing	1,643	898,957	-	-	-	900,600	-	900,600		-
A3b - Residential Statewide Database	106,895	-	-	612	-	107,507	-	107,507		-
A3c - Residential DOER Assessment	466,411	-	-	-	-	466,411	-	466,411		-
A3d - Residential EEAC Consultants	275,659	-	-	-	-	275,659	-	275,659		-
A3e - Residential Sponsorships & Subscriptions	171,626	5,000	-	-	-	176,626	-	176,626		-
A3f - Residential HEAT Loan	5,710	57,055	1,150,936	117,464	-	1,331,165	-	1,331,165		-
A3g - Residential Workforce Development	-	-	-	239,583	-	239,583	-	239,583		-
A3h - Residential R&D and Demonstration	-	20,000	164,000	193,758	-	377,758	-	377,758		-
A3i - Residential Education	-	202,833	-	55,000	-	257,833	-	257,833		-
B - Low-Income	**2,308,738**	**814,134**	**32,447,649**	**7,530,772**	**1,451,402**	**44,552,694**	**808,692**	**45,361,386**	**4,204.67**	**0.98**
B1 - Low-Income Whole House	1,556,975	500,538	32,447,649	7,530,772	1,451,402	43,487,336	808,692	44,296,029	4,104.13	1.00
B1a - Low-Income Single Family Retrofit	792,872	303,452	16,133,086	3,978,498	737,012	21,944,921	252,836	22,197,756	7,727.08	0.87
B1b - Low-Income Multi-Family Retrofit	764,103	197,086	16,314,563	3,552,274	714,390	21,542,416	555,857	22,098,273	2,777.52	1.13
B2 - Low-Income Hard-to-Measure	751,762	313,595	-	-	-	1,065,358	-	1,065,358		-
B2a - Low-Income Statewide Marketing	474	313,595	-	-	-	314,070	-	314,070		-
B2b - Low-Income Statewide Database	42,355	-	-	-	-	42,355	-	42,355		-
B2c - Low-Income DOER Assessment	231,354	-	-	-	-	231,354	-	231,354		-
B2d - Low-Income Energy Affordability Network	437,933	-	-	-	-	437,933	-	437,933		-
B2e - Low-Income Sponsorships & Subscriptions	39,646	-	-	-	-	39,646	-	39,646		-
C - Commercial & Industrial	**3,358,386**	**2,153,565**	**28,687,144**	**7,941,718**	**1,794,732**	**43,935,544**	**2,009,099**	**45,944,644**	**6,992.85**	**3.12**
C1 - C&I New Construction	1,008,164	515,282	11,528,329	2,679,810	697,635	16,429,220	747,787	17,177,007	9,733.24	3.70
C1a - C&I New Buildings & Major Renovations	607,548	431,573	6,772,364	1,697,671	414,401	9,923,558	523,747	10,447,305	30,082.79	4.20
C1b - C&I Initial Purchase & End of Useful Life	400,616	83,709	4,755,965	982,139	283,234	6,505,662	224,040	6,729,702	4,790.36	2.95
C2 - C&I Retrofit	1,780,199	1,250,414	17,033,815	5,045,152	1,097,097	26,206,676	1,261,312	27,467,989	5,703.33	2.91
C2a - C&I Existing Building Retrofit	1,411,276	985,636	13,082,982	3,862,434	850,090	20,192,419	1,118,746	21,311,165	12,283.01	3.22
C2b - C&I Small Business	174,112	141,041	1,176,654	357,400	97,940	1,947,147	75,180	2,022,327	1,199.69	2.94
C2c - C&I Multifamily Retrofit	194,811	123,737	2,774,178	825,318	149,067	4,067,110	67,386	4,134,497	3,062.58	1.34
C3 - C&I Hard-to-Measure	570,024	387,869	125,000	216,755	-	1,299,648	-	1,299,648		-
C3a - C&I Statewide Marketing	3,451	362,869	-	-	-	366,320	-	366,320		-
C3b - C&I Statewide Database	41,117	-	-	-	-	41,117	-	41,117		-
C3c - C&I DOER Assessment	411,531	-	-	-	-	411,531	-	411,531		-
C3d - C&I EEAC Consultants	78,383	-	-	-	-	78,383	-	78,383		-
C3e - C&I Sponsorships & Subscriptions	35,541	5,000	-	-	-	40,541	-	40,541		-
C3f - C&I Workforce Development	-	-	-	60,755	-	60,755	-	60,755		-
C3g - C&I R&D and Demonstration	-	20,000	125,000	156,000	-	301,000	-	301,000		-
Grand Total	**10,820,064**	**7,311,344**	**152,799,454**	**38,752,066**	**7,185,887**	**216,868,815**	**5,968,662**	**222,837,477**	**344.71**	**1.85**

2017 Program Administrator Budget										
	Program Costs									
Program	Program Planning and Administration	Marketing and Advertising	Participant Incentive	Sales, Technical Assistance & Training	Evaluation and Market Research	Total Program Costs	Performance Incentive	Total Program Administrator Budget	Program Cost per Participant	Energy Benefit per Program Cost
A - Residential	**5,203,055**	**4,684,087**	**93,572,833**	**23,834,788**	**3,961,747**	**131,256,509**	**3,221,225**	**134,477,734**	**214.28**	**1.68**
A1 - Residential Whole House	3,188,065	2,222,899	71,836,138	22,055,491	3,089,667	102,392,260	2,670,673	105,062,934	176.07	1.69
A1a - Residential New Construction	392,437	116,443	8,812,600	835,238	363,315	10,520,034	503,289	11,023,323	2,495.86	2.67
A1b - Residential Multi-Family Retrofit	279,916	181,019	5,635,485	990,849	278,382	7,365,651	144,648	7,510,299	801.33	1.11
A1c - Residential Home Energy Services - Measures	1,951,716	1,057,449	55,028,128	8,840,583	2,015,357	68,893,232	1,950,421	70,843,653	4,033.49	1.89
A1d - Residential Home Energy Services - RCS	394,975	849,423	4,700	10,587,016	317,774	12,153,888	-	12,153,888	267.85	-
A1e - Residential Behavior/Feedback Program	169,022	18,564	2,355,225	801,805	114,839	3,459,456	72,316	3,531,772	6.84	1.96
A2 - Residential Products	860,655	1,232,643	20,393,573	1,175,290	872,080	24,534,241	550,552	25,084,794	791.38	1.95
A2a - Residential Heating & Cooling Equipment	860,655	1,232,643	20,393,573	1,175,290	872,080	24,534,241	550,552	25,084,794	791.38	1.95
A3 - Residential Hard-to-Measure	1,154,335	1,228,544	1,343,121	604,006	-	4,330,007	-	4,330,007		-
A3a - Residential Statewide Marketing	1,887	899,078	-	-	-	900,964	-	900,964		-
A3b - Residential Statewide Database	243,618	-	-	-	-	243,618	-	243,618		-
A3c - Residential DOER Assessment	444,991	-	-	-	-	444,991	-	444,991		-
A3d - Residential EEAC Consultants	278,138	-	-	-	-	278,138	-	278,138		-
A3e - Residential Sponsorships & Subscriptions	179,823	5,000	-	-	-	184,823	-	184,823		-
A3f - Residential HEAT Loan	5,879	58,267	1,164,621	118,616	-	1,347,382	-	1,347,382		-
A3g - Residential Workforce Development	-	-	-	244,557	-	244,557	-	244,557		-
A3h - Residential R&D and Demonstration	-	25,000	178,500	185,834	-	389,334	-	389,334		-
A3i - Residential Education	-	241,200	-	55,000	-	296,200	-	296,200		-
B - Low-Income	**2,278,043**	**838,674**	**32,836,670**	**7,593,981**	**1,441,116**	**44,988,485**	**834,280**	**45,822,765**	**4,234.21**	**0.96**
B1 - Low-Income Whole House	1,516,504	524,658	32,836,670	7,593,981	1,441,116	43,912,929	834,280	44,747,209	4,132.98	0.98
B1a - Low-Income Single Family Retrofit	779,387	324,439	16,433,411	4,040,653	733,551	22,311,441	265,649	22,577,090	7,774.02	0.86
B1b - Low-Income Multi-Family Retrofit	737,117	200,219	16,403,259	3,553,328	707,565	21,601,488	568,632	22,170,120	2,785.49	1.11
B2 - Low-Income Hard-to-Measure	761,539	314,016	-	-	-	1,075,556	-	1,075,556		-
B2a - Low-Income Statewide Marketing	486	314,016	-	-	-	314,502	-	314,502		-
B2b - Low-Income Statewide Database	42,870	-	-	-	-	42,870	-	42,870		-
B2c - Low-Income DOER Assessment	234,329	-	-	-	-	234,329	-	234,329		-
B2d - Low-Income Energy Affordability Network	442,159	-	-	-	-	442,159	-	442,159		-
B2e - Low-Income Sponsorships & Subscriptions	41,696	-	-	-	-	41,696	-	41,696		-
C - Commercial & Industrial	**3,373,907**	**2,167,935**	**29,487,561**	**8,052,031**	**1,811,977**	**44,893,412**	**2,048,479**	**46,941,890**	**6,882.80**	**3.03**
C1 - C&I New Construction	1,013,915	517,688	11,642,654	2,737,660	697,812	16,609,729	778,674	17,388,403	8,780.15	3.70
C1a - C&I New Buildings & Major Renovations	610,612	434,999	6,769,676	1,737,610	410,831	9,963,727	549,233	10,512,961	23,940.77	4.24
C1b - C&I Initial Purchase & End of Useful Life	403,304	82,689	4,872,978	1,000,050	286,981	6,646,001	229,441	6,875,442	4,504.07	2.90
C2 - C&I Retrofit	1,784,557	1,260,981	17,728,908	5,133,590	1,113,162	27,021,198	1,269,804	28,291,002	5,835.08	2.76
C2a - C&I Existing Building Retrofit	1,433,971	991,549	13,653,853	3,931,955	863,540	20,874,869	1,120,333	21,995,202	12,657.88	3.04
C2b - C&I Small Business	170,551	143,091	1,243,319	363,265	99,997	2,020,223	80,513	2,100,736	1,203.65	2.92
C2c - C&I Multifamily Retrofit	180,035	126,341	2,831,735	838,369	149,626	4,126,105	68,959	4,195,064	3,166.04	1.27
C3 - C&I Hard-to-Measure	575,435	389,266	116,000	180,782	1,003	1,262,486	-	1,262,486		-
C3a - C&I Statewide Marketing	3,532	363,694	-	-	-	367,226	-	367,226		-
C3b - C&I Statewide Database	41,020	-	-	-	-	41,020	-	41,020		-
C3c - C&I DOER Assessment	414,892	-	-	-	-	414,892	-	414,892		-
C3d - C&I EEAC Consultants	79,623	-	-	-	-	79,623	-	79,623		-
C3e - C&I Sponsorships & Subscriptions	36,368	5,000	-	-	-	41,368	-	41,368		-
C3f - C&I Workforce Development	-	307	-	60,782	538	61,626	-	61,626		-
C3g - C&I R&D and Demonstration	-	20,265	116,000	120,000	465	256,730	-	256,730		-
Grand Total	**10,855,006**	**7,690,696**	**155,897,064**	**39,480,800**	**7,214,839**	**221,138,405**	**6,103,984**	**227,242,389**	**351.18**	**1.81**

2018 Program Administrator Budget										
	Program Costs									
Program	Program Planning and Administration	Marketing and Advertising	Participant Incentive	Sales, Technical Assistance & Training	Evaluation and Market Research	Total Program Costs	Performance Incentive	Total Program Administrator Budget	Program Cost per Participant	Energy Benefit per Program Cost
A - Residential	**5,369,293**	**4,638,558**	**96,792,795**	**24,669,750**	**3,998,065**	**135,468,460**	**3,400,695**	**138,869,155**	**226.89**	**1.68**
A1 - Residential Whole House	3,310,763	2,245,401	74,178,192	22,870,655	3,111,549	105,716,560	2,822,974	108,539,534	181.44	1.69
A1a - Residential New Construction	410,104	122,871	8,875,521	857,781	364,464	10,630,741	566,034	11,196,776	2,489.05	2.90
A1b - Residential Multi-Family Retrofit	287,740	188,756	5,791,340	1,022,042	282,795	7,572,672	152,860	7,725,532	813.89	1.10
A1c - Residential Home Energy Services - Measures	2,022,735	1,062,749	57,152,953	9,088,220	2,032,802	71,359,459	2,043,061	73,402,520	4,114.15	1.87
A1d - Residential Home Energy Services - RCS	415,702	852,399	4,700	11,026,753	318,054	12,617,608	-	12,617,608	272.90	-
A1e - Residential Behavior/Feedback Program	174,483	18,626	2,353,677	875,859	113,435	3,536,080	61,019	3,597,099	7.00	1.66
A2 - Residential Products	885,970	1,148,774	21,257,904	1,183,709	886,516	25,362,873	577,721	25,940,593	1,762.47	1.92
A2a - Residential Heating & Cooling Equipment	885,970	1,148,774	21,257,904	1,183,709	886,516	25,362,873	577,721	25,940,593	1,762.47	1.92
A3 - Residential Hard-to-Measure	1,172,560	1,244,382	1,356,699	615,386	-	4,389,027	-	4,389,027		-
A3a - Residential Statewide Marketing	1,871	899,249	-	-	-	901,120	-	901,120		-
A3b - Residential Statewide Database	243,484	-	-	-	-	243,484	-	243,484		-
A3c - Residential DOER Assessment	451,701	-	-	-	-	451,701	-	451,701		-
A3d - Residential EEAC Consultants	281,117	-	-	-	-	281,117	-	281,117		-
A3e - Residential Sponsorships & Subscriptions	188,324	5,000	-	-	-	193,324	-	193,324		-
A3f - Residential HEAT Loan	6,061	59,483	1,177,949	119,959	-	1,363,453	-	1,363,453		-
A3g - Residential Workforce Development	-	-	-	239,616	-	239,616	-	239,616		-
A3h - Residential R&D and Demonstration	-	38,750	178,750	200,811	-	418,311	-	418,311		-
A3i - Residential Education	-	241,900	-	55,000	-	296,900	-	296,900		-
B - Low-Income	**2,334,232**	**843,710**	**33,286,684**	**7,738,339**	**1,432,249**	**45,635,214**	**868,487**	**46,503,701**	**4,243.16**	**0.95**
B1 - Low-Income Whole House	1,561,293	528,843	33,286,684	7,738,339	1,432,249	44,547,408	868,487	45,415,895	4,142.02	0.97
B1a - Low-Income Single Family Retrofit	801,443	322,601	16,685,960	4,124,810	728,105	22,662,920	279,336	22,942,256	7,814.80	0.85
B1b - Low-Income Multi-Family Retrofit	759,849	206,242	16,600,724	3,613,529	704,144	21,884,489	589,150	22,473,639	2,786.06	1.10
B2 - Low-Income Hard-to-Measure	772,939	314,867	-	-	-	1,087,806	-	1,087,806		-
B2a - Low-Income Statewide Marketing	497	314,867	-	-	-	315,364	-	315,364		-
B2b - Low-Income Statewide Database	43,244	-	-	-	-	43,244	-	43,244		-
B2c - Low-Income DOER Assessment	236,958	-	-	-	-	236,958	-	236,958		-
B2d - Low-Income Energy Affordability Network	448,373	-	-	-	-	448,373	-	448,373		-
B2e - Low-Income Sponsorships & Subscriptions	43,868	-	-	-	-	43,868	-	43,868		-
C - Commercial & Industrial	**3,413,174**	**2,202,579**	**30,728,625**	**8,259,655**	**1,838,349**	**46,442,384**	**2,122,085**	**48,564,469**	**6,963.14**	**2.96**
C1 - C&I New Construction	1,019,953	528,288	11,696,855	2,832,803	693,967	16,771,866	795,736	17,567,603	8,142.15	3.65
C1a - C&I New Buildings & Major Renovations	611,026	441,529	6,663,378	1,797,899	403,161	9,916,994	555,529	10,472,523	22,395.91	4.19
C1b - C&I Initial Purchase & End of Useful Life	408,927	86,759	5,033,477	1,034,904	290,806	6,854,873	240,207	7,095,080	4,239.05	2.87
C2 - C&I Retrofit	1,813,631	1,285,211	18,983,770	5,271,129	1,144,383	28,498,123	1,326,349	29,824,472	6,181.99	2.67
C2a - C&I Existing Building Retrofit	1,454,377	1,011,141	14,852,819	4,034,947	893,554	22,246,838	1,171,511	23,418,349	13,877.34	2.92
C2b - C&I Small Business	174,836	146,605	1,229,367	376,602	100,556	2,027,966	83,152	2,111,118	1,192.15	2.92
C2c - C&I Multifamily Retrofit	184,418	127,464	2,901,584	859,581	150,272	4,223,319	71,686	4,295,004	3,234.61	1.25
C3 - C&I Hard-to-Measure	579,591	389,081	48,000	155,723	-	1,172,394	-	1,172,394		-
C3a - C&I Statewide Marketing	3,614	364,081	-	-	-	367,694	-	367,694		-
C3b - C&I Statewide Database	40,780	-	-	-	-	40,780	-	40,780		-
C3c - C&I DOER Assessment	417,391	-	-	-	-	417,391	-	417,391		-
C3d - C&I EEAC Consultants	80,544	-	-	-	-	80,544	-	80,544		-
C3e - C&I Sponsorships & Subscriptions	37,261	5,000	-	-	-	42,261	-	42,261		-
C3f - C&I Workforce Development	-	-	-	52,723	-	52,723	-	52,723		-
C3g - C&I R&D and Demonstration	-	20,000	48,000	103,000	-	171,000	-	171,000		-
Grand Total	**11,116,699**	**7,684,847**	**160,808,104**	**40,667,745**	**7,268,664**	**227,546,058**	**6,391,266**	**233,937,325**	**370.31**	**1.79**

IV.C. Program Administrator Budgets

1. Summary Table

Statewide Gas

October 30, 2015

2016-2018 Program Administrator Budget										
	Program Costs									
Program	Program Planning and Administration	Marketing and Advertising	Participant Incentive	Sales, Technical Assistance & Training	Evaluation and Market Research	Total Program Costs	Performance Incentive	Total Program Administrator Budget	Program Cost per Participant	Energy Benefit per Program Cost
A - Residential	**15,725,289**	**13,666,290**	**282,030,288**	**71,784,113**	**11,899,565**	**395,105,545**	**9,772,790**	**404,878,335**	**216.87**	**1.69**
A1 - Residential Whole House	9,745,701	6,582,558	216,055,061	66,426,295	9,266,334	308,075,950	8,120,479	316,196,429	176.51	1.70
A1a - Residential New Construction	1,232,908	349,933	26,853,504	2,522,707	1,091,303	32,050,355	1,578,594	33,628,949	2,452.40	2.75
A1b - Residential Multi-Family Retrofit	859,173	546,897	16,982,549	2,978,255	839,040	22,205,914	438,438	22,644,351	803.34	1.11
A1c - Residential Home Energy Services - Measures	5,950,432	3,125,590	165,145,701	26,544,997	6,039,465	206,806,184	5,885,428	212,691,613	4,025.19	1.89
A1d - Residential Home Energy Services - RCS	1,188,994	2,504,443	9,400	31,888,169	952,179	36,543,185	-	36,543,185	268.07	-
A1e - Residential Behavior/Feedback Program	514,194	55,696	7,063,907	2,492,167	344,348	10,470,312	218,019	10,688,331	6.90	1.96
A2 - Residential Products	2,624,748	3,426,961	61,960,471	3,532,009	2,633,231	74,177,419	1,652,311	75,829,730	969.25	1.94
A2a - Residential Heating & Cooling Equipment	2,624,748	3,426,961	61,960,471	3,532,009	2,633,231	74,177,419	1,652,311	75,829,730	969.25	1.94
A3 - Residential Hard-to-Measure	3,354,839	3,656,771	4,014,757	1,825,809	-	12,852,176	-	12,852,176		-
A3a - Residential Statewide Marketing	5,402	2,697,284	-	-	-	2,702,685	-	2,702,685		-
A3b - Residential Statewide Database	593,997	-	-	612	-	594,609	-	594,609		-
A3c - Residential DOER Assessment	1,363,103	-	-	-	-	1,363,103	-	1,363,103		-
A3d - Residential EEAC Consultants	834,914	-	-	-	-	834,914	-	834,914		-
A3e - Residential Sponsorships & Subscriptions	539,774	15,000	-	-	-	554,774	-	554,774		-
A3f - Residential HEAT Loan	17,649	174,804	3,493,507	356,039	-	4,042,000	-	4,042,000		-
A3g - Residential Workforce Development	-	-	-	723,755	-	723,755	-	723,755		-
A3h - Residential R&D and Demonstration	-	83,750	521,250	580,403	-	1,185,403	-	1,185,403		-
A3i - Residential Education	-	685,933	-	165,000	-	850,933	-	850,933		-
B - Low-Income	**6,921,013**	**2,496,518**	**98,571,003**	**22,863,092**	**4,324,767**	**135,176,393**	**2,511,460**	**137,687,853**	**4,227.43**	**0.96**
B1 - Low-Income Whole House	4,634,772	1,554,039	98,571,003	22,863,092	4,324,767	131,947,674	2,511,460	134,459,133	4,126.46	0.99
B1a - Low-Income Single Family Retrofit	2,373,703	950,491	49,252,458	12,143,961	2,198,668	66,919,281	797,821	67,717,102	7,772.27	0.86
B1b - Low-Income Multi-Family Retrofit	2,261,069	603,548	49,318,545	10,719,131	2,126,099	65,028,392	1,713,639	66,742,031	2,783.03	1.11
B2 - Low-Income Hard-to-Measure	2,286,241	942,479	-	-	-	3,228,720	-	3,228,720		-
B2a - Low-Income Statewide Marketing	1,457	942,479	-	-	-	943,935	-	943,935		-
B2b - Low-Income Statewide Database	128,469	-	-	-	-	128,469	-	128,469		-
B2c - Low-Income DOER Assessment	702,641	-	-	-	-	702,641	-	702,641		-
B2d - Low-Income Energy Affordability Network	1,328,465	-	-	-	-	1,328,465	-	1,328,465		-
B2e - Low-Income Sponsorships & Subscriptions	125,210	-	-	-	-	125,210	-	125,210		-
C - Commercial & Industrial	**10,145,468**	**6,524,079**	**88,903,330**	**24,253,405**	**5,445,058**	**135,271,340**	**6,179,663**	**141,451,003**	**6,945.82**	**3.03**
C1 - C&I New Construction	3,042,033	1,561,257	34,867,838	8,250,274	2,089,414	49,810,815	2,322,197	52,133,013	8,832.38	3.69
C1a - C&I New Buildings & Major Renovations	1,829,186	1,308,101	20,205,418	5,233,181	1,228,393	29,804,279	1,628,510	31,432,789	25,069.60	4.21
C1b - C&I Initial Purchase & End of Useful Life	1,212,847	253,156	14,662,420	3,017,093	861,021	20,006,536	693,688	20,700,224	4,495.14	2.90
C2 - C&I Retrofit	5,378,386	3,796,606	53,746,492	15,449,871	3,354,641	81,725,997	3,857,466	85,583,463	5,906.91	2.78
C2a - C&I Existing Building Retrofit	4,299,624	2,988,327	41,589,655	11,829,337	2,607,184	63,314,126	3,410,590	66,724,716	12,931.29	3.05
C2b - C&I Small Business	519,498	430,738	3,649,341	1,097,267	298,493	5,995,337	238,844	6,234,181	1,198.45	2.93
C2c - C&I Multifamily Retrofit	559,263	377,542	8,507,497	2,523,267	448,965	12,416,534	208,031	12,624,565	3,153.88	1.29
C3 - C&I Hard-to-Measure	1,725,050	1,166,215	289,000	553,260	1,003	3,734,528	-	3,734,528		-
C3a - C&I Statewide Marketing	10,597	1,090,644	-	-	-	1,101,241	-	1,101,241		-
C3b - C&I Statewide Database	122,918	-	-	-	-	122,918	-	122,918		-
C3c - C&I DOER Assessment	1,243,815	-	-	-	-	1,243,815	-	1,243,815		-
C3d - C&I EEAC Consultants	238,550	-	-	-	-	238,550	-	238,550		-
C3e - C&I Sponsorships & Subscriptions	109,170	15,000	-	-	-	124,170	-	124,170		-
C3f - C&I Workforce Development	-	307	-	174,260	538	175,104	-	175,104		-
C3g - C&I R&D and Demonstration	-	60,265	289,000	379,000	465	728,730	-	728,730		-
Grand Total	**32,791,769**	**22,686,886**	**469,504,622**	**118,900,611**	**21,669,390**	**665,553,278**	**18,463,913**	**684,017,191**	**355.28**	**1.82**

Notes:

Budgets for each year in 2016-2018 are represented in nominal dollars (2016$, 2017$, 2018$).

Refer to common definitions for allocation of costs.

IV.C. Program Administrator Budgets

2.2 PA Budget Comparison Table - Three Year Plan vs. Previous Years

Statewide Gas

October 30, 2015

Residential Programs

PA Budget Categories	Program Administrator Budget ($)									Budget Categories as a Percent of Total Program Administrator Budget (%)									
	2013		2014		2015		2016	2017	2018	2013		2014		2015		2016	2017	2018
	Planned	Evaluated	Planned	Evaluated	Planned	YTD	Planned	Planned	Planned	Planned	Evaluated	Planned	Evaluated	Planned	YTD	Planned	Planned	Planned
Program Planning and Administration	4,190,464	3,456,667	4,301,814	4,015,397	4,434,389	2,720,414	5,152,941	5,203,055	5,369,293	5%	4%	5%	4%	5%	5%	4%	4%	4%
Marketing and Advertising	4,284,177	2,772,266	4,612,595	3,744,685	4,966,226	2,224,807	4,343,646	4,684,087	4,638,558	5%	3%	5%	4%	5%	4%	3%	3%	3%
Participant Incentive	57,990,210	64,402,505	59,287,082	71,363,352	60,372,476	43,073,868	91,664,661	93,572,833	96,792,795	67%	71%	66%	70%	66%	72%	70%	70%	70%
Sales, Technical Assistance & Training	14,777,100	16,068,549	15,107,397	17,709,028	15,324,174	11,294,622	23,279,576	23,834,788	24,669,750	17%	18%	17%	17%	17%	19%	18%	18%	18%
Evaluation and Market Research	3,543,929	857,670	3,593,781	2,065,013	3,674,410	903,834	3,939,753	3,961,747	3,998,065	4%	1%	4%	2%	4%	2%	3%	3%	3%
Performance Incentive	2,287,791	2,638,062	2,643,044	3,633,343	2,422,264	-	3,150,870	3,221,225	3,400,695	3%	3%	3%	4%	3%	0%	2%	2%	2%
Total Program Administrator Budget	**87,073,672**	**90,195,718**	**89,545,713**	**102,530,819**	**91,193,939**	**60,217,545**	**131,531,447**	**134,477,734**	**138,869,155**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Low-Income Programs

PA Budget Categories	Program Administrator Budget ($)									Budget Categories as a Percent of Total Program Administrator Budget (%)									
	2013		2014		2015		2016	2017	2018	2013		2014		2015		2016	2017	2018
	Planned	Evaluated	Planned	Evaluated	Planned	YTD	Planned	Planned	Planned	Planned	Evaluated	Planned	Evaluated	Planned	YTD	Planned	Planned	Planned
Program Planning and Administration	2,152,734	1,606,042	2,223,449	1,728,323	2,313,491	1,192,130	2,308,738	2,278,043	2,334,232	6%	5%	6%	4%	6%	5%	5%	5%	5%
Marketing and Advertising	1,091,048	162,809	1,575,031	409,985	2,100,427	343,337	814,134	838,674	843,710	3%	0%	4%	1%	5%	1%	2%	2%	2%
Participant Incentive	23,801,877	27,050,734	24,559,473	29,600,411	25,375,585	17,675,705	32,447,649	32,836,670	33,286,684	68%	76%	67%	75%	66%	76%	72%	72%	72%
Sales, Technical Assistance & Training	5,942,972	5,464,371	6,089,880	6,099,858	6,499,530	3,733,561	7,530,772	7,593,981	7,738,339	17%	15%	17%	15%	17%	16%	17%	17%	17%
Evaluation and Market Research	1,420,344	254,195	1,480,506	445,437	1,554,953	245,363	1,451,402	1,441,116	1,432,249	4%	1%	4%	1%	4%	1%	3%	3%	3%
Performance Incentive	588,585	916,967	636,261	1,203,803	606,541	-	808,692	834,280	868,487	2%	3%	2%	3%	2%	0%	2%	2%	2%
Total Program Administrator Budget	**34,997,560**	**35,455,117**	**36,564,599**	**39,487,817**	**38,450,527**	**23,190,096**	**45,361,386**	**45,822,765**	**46,503,701**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Commercial & Industrial Programs

PA Budget Categories	Program Administrator Budget ($)									Budget Categories as a Percent of Total Program Administrator Budget (%)									
	2013		2014		2015		2016	2017	2018	2013		2014		2015		2016	2017	2018
	Planned	Evaluated	Planned	Evaluated	Planned	YTD	Planned	Planned	Planned	Planned	Evaluated	Planned	Evaluated	Planned	YTD	Planned	Planned	Planned
Program Planning and Administration	2,424,177	2,403,545	2,479,810	2,870,313	2,557,227	2,029,146	3,358,386	3,373,907	3,413,174	5%	8%	5%	8%	5%	11%	7%	7%	7%
Marketing and Advertising	2,517,420	2,031,135	2,507,761	2,410,952	2,530,905	1,933,796	2,153,565	2,167,935	2,202,579	5%	6%	5%	7%	5%	10%	5%	5%	5%
Participant Incentive	36,181,594	19,783,077	38,369,882	22,203,081	39,771,883	9,676,786	28,687,144	29,487,561	30,728,625	71%	63%	71%	61%	71%	51%	62%	63%	63%
Sales, Technical Assistance & Training	6,091,214	4,277,877	6,272,346	4,239,315	6,436,840	3,403,701	7,941,718	8,052,031	8,259,655	12%	14%	12%	12%	12%	18%	17%	17%	17%
Evaluation and Market Research	2,071,154	1,070,888	2,174,666	2,190,924	2,241,637	1,955,360	1,794,732	1,811,977	1,838,349	4%	3%	4%	6%	4%	10%	4%	4%	4%
Performance Incentive	2,012,691	1,750,161	2,447,269	2,190,743	2,332,448	-	2,009,099	2,048,479	2,122,085	4%	6%	5%	6%	4%	0%	4%	4%	4%
Total Program Administrator Budget	**51,298,251**	**31,316,683**	**54,251,735**	**36,105,327**	**55,870,939**	**18,998,788**	**45,944,644**	**46,941,890**	**48,564,469**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Total Programs

PA Budget Categories	Program Administrator Budget ($)									Budget Categories as a Percent of Total Program Administrator Budget (%)									
	2013		2014		2015		2016	2017	2018	2013		2014		2015		2016	2017	2018
	Planned	Evaluated	Planned	Evaluated	Planned	YTD	Planned	Planned	Planned	Planned	Evaluated	Planned	Evaluated	Planned	YTD	Planned	Planned	Planned
Program Planning and Administration	8,767,375	7,466,253	9,005,073	8,614,033	9,305,106	5,941,690	10,820,064	10,855,006	11,116,699	5%	5%	5%	5%	5%	6%	5%	5%	5%
Marketing and Advertising	7,892,645	4,966,210	8,695,386	6,565,622	9,597,558	4,501,940	7,311,344	7,690,696	7,684,847	5%	3%	5%	4%	5%	4%	3%	3%	3%
Participant Incentive	117,973,681	111,236,316	122,216,437	123,166,844	125,519,944	70,426,359	152,799,454	155,897,064	160,808,104	68%	71%	68%	69%	68%	69%	69%	69%	69%
Sales, Technical Assistance & Training	26,811,287	25,810,797	27,469,623	28,048,202	28,260,545	18,431,884	38,752,066	39,480,800	40,667,745	15%	16%	15%	16%	15%	18%	17%	17%	17%
Evaluation and Market Research	7,035,427	2,182,753	7,248,953	4,701,374	7,470,999	3,104,556	7,185,887	7,214,839	7,268,664	4%	1%	4%	3%	4%	3%	3%	3%	3%
Performance Incentive	4,889,067	5,305,189	5,726,574	7,027,889	5,361,253	-	5,968,662	6,103,984	6,391,266	3%	3%	3%	4%	3%	0%	3%	3%	3%
Total Program Administrator Budget	**173,369,483**	**156,967,518**	**180,362,047**	**178,123,962**	**185,515,405**	**102,406,429**	**222,837,477**	**227,242,389**	**233,937,325**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Notes:

2013-2015 planned values are from the Program Administrator's 2013-2015 Three-Year Plan, D.P.U. , in nominal dollars (2013$, 2014$, 2015$).

2013 evaluated values are from the Program Administrator's 2013 Plan Year Report, D.P.U. , in 2013$.

2014 evaluated values are from the Program Administrator's 2014 Plan Year Report, D.P.U. , in 2014$.

2015 YTD values are estimated actual cost through August 2015, in 2015$.

For supporting information on the 2016-2018 values, see Table IV.C.1. Budgets for each year in 2016-2018 are represented in nominal dollars (2016$, 2017$, 2018$).

The Program Administrators have better aligned cost allocations across Program Administrators for the 2016-2018 Three-Year Plan, consistent with the Department's directives in the 2013-2015 Three-Year Plan Order (January 31, 2013). As a result, historical budget categories may not be directly comparable for each Program Administrator.

IV.D. Cost-Effectiveness

1. Summary Table

Statewide Gas
October 30, 2015

D.P.U. 15-160 to D.P.U. 15-169
Exh. 1, Appendix C
H.O.s Gold and Sawyer

2016 Total Resource Cost Test (2016$)

Program	Benefit-Cost Ratio	Net Benefits	Total TRC Test Benefits	Costs			
				Total Program Costs	Performance Incentive	Participant Costs	Total TRC Test Costs
A - Residential	**1.63**	**117,804,606**	**303,860,365**	**128,251,425**	**3,150,870**	**54,175,424**	**186,055,759**
A1 - Residential Whole House	1.79	107,225,734	243,393,389	99,837,978	2,626,832	33,323,676	136,167,655
A1a - Residential New Construction	2.24	25,428,076	45,950,287	10,856,215	509,271	9,107,113	20,522,211
A1b - Residential Multi-Family Retrofit	1.91	6,419,123	13,434,747	7,181,804	140,930	(333,197)	7,015,624
A1c - Residential Home Energy Services - Measures	1.89	82,890,787	176,171,064	66,553,493	1,891,947	24,549,760	93,280,277
A1d - Residential Home Energy Services - RCS	0.00	-11,771,690	0	11,771,690	-	-	11,771,690
A1e - Residential Behavior/Feedback Program	2.19	4,259,439	7,837,292	3,474,775	84,685	-	3,577,853
A2 - Residential Products	1.32	14,712,014	60,466,976	24,280,305	524,039	20,851,748	45,754,963
A2a - Residential Heating & Cooling Equipment	1.32	14,712,014	60,466,976	24,280,305	524,039	20,851,748	45,754,963
A3 - Residential Hard-to-Measure	0.00	-4,133,142	0	4,133,142	-	-	4,133,142
B - Low-Income	**1.71**	**32,558,011**	**78,097,881**	**44,552,694**	**808,692**	**-**	**45,539,870**
B1 - Low-Income Whole House	1.76	33,623,369	78,097,881	43,487,336	808,692	-	44,474,513
B1a - Low-Income Single Family Retrofit	1.31	7,008,783	29,299,063	21,944,921	252,836	-	22,290,280
B1b - Low-Income Multi-Family Retrofit	2.20	26,614,586	48,798,818	21,542,416	555,857	-	22,184,233
B2 - Low-Income Hard-to-Measure	0.00	-1,065,358	0	1,065,358	-	-	1,065,358
C - Commercial & Industrial	**2.61**	**101,198,400**	**164,170,127**	**43,935,544**	**2,009,099**	**16,885,775**	**62,971,727**
C1 - C&I New Construction	2.79	39,007,122	60,837,811	16,429,220	747,787	4,593,393	21,830,689
C1a - C&I New Buildings & Major Renovations	3.12	28,336,922	41,677,003	9,923,558	523,747	2,851,529	13,340,082
C1b - C&I Initial Purchase & End of Useful Life	2.26	10,670,200	19,160,807	6,505,662	224,040	1,741,865	8,490,607
C2 - C&I Retrofit	2.59	63,490,925	103,332,316	26,206,676	1,261,312	12,292,381	39,841,391
C2a - C&I Existing Building Retrofit	2.74	57,338,595	90,379,102	20,192,419	1,118,746	11,670,264	33,040,507
C2b - C&I Small Business	2.64	3,763,133	6,052,156	1,947,147	75,180	263,493	2,289,023
C2c - C&I Multifamily Retrofit	1.53	2,389,198	6,901,059	4,067,110	67,386	358,624	4,511,862
C3 - C&I Hard-to-Measure	0.00	-1,299,648	0	1,299,648	-	-	1,299,648
Grand Total	**1.85**	**251,561,017**	**546,128,374**	**216,739,663**	**5,968,662**	**71,061,198**	**294,567,357**

2017 Total Resource Cost Test (2016$)

Program	Benefit-Cost Ratio	Net Benefits	Total TRC Test Benefits	Costs			
				Total Program Costs	Performance Incentive	Participant Costs	Total TRC Test Costs
A - Residential	**1.62**	**115,718,116**	**303,769,632**	**128,005,177**	**3,141,433**	**56,424,721**	**188,051,515**
A1 - Residential Whole House	1.75	104,357,940	242,944,290	99,855,920	2,604,518	35,745,041	138,586,350
A1a - Residential New Construction	2.29	24,738,532	43,893,831	10,259,444	490,822	8,355,199	19,155,299
A1b - Residential Multi-Family Retrofit	1.91	6,389,136	13,423,403	7,183,198	141,065	(316,199)	7,034,267
A1c - Residential Home Energy Services - Measures	1.84	81,758,886	178,840,081	67,186,690	1,902,107	27,706,042	97,081,195
A1d - Residential Home Energy Services - RCS	0.00	-11,852,826	0	11,852,826	-	-	11,852,826
A1e - Residential Behavior/Feedback Program	1.96	3,324,212	6,786,975	3,373,762	70,525	-	3,462,763
A2 - Residential Products	1.34	15,582,925	60,825,342	23,926,508	536,914	20,679,680	45,242,417
A2a - Residential Heating & Cooling Equipment	1.34	15,582,925	60,825,342	23,926,508	536,914	20,679,680	45,242,417
A3 - Residential Hard-to-Measure	0.00	-4,222,749	0	4,222,749	-	-	4,222,749
B - Low-Income	**1.74**	**33,126,372**	**77,993,354**	**43,874,083**	**813,615**	**-**	**44,866,982**
B1 - Low-Income Whole House	1.78	34,175,286	77,993,354	42,825,170	813,615	-	43,818,069
B1a - Low-Income Single Family Retrofit	1.34	7,435,884	29,546,659	21,758,768	259,068	-	22,110,775
B1b - Low-Income Multi-Family Retrofit	2.23	26,739,402	48,446,695	21,066,401	554,546	-	21,707,293
B2 - Low-Income Hard-to-Measure	0.00	-1,048,913	0	1,048,913	-	-	1,048,913
C - Commercial & Industrial	**2.58**	**100,141,576**	**163,375,746**	**43,781,365**	**1,997,736**	**17,313,126**	**63,234,170**
C1 - C&I New Construction	2.82	39,724,923	61,507,536	16,198,292	759,386	4,764,377	21,782,613
C1a - C&I New Buildings & Major Renovations	3.22	29,154,772	42,262,482	9,716,918	535,628	2,813,732	13,107,710
C1b - C&I Initial Purchase & End of Useful Life	2.22	10,570,152	19,245,054	6,481,374	223,757	1,950,645	8,674,903
C2 - C&I Retrofit	2.53	61,647,866	101,868,210	26,351,860	1,238,350	12,548,749	40,220,344
C2a - C&I Existing Building Retrofit	2.65	55,296,548	88,731,425	20,357,781	1,092,581	11,925,171	33,434,877
C2b - C&I Small Business	2.69	3,949,453	6,292,676	1,970,181	78,518	291,308	2,343,223
C2c - C&I Multifamily Retrofit	1.54	2,401,864	6,844,109	4,023,898	67,250	332,271	4,442,245
C3 - C&I Hard-to-Measure	0.00	-1,231,213	0	1,231,213	-	-	1,231,213
Grand Total	**1.84**	**248,986,065**	**545,138,732**	**215,660,625**	**5,952,784**	**73,737,846**	**296,152,668**

IV.D. Cost-Effectiveness

1. Summary Table

Statewide Gas
October 30, 2015

D.P.U. 15-160 to D.P.U. 15-169
Exh. 1, Appendix C
H.O.s Gold and Sawyer

2018 Total Resource Cost Test (2016$)

Program	Benefit-Cost Ratio	Net Benefits	Total TRC Test Benefits	Costs			
				Total Program Costs	Performance Incentive	Participant Costs	Total TRC Test Costs
A - Residential	**1.63**	**120,718,624**	**311,383,203**	**128,840,253**	**3,234,305**	**58,107,682**	**190,664,579**
A1 - Residential Whole House	1.77	108,379,020	249,555,905	100,544,055	2,684,851	37,565,400	141,176,885
A1a - Residential New Construction	2.46	27,853,562	46,937,840	10,110,600	538,339	8,385,280	19,084,278
A1b - Residential Multi-Family Retrofit	1.94	6,659,684	13,747,514	7,202,156	145,381	(286,028)	7,087,830
A1c - Residential Home Energy Services - Measures	1.84	83,428,194	182,993,059	67,867,980	1,943,098	29,466,148	99,564,866
A1d - Residential Home Energy Services - RCS	0.00	-12,000,253	0	12,000,253	-	-	12,000,253
A1e - Residential Behavior/Feedback Program	1.71	2,437,832	5,877,491	3,363,067	58,033	-	3,439,659
A2 - Residential Products	1.36	16,513,885	61,827,298	24,121,917	549,454	20,542,283	45,313,413
A2a - Residential Heating & Cooling Equipment	1.36	16,513,885	61,827,298	24,121,917	549,454	20,542,283	45,313,413
A3 - Residential Hard-to-Measure	0.00	-4,174,281	0	4,174,281	-	-	4,174,281
B - Low-Income	**1.77**	**34,135,933**	**78,544,387**	**43,402,372**	**825,993**	**-**	**44,408,454**
B1 - Low-Income Whole House	1.81	35,170,515	78,544,387	42,367,791	825,993	-	43,373,872
B1a - Low-Income Single Family Retrofit	1.36	7,948,073	29,861,164	21,554,067	265,669	-	21,913,091
B1b - Low-Income Multi-Family Retrofit	2.27	27,222,442	48,683,223	20,813,723	560,324	-	21,460,781
B2 - Low-Income Hard-to-Measure	0.00	-1,034,582	0	1,034,582	-	-	1,034,582
C - Commercial & Industrial	**2.56**	**100,819,711**	**165,472,234**	**44,170,049**	**2,018,256**	**18,321,639**	**64,652,523**
C1 - C&I New Construction	2.82	39,524,759	61,213,540	15,951,252	756,803	4,919,897	21,688,782
C1a - C&I New Buildings & Major Renovations	3.25	28,767,329	41,554,423	9,431,774	528,348	2,785,352	12,787,094
C1b - C&I Initial Purchase & End of Useful Life	2.21	10,757,430	19,659,118	6,519,477	228,454	2,134,545	8,901,688
C2 - C&I Retrofit	2.49	62,409,983	104,258,693	27,103,766	1,261,453	13,401,741	41,848,710
C2a - C&I Existing Building Retrofit	2.60	55,962,995	91,032,433	21,158,344	1,114,191	12,737,294	35,069,439
C2b - C&I Small Business	2.73	3,999,879	6,309,890	1,928,742	79,084	298,954	2,310,011
C2c - C&I Multifamily Retrofit	1.55	2,447,110	6,916,371	4,016,680	68,178	365,493	4,469,261
C3 - C&I Hard-to-Measure	0.00	-1,115,031	0	1,115,031	-	-	1,115,031
Grand Total	**1.85**	**255,674,268**	**555,399,824**	**216,412,674**	**6,078,554**	**76,429,321**	**299,725,557**

2016-2018 Total Resource Cost Test (2016$)

Program	Benefit-Cost Ratio	Net Benefits	Total TRC Test Benefits	Costs			
				Total Program Costs	Performance Incentive	Participant Costs	Total TRC Test Costs
A - Residential	**1.63**	**354,241,346**	**919,013,200**	**385,096,854**	**9,526,609**	**168,707,827**	**564,771,854**
A1 - Residential Whole House	1.77	319,962,694	735,893,584	300,237,953	7,916,202	106,634,116	415,930,890
A1a - Residential New Construction	2.33	78,020,170	136,781,958	31,226,259	1,538,432	25,847,591	58,761,788
A1b - Residential Multi-Family Retrofit	1.92	19,467,943	40,605,664	21,567,158	427,375	(935,425)	21,137,721
A1c - Residential Home Energy Services - Measures	1.86	248,077,867	538,004,204	201,608,163	5,737,152	81,721,949	289,926,337
A1d - Residential Home Energy Services - RCS	0.00	-35,624,769	0	35,624,769	-	-	35,624,769
A1e - Residential Behavior/Feedback Program	1.96	10,021,483	20,501,758	10,211,605	213,243	-	10,480,275
A2 - Residential Products	1.34	46,808,823	183,119,616	72,328,730	1,610,407	62,073,711	136,310,793
A2a - Residential Heating & Cooling Equipment	1.34	46,808,823	183,119,616	72,328,730	1,610,407	62,073,711	136,310,793
A3 - Residential Hard-to-Measure	0.00	-12,530,172	0	12,530,172	-	-	12,530,172
B - Low-Income	**1.74**	**99,820,316**	**234,635,623**	**131,829,149**	**2,448,300**	**-**	**134,815,307**
B1 - Low-Income Whole House	1.78	102,969,169	234,635,623	128,680,297	2,448,300	-	131,666,454
B1a - Low-Income Single Family Retrofit	1.34	22,392,740	88,706,887	65,257,756	777,573	-	66,314,147
B1b - Low-Income Multi-Family Retrofit	2.23	80,576,429	145,928,736	63,422,541	1,670,727	-	65,352,307
B2 - Low-Income Hard-to-Measure	0.00	-3,148,853	0	3,148,853	-	-	3,148,853
C - Commercial & Industrial	**2.58**	**302,159,687**	**493,018,107**	**131,886,958**	**6,025,091**	**52,520,539**	**190,858,420**
C1 - C&I New Construction	2.81	118,256,805	183,558,888	48,578,764	2,263,975	14,277,667	65,302,083
C1a - C&I New Buildings & Major Renovations	3.20	86,259,022	125,493,908	29,072,250	1,587,724	8,450,612	39,234,886
C1b - C&I Initial Purchase & End of Useful Life	2.23	31,997,782	58,064,980	19,506,514	676,251	5,827,055	26,067,197
C2 - C&I Retrofit	2.54	187,548,774	309,459,220	79,662,302	3,761,116	38,242,872	121,910,445
C2a - C&I Existing Building Retrofit	2.66	168,598,137	270,142,959	61,708,544	3,325,519	36,332,729	101,544,822
C2b - C&I Small Business	2.69	11,712,465	18,654,722	5,846,070	232,781	853,755	6,942,256
C2c - C&I Multifamily Retrofit	1.54	7,238,172	20,661,539	12,107,689	202,815	1,056,388	13,423,367
C3 - C&I Hard-to-Measure	0.00	-3,645,892	0	3,645,892	-	-	3,645,892
Grand Total	**1.85**	**756,221,349**	**1,646,666,930**	**648,812,962**	**18,000,000**	**221,228,366**	**890,445,581**

Notes:

The Benefit-Cost Ratio is the Total TRC Test Benefits divided by the Total TRC Test Costs.
The Net Benefits are the Total TRC Test Benefits minus the Total TRC Test Costs.
For supporting information on the Total TRC Test Benefits, see Table IV.D.3.1.i.
For supporting information on the Total Program Costs, see Table IV.C.1.
For supporting information on the Performance Incentive, refer to the Performance Incentive Model.
The Total TRC Costs are the sum of the Total Program Costs, Performance Incentives, and Participant Costs.

IV.D Cost-Effectiveness

2.3 Cost Comparison Table - Three-Year Plan vs. Previous Years

Statewide Gas

October 30, 2015

TRC Costs Categories	TRC Costs						TRC Cost Categories as a Percent of Total TRC Costs (%)					
	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018
Residential												
PA Budget	90,195,718	99,820,450	86,448,950	131,402,295	131,146,610	132,074,558	67%	70%	72%	71%	70%	69%
Participant Cost	43,765,946	42,075,682	34,064,046	54,175,424	56,424,721	58,107,682	33%	30%	28%	29%	30%	30%
Residential Total TRC Costs	134,143,802	142,141,505	120,512,996	186,055,759	188,051,515	190,664,579	100%	100%	100%	100%	100%	100%
Low-Income												
PA Budget	35,455,117	38,438,804	36,448,775	45,361,386	44,687,698	44,228,366	99%	100%	100%	100%	100%	100%
Participant Cost	162,629	-	-	-	-	-	0%	0%	0%	0%	0%	0%
Low-Income Total TRC Costs	35,682,714	38,438,807	36,448,775	45,539,870	44,866,982	44,408,454	100%	100%	100%	100%	100%	100%
Commercial & Industrial												
PA Budget	31,316,683	35,118,706	53,002,562	45,944,644	45,779,101	46,188,304	72%	67%	70%	73%	72%	71%
Participant Cost	11,566,166	16,780,351	23,229,433	16,885,775	17,313,126	18,321,639	27%	32%	30%	27%	27%	28%
C&I Total TRC Costs	43,303,079	52,333,799	76,231,996	62,971,727	63,234,170	64,652,523	100%	100%	100%	100%	100%	100%
Grand Total												
PA Budget	156,967,518	173,377,960	175,900,286	222,708,325	221,613,409	222,491,228	74%	74%	75%	76%	75%	74%
Participant Cost	55,494,741	58,856,034	57,293,480	71,061,198	73,737,846	76,429,321	26%	25%	25%	24%	25%	25%
Grand Total TRC Costs	213,129,594	232,914,110	233,193,766	294,567,357	296,152,668	299,725,557	100%	100%	100%	100%	100%	100%

Notes:
2013 values are from the Program Administrator's 2013 Plan Year Report D.P.U. , in 2013$.
2014 values are from the Program Administrator's 2014 Plan Year Report, D.P.U. , in 2013$.
2015 values are from the Program Administrator's 2013-2015 Three-Year Plan, D.P.U. , in 2013$.
For supporting information on 2016-2018 TRC values, see Table IV.D.1. The 2016-2018 values are in 2016$.

IV.D Cost-Effectiveness

3.1.i. Benefits Summary Table

Statewide Gas
October 30, 2015

D.P.U. 15-160 to D.P.U. 15-169
Exh. 1, Appendix C
H.O.s Gold and Sawyer

2016 Benefits								
Program	Electric Benefits							
	Capacity					Electric Energy		
	Summer Generation	Transmission	Distribution	Capacity DRIPE	Total Capacity Benefits	Electric Energy	Electric Energy DRIPE	Total Electric Energy Benefits
A - Residential	**18,488,616**	**2,567,377**	**11,770,719**	**-**	**32,826,711**	**14,036,338**	**776,203**	**14,812,541**
A1 - Residential Whole House	15,859,308	2,179,763	9,998,130	-	28,037,202	13,464,002	724,474	14,188,477
A1a - Residential New Construction	676,569	94,524	428,168	-	1,199,261	1,697,075	67,462	1,764,537
A1b - Residential Multi-Family Retrofit	1,053,954	143,098	650,547	-	1,847,598	281,538	17,219	298,758
A1c - Residential Home Energy Services - Measures	14,128,786	1,942,142	8,919,415	-	24,990,343	11,485,389	639,793	12,125,182
A1d - Residential Home Energy Services - RCS	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	-	-	-	-	-	-	-	-
A2 - Residential Products	2,629,307	387,614	1,772,588	-	4,789,509	572,336	51,728	624,064
A2a - Residential Heating & Cooling Equipment	2,629,307	387,614	1,772,588	-	4,789,509	572,336	51,728	624,064
B - Low-Income	**2,060,401**	**283,422**	**1,326,737**	**-**	**3,670,560**	**1,242,483**	**61,593**	**1,304,076**
B1 - Low-Income Whole House	2,060,401	283,422	1,326,737	-	3,670,560	1,242,483	61,593	1,304,076
B1a - Low-Income Single Family Retrofit	2,060,401	283,422	1,326,737	-	3,670,560	1,242,483	61,593	1,304,076
B1b - Low-Income Multi-Family Retrofit	-	-	-	-	-	-	-	-
C - Commercial & Industrial	**-**	**-**	**-**	**-**	**-**	**5,618**	**512**	**6,130**
C1 - C&I New Construction	-	-	-	-	-	5,618	512	6,130
C1a - C&I New Buildings & Major Renovations	-	-	-	-	-	1,108	55	1,164
C1b - C&I Initial Purchase & End of Useful Life	-	-	-	-	-	4,509	457	4,966
C2 - C&I Retrofit	-	-	-	-	-	-	-	-
C2a - C&I Existing Building Retrofit	-	-	-	-	-	-	-	-
C2b - C&I Small Business	-	-	-	-	-	-	-	-
C2c - C&I Multifamily Retrofit	-	-	-	-	-	-	-	-
Grand Total	**20,549,016**	**2,850,800**	**13,097,455**	**-**	**36,497,271**	**15,284,440**	**838,307**	**16,122,747**

2017 Benefits								
Program	Electric Benefits							
	Capacity					Electric Energy		
	Summer Generation	Transmission	Distribution	Capacity DRIPE	Total Capacity Benefits	Electric Energy	Electric Energy DRIPE	Total Electric Energy Benefits
A - Residential	**19,631,720**	**2,604,109**	**11,941,714**	**-**	**34,177,543**	**14,440,993**	**459,976**	**14,900,969**
A1 - Residential Whole House	16,731,833	2,203,008	10,108,029	-	29,042,870	13,823,333	429,277	14,252,610
A1a - Residential New Construction	700,081	93,250	422,400	-	1,215,732	1,735,006	39,349	1,774,355
A1b - Residential Multi-Family Retrofit	1,095,539	143,010	652,729	-	1,891,277	294,043	10,749	304,792
A1c - Residential Home Energy Services - Measures	14,936,212	1,966,748	9,032,900	-	25,935,860	11,794,284	379,179	12,173,462
A1d - Residential Home Energy Services - RCS	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	-	-	-	-	-	-	-	-
A2 - Residential Products	2,899,887	401,102	1,833,684	-	5,134,673	617,660	30,699	648,359
A2a - Residential Heating & Cooling Equipment	2,899,887	401,102	1,833,684	-	5,134,673	617,660	30,699	648,359
B - Low-Income	**2,173,131**	**284,712**	**1,338,711**	**-**	**3,796,554**	**1,290,067**	**37,356**	**1,327,424**
B1 - Low-Income Whole House	2,173,131	284,712	1,338,711	-	3,796,554	1,290,067	37,356	1,327,424
B1a - Low-Income Single Family Retrofit	2,173,131	284,712	1,338,711	-	3,796,554	1,290,067	37,356	1,327,424
B1b - Low-Income Multi-Family Retrofit	-	-	-	-	-	-	-	-
C - Commercial & Industrial	**-**	**-**	**-**	**-**	**-**	**5,729**	**316**	**6,046**
C1 - C&I New Construction	-	-	-	-	-	5,729	316	6,046
C1a - C&I New Buildings & Major Renovations	-	-	-	-	-	1,130	34	1,164
C1b - C&I Initial Purchase & End of Useful Life	-	-	-	-	-	4,599	282	4,881
C2 - C&I Retrofit	-	-	-	-	-	-	-	-
C2a - C&I Existing Building Retrofit	-	-	-	-	-	-	-	-
C2b - C&I Small Business	-	-	-	-	-	-	-	-
C2c - C&I Multifamily Retrofit	-	-	-	-	-	-	-	-
Grand Total	**21,804,850**	**2,888,822**	**13,280,424**	**-**	**37,974,096**	**15,736,790**	**497,648**	**16,234,438**

IV.D Cost-Effectiveness

3.1.i. Benefits Summary Table

D.P.U. 15-160 to D.P.U. 15-169
Exh. 1, Appendix C
H.O.s Gold and Sawyer

Statewide Gas
October 30, 2015

	2016 Benefits									
	Natural Gas Benefits			Deliverable Fuel Benefits		Other Benefits				
Program	Natural Gas	Natural Gas DRIPE	Total Gas Benefits	Oil	Propane	Water	Total Energy Benefits	Non-Energy Impacts	Total TRC Test Benefits	Total Energy Benefits per Participant
A - Residential	**151,204,027**	**18,641,745**	**169,845,772**	**-**	**-**	**3,182,821**	**220,667,845**	**83,192,520**	**303,860,365**	**360.42**
A1 - Residential Whole House	113,262,502	14,400,889	127,663,392	-	-	3,182,821	173,071,891	70,321,498	243,393,389	297.83
A1a - Residential New Construction	24,233,014	2,069,931	26,302,945	-	-	-	29,266,742	16,683,544	45,950,287	6,385.94
A1b - Residential Multi-Family Retrofit	5,018,256	580,268	5,598,524	-	-	487,130	8,232,009	5,202,737	13,434,747	900.07
A1c - Residential Home Energy Services - Measures	79,856,656	8,067,975	87,924,631	-	-	2,695,691	127,735,847	48,435,216	176,171,064	7,534.80
A1d - Residential Home Energy Services - RCS	-	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	4,154,577	3,682,715	7,837,292	-	-	-	7,837,292	-	7,837,292	15.50
A2 - Residential Products	37,941,524	4,240,856	42,182,380	-	-	-	47,595,954	12,871,022	60,466,976	1,528.53
A2a - Residential Heating & Cooling Equipment	37,941,524	4,240,856	42,182,380	-	-	-	47,595,954	12,871,022	60,466,976	1,528.53
B - Low-Income	**34,607,639**	**3,419,859**	**38,027,497**	**-**	**-**	**471,894**	**43,474,027**	**34,623,855**	**78,097,881**	**4,102.87**
B1 - Low-Income Whole House	34,607,639	3,419,859	38,027,497	-	-	471,894	43,474,027	34,623,855	78,097,881	4,102.87
B1a - Low-Income Single Family Retrofit	12,811,225	1,259,769	14,070,993	-	-	8,011	19,053,640	10,245,423	29,299,063	6,709.03
B1b - Low-Income Multi-Family Retrofit	21,796,414	2,160,090	23,956,504	-	-	463,882	24,420,387	24,378,432	48,798,818	3,148.58
C - Commercial & Industrial	**118,203,717**	**16,338,246**	**134,541,963**	**-**	**-**	**2,529,026**	**137,077,119**	**27,093,008**	**164,170,127**	**21,817.40**
C1 - C&I New Construction	54,830,550	5,867,365	60,697,916	-	-	133,765	60,837,811	-	60,837,811	36,042.43
C1a - C&I New Buildings & Major Renovations	37,720,145	3,955,695	41,675,840	-	-	-	41,677,003	-	41,677,003	126,341.83
C1b - C&I Initial Purchase & End of Useful Life	17,110,406	1,911,671	19,022,076	-	-	133,765	19,160,807	-	19,160,807	14,108.80
C2 - C&I Retrofit	63,373,167	10,470,881	73,844,047	-	-	2,395,261	76,239,308	27,093,008	103,332,316	16,591.88
C2a - C&I Existing Building Retrofit	55,772,520	9,267,656	65,040,176	-	-	36,126	65,076,301	25,302,801	90,379,102	39,585.80
C2b - C&I Small Business	3,290,498	604,720	3,895,218	-	-	1,835,708	5,730,926	321,230	6,052,156	3,530.97
C2c - C&I Multifamily Retrofit	4,310,149	598,505	4,908,654	-	-	523,427	5,432,081	1,468,978	6,901,059	4,090.42
Grand Total	**304,015,383**	**38,399,850**	**342,415,233**	**-**	**-**	**6,183,740**	**401,218,991**	**144,909,383**	**546,128,374**	**637.74**

	2017 Benefits									
	Natural Gas Benefits			Deliverable Fuel Benefits		Other Benefits				
Program	Natural Gas	Natural Gas DRIPE	Total Gas Benefits	Oil	Propane	Water	Total Energy Benefits	Non-Energy Impacts	Total TRC Test Benefits	Total Energy Benefits per Participant
A - Residential	**156,548,034**	**12,006,515**	**168,554,549**	**-**	**-**	**3,154,926**	**220,787,986**	**82,981,646**	**303,769,632**	**360.44**
A1 - Residential Whole House	117,220,468	9,231,517	126,451,985	-	-	3,154,926	172,902,391	70,041,899	242,944,290	297.31
A1a - Residential New Construction	23,737,992	1,330,156	25,068,148	-	-	-	28,058,235	15,835,597	43,893,831	6,656.76
A1b - Residential Multi-Family Retrofit	5,175,045	373,106	5,548,151	-	-	417,599	8,161,820	5,261,583	13,423,403	887.95
A1c - Residential Home Energy Services - Measures	83,671,285	5,377,427	89,048,712	-	-	2,737,327	129,895,361	48,944,720	178,840,081	7,604.99
A1d - Residential Home Energy Services - RCS	-	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	4,636,146	2,150,828	6,786,975	-	-	-	6,786,975	-	6,786,975	13.42
A2 - Residential Products	39,327,566	2,774,997	42,102,563	-	-	-	47,885,595	12,939,746	60,825,342	1,544.60
A2a - Residential Heating & Cooling Equipment	39,327,566	2,774,997	42,102,563	-	-	-	47,885,595	12,939,746	60,825,342	1,544.60
B - Low-Income	**35,369,654**	**2,236,813**	**37,606,467**	**-**	**-**	**472,412**	**43,202,857**	**34,790,497**	**77,993,354**	**4,066.15**
B1 - Low-Income Whole House	35,369,654	2,236,813	37,606,467	-	-	472,412	43,202,857	34,790,497	77,993,354	4,066.15
B1a - Low-Income Single Family Retrofit	13,208,865	829,867	14,038,731	-	-	9,156	19,171,864	10,374,795	29,546,659	6,680.09
B1b - Low-Income Multi-Family Retrofit	22,160,790	1,406,946	23,567,736	-	-	463,257	24,030,993	24,415,702	48,446,695	3,098.77
C - Commercial & Industrial	**122,170,199**	**11,487,316**	**133,657,515**	**-**	**-**	**2,397,113**	**136,060,674**	**27,315,073**	**163,375,746**	**20,860.03**
C1 - C&I New Construction	56,941,276	4,426,449	61,367,726	-	-	133,765	61,507,536	-	61,507,536	32,513.82
C1a - C&I New Buildings & Major Renovations	39,183,990	3,077,328	42,261,318	-	-	-	42,262,482	-	42,262,482	101,547.99
C1b - C&I Initial Purchase & End of Useful Life	17,757,286	1,349,122	19,106,408	-	-	133,765	19,245,054	-	19,245,054	13,042.60
C2 - C&I Retrofit	65,228,922	7,060,867	72,289,789	-	-	2,263,348	74,553,137	27,315,073	101,868,210	16,099.34
C2a - C&I Existing Building Retrofit	57,094,409	6,263,312	63,357,721	-	-	36,126	63,393,847	25,337,578	88,731,425	38,440.09
C2b - C&I Small Business	3,609,533	405,952	4,015,485	-	-	1,885,906	5,901,391	391,285	6,292,676	3,516.04
C2c - C&I Multifamily Retrofit	4,524,980	391,602	4,916,582	-	-	341,317	5,257,899	1,586,210	6,844,109	4,034.48
Grand Total	**314,087,887**	**25,730,644**	**339,818,531**	**-**	**-**	**6,024,452**	**400,051,517**	**145,087,216**	**545,138,732**	**635.31**

IV.D Cost-Effectiveness

3.1.i. Benefits Summary Table

Statewide Gas
October 30, 2015

D.P.U. 15-160 to D.P.U. 15-169
Exh. 1, Appendix C
H.O.s Gold and Sawyer

2018 Benefits

Program	Electric Benefits							
	Capacity					Electric Energy		
	Summer Generation	Transmission	Distribution	Capacity DRIPE	Total Capacity Benefits	Electric Energy	Electric Energy DRIPE	Total Electric Energy Benefits
A - Residential	**20,702,420**	**2,652,885**	**12,200,729**	**-**	**35,556,034**	**14,980,012**	**205,268**	**15,185,281**
A1 - Residential Whole House	17,564,471	2,238,050	10,304,837	-	30,107,358	14,314,458	193,780	14,508,238
A1a - Residential New Construction	715,145	92,102	417,196	-	1,224,442	1,789,101	16,971	1,806,072
A1b - Residential Multi-Family Retrofit	1,125,574	143,008	652,721	-	1,921,302	306,463	5,410	311,873
A1c - Residential Home Energy Services - Measures	15,723,753	2,002,941	9,234,920	-	26,961,613	12,218,893	171,400	12,390,293
A1d - Residential Home Energy Services - RCS	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	-	-	-	-	-	-	-	-
A2 - Residential Products	3,137,949	414,835	1,895,893	-	5,448,677	665,555	11,488	677,043
A2a - Residential Heating & Cooling Equipment	3,137,949	414,835	1,895,893	-	5,448,677	665,555	11,488	677,043
B - Low-Income	**2,259,004**	**286,146**	**1,346,430**	**-**	**3,891,580**	**1,340,563**	**16,978**	**1,357,541**
B1 - Low-Income Whole House	2,259,004	286,146	1,346,430	-	3,891,580	1,340,563	16,978	1,357,541
B1a - Low-Income Single Family Retrofit	2,259,004	286,146	1,346,430	-	3,891,580	1,340,563	16,978	1,357,541
B1b - Low-Income Multi-Family Retrofit	-	-	-	-	-	-	-	-
C - Commercial & Industrial	**-**	**-**	**-**	**-**	**-**	**5,079**	**177**	**5,255**
C1 - C&I New Construction	-	-	-	-	-	5,079	177	5,255
C1a - C&I New Buildings & Major Renovations	-	-	-	-	-	368	13	381
C1b - C&I Initial Purchase & End of Useful Life	-	-	-	-	-	4,711	164	4,875
C2 - C&I Retrofit	-	-	-	-	-	-	-	-
C2a - C&I Existing Building Retrofit	-	-	-	-	-	-	-	-
C2b - C&I Small Business	-	-	-	-	-	-	-	-
C2c - C&I Multifamily Retrofit	-	-	-	-	-	-	-	-
Grand Total	**22,961,424**	**2,939,031**	**13,547,159**	**-**	**39,447,615**	**16,325,654**	**222,423**	**16,548,077**

2016-2018 Benefits

Program	Electric Benefits							
	Capacity					Electric Energy		
	Summer Generation	Transmission	Distribution	Capacity DRIPE	Total Capacity Benefits	Electric Energy	Electric Energy DRIPE	Total Electric Energy Benefits
A - Residential	**58,822,755**	**7,824,372**	**35,913,162**	**-**	**102,560,289**	**43,457,344**	**1,441,447**	**44,898,791**
A1 - Residential Whole House	50,155,612	6,620,822	30,410,996	-	87,187,429	41,601,792	1,347,532	42,949,324
A1a - Residential New Construction	2,091,795	279,876	1,267,764	-	3,639,435	5,221,182	123,781	5,344,964
A1b - Residential Multi-Family Retrofit	3,275,066	429,115	1,955,996	-	5,660,178	882,045	33,379	915,424
A1c - Residential Home Energy Services - Measures	44,788,751	5,911,830	27,187,236	-	77,887,817	35,498,565	1,190,372	36,688,937
A1d - Residential Home Energy Services - RCS	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	-	-	-	-	-	-	-	-
A2 - Residential Products	8,667,143	1,203,550	5,502,165	-	15,372,859	1,855,551	93,915	1,949,466
A2a - Residential Heating & Cooling Equipment	8,667,143	1,203,550	5,502,165	-	15,372,859	1,855,551	93,915	1,949,466
B - Low-Income	**6,492,535**	**854,281**	**4,011,878**	**-**	**11,358,694**	**3,873,114**	**115,927**	**3,989,041**
B1 - Low-Income Whole House	6,492,535	854,281	4,011,878	-	11,358,694	3,873,114	115,927	3,989,041
B1a - Low-Income Single Family Retrofit	6,492,535	854,281	4,011,878	-	11,358,694	3,873,114	115,927	3,989,041
B1b - Low-Income Multi-Family Retrofit	-	-	-	-	-	-	-	-
C - Commercial & Industrial	**-**	**-**	**-**	**-**	**-**	**16,426**	**1,005**	**17,431**
C1 - C&I New Construction	-	-	-	-	-	16,426	1,005	17,431
C1a - C&I New Buildings & Major Renovations	-	-	-	-	-	2,607	102	2,709
C1b - C&I Initial Purchase & End of Useful Life	-	-	-	-	-	13,819	903	14,722
C2 - C&I Retrofit	-	-	-	-	-	-	-	-
C2a - C&I Existing Building Retrofit	-	-	-	-	-	-	-	-
C2b - C&I Small Business	-	-	-	-	-	-	-	-
C2c - C&I Multifamily Retrofit	-	-	-	-	-	-	-	-
Grand Total	**65,315,291**	**8,678,653**	**39,925,039**	**-**	**113,918,982**	**47,346,883**	**1,558,379**	**48,905,262**

Notes:
Total Energy Benefits is the sum of electric benefits, natural gas benefits, deliverable fuel benefits, and other benefits.

IV.D Cost-Effectiveness

3.1.i. Benefits Summary Table

Statewide Gas
October 30, 2015

D.P.U. 15-160 to D.P.U. 15-169
Exh. 1, Appendix C
H.O.s Gold and Sawyer

Program	2018 Benefits									
	Natural Gas Benefits			Deliverable Fuel Benefits		Other Benefits	Total Energy Benefits	Non-Energy Impacts	Total TRC Test Benefits	Total Energy Benefits per Participant
	Natural Gas	Natural Gas DRIPE	Total Gas Benefits	Oil	Propane	Water				
A - Residential	**165,093,368**	**8,088,159**	**173,181,527**	**-**	**-**	**3,219,206**	**227,142,048**	**84,241,155**	**311,383,203**	**380.44**
A1 - Residential Whole House	124,366,679	6,154,058	130,520,737	-	-	3,219,206	178,355,539	71,200,366	249,555,905	306.10
A1a - Residential New Construction	26,703,437	1,070,737	27,774,173	-	-	-	30,804,687	16,133,153	46,937,840	7,212.52
A1b - Residential Multi-Family Retrofit	5,429,667	258,766	5,688,432	-	-	420,452	8,342,060	5,405,455	13,747,514	896.58
A1c - Residential Home Energy Services - Measures	87,371,175	3,809,465	91,180,641	-	-	2,798,754	133,331,301	49,661,759	182,993,059	7,687.06
A1d - Residential Home Energy Services - RCS	-	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	4,862,401	1,015,090	5,877,491	-	-	-	5,877,491	-	5,877,491	11.63
A2 - Residential Products	40,726,688	1,934,101	42,660,790	-	-	-	48,786,509	13,040,789	61,827,298	3,390.19
A2a - Residential Heating & Cooling Equipment	40,726,688	1,934,101	42,660,790	-	-	-	48,786,509	13,040,789	61,827,298	3,390.19
B - Low-Income	**36,126,037**	**1,562,289**	**37,688,326**	**-**	**-**	**472,668**	**43,410,115**	**35,134,272**	**78,544,387**	**4,036.27**
B1 - Low-Income Whole House	36,126,037	1,562,289	37,688,326	-	-	472,668	43,410,115	35,134,272	78,544,387	4,036.27
B1a - Low-Income Single Family Retrofit	13,533,956	580,361	14,114,317	-	-	9,156	19,372,594	10,488,571	29,861,164	6,680.20
B1b - Low-Income Multi-Family Retrofit	22,592,081	981,929	23,574,009	-	-	463,512	24,037,522	24,645,702	48,683,223	3,060.16
C - Commercial & Industrial	**126,938,545**	**7,928,066**	**134,866,611**	**-**	**-**	**2,457,607**	**137,329,473**	**28,142,761**	**165,472,234**	**20,589.91**
C1 - C&I New Construction	57,952,852	3,121,668	61,074,520	-	-	133,765	61,213,540	-	61,213,540	29,717.02
C1a - C&I New Buildings & Major Renovations	39,427,284	2,126,758	41,554,042	-	-	-	41,554,423	-	41,554,423	93,843.86
C1b - C&I Initial Purchase & End of Useful Life	18,525,568	994,910	19,520,478	-	-	133,765	19,659,118	-	19,659,118	12,157.19
C2 - C&I Retrofit	68,985,692	4,806,398	73,792,091	-	-	2,323,842	76,115,933	28,142,761	104,258,693	16,511.53
C2a - C&I Existing Building Retrofit	60,596,084	4,263,399	64,859,483	-	-	36,126	64,895,608	26,136,825	91,032,433	40,481.18
C2b - C&I Small Business	3,713,611	271,200	3,984,812	-	-	1,937,966	5,922,778	387,112	6,309,890	3,481.75
C2c - C&I Multifamily Retrofit	4,675,998	271,799	4,947,797	-	-	349,750	5,297,547	1,618,824	6,916,371	4,057.35
Grand Total	**328,157,950**	**17,578,515**	**345,736,464**	**-**	**-**	**6,149,481**	**407,881,637**	**147,518,188**	**555,399,824**	**663.78**

Program	2016-2018 Benefits									
	Natural Gas Benefits			Deliverable Fuel Benefits		Other Benefits	Total Energy Benefits	Non-Energy Impacts	Total TRC Test Benefits	Total Energy Benefits per Participant
	Natural Gas	Natural Gas DRIPE	Total Gas Benefits	Oil	Propane	Water				
A - Residential	**472,845,428**	**38,736,419**	**511,581,848**	**-**	**-**	**9,556,953**	**668,597,880**	**250,415,320**	**919,013,200**	**366.99**
A1 - Residential Whole House	354,849,650	29,786,465	384,636,114	-	-	9,556,953	524,329,821	211,563,763	735,893,584	300.42
A1a - Residential New Construction	74,674,442	4,470,824	79,145,266	-	-	-	88,129,664	48,652,294	136,781,958	6,743.41
A1b - Residential Multi-Family Retrofit	15,622,968	1,212,139	16,835,107	-	-	1,325,181	24,735,889	15,869,775	40,605,664	894.86
A1c - Residential Home Energy Services - Measures	250,899,116	17,254,868	268,153,984	-	-	8,231,772	390,962,509	147,041,695	538,004,204	7,609.53
A1d - Residential Home Energy Services - RCS	-	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	13,653,124	6,848,634	20,501,758	-	-	-	20,501,758	-	20,501,758	13.52
A2 - Residential Products	117,995,778	8,949,955	126,945,733	-	-	-	144,268,059	38,851,557	183,119,616	1,885.09
A2a - Residential Heating & Cooling Equipment	117,995,778	8,949,955	126,945,733	-	-	-	144,268,059	38,851,557	183,119,616	1,885.09
B - Low-Income	**106,103,330**	**7,218,961**	**113,322,291**	**-**	**-**	**1,416,974**	**130,086,999**	**104,548,624**	**234,635,623**	**4,068.27**
B1 - Low-Income Whole House	106,103,330	7,218,961	113,322,291	-	-	1,416,974	130,086,999	104,548,624	234,635,623	4,068.27
B1a - Low-Income Single Family Retrofit	39,554,046	2,669,996	42,224,041	-	-	26,322	57,598,098	31,108,789	88,706,887	6,689.67
B1b - Low-Income Multi-Family Retrofit	66,549,285	4,548,965	71,098,249	-	-	1,390,651	72,488,901	73,439,836	145,928,736	3,102.32
C - Commercial & Industrial	**367,312,461**	**35,753,628**	**403,066,089**	**-**	**-**	**7,383,746**	**410,467,265**	**82,550,842**	**493,018,107**	**21,076.38**
C1 - C&I New Construction	169,724,679	13,415,483	183,140,162	-	-	401,295	183,558,888	-	183,558,888	32,548.40
C1a - C&I New Buildings & Major Renovations	116,331,419	9,159,781	125,491,200	-	-	-	125,493,908	-	125,493,908	105,558.09
C1b - C&I Initial Purchase & End of Useful Life	53,393,260	4,255,702	57,648,962	-	-	401,295	58,064,980	-	58,064,980	13,046.24
C2 - C&I Retrofit	197,587,781	22,338,146	219,925,927	-	-	6,982,451	226,908,378	82,550,842	309,459,220	16,400.25
C2a - C&I Existing Building Retrofit	173,463,013	19,794,366	193,257,379	-	-	108,377	193,365,756	76,777,203	270,142,959	39,493.06
C2b - C&I Small Business	10,613,642	1,281,873	11,895,515	-	-	5,659,580	17,555,095	1,099,627	18,654,722	3,509.22
C2c - C&I Multifamily Retrofit	13,511,126	1,261,906	14,773,033	-	-	1,214,494	15,987,527	4,674,012	20,661,539	4,060.94
Grand Total	**946,261,219**	**81,709,008**	**1,027,970,227**	**-**	**-**	**18,357,672**	**1,209,152,144**	**437,514,786**	**1,646,666,930**	**645.46**

IV.D Cost-Effectiveness

3.1.iii. Benefits Comparison Table - Three Year Plan vs. Previous Years

Statewide Gas

October 30, 2015

D.P.U. 15-160 to D.P.U. 15-169
Exh. 1, Appendix C
H.O.s Gold and Sawyer

2013-2018 Benefits

Sector	Electric Benefits – Capacity – Summer Generation	Transmission	Distribution	Capacity DRIPE	Total Capacity Benefits	Electric Energy – Electric Energy	Electric Energy DRIPE	Total Electric Energy Benefits	Natural Gas Benefits – Natural Gas	Natural Gas DRIPE	Total Gas Benefits	Deliverable Fuel Benefits – Oil	Propane	Other Benefits – Water	Total Energy Benefits	Non-Energy Impacts	Total TRC Test Benefits
A - Residential	**78,700,130**	**11,134,196**	**51,983,940**	**5,028,645**	**146,846,910**	**65,283,618**	**4,558,275**	**69,841,893**	**858,565,318**	**114,609,404**	**973,174,722**	**-**	**-**	**23,181,246**	**1,213,044,771**	**485,892,819**	**1,698,937,590**
2013	4,431,334	1,082,394	5,212,144	2,445,013	13,170,884	6,944,219	1,125,797	8,070,017	148,767,983	-	148,767,983	-	-	4,385,393	174,394,277	72,116,763	246,511,040
2014	7,763,203	1,363,948	6,456,474	1,647,172	17,230,798	8,681,402	1,433,839	10,115,241	142,259,974	53,108,472	195,368,446	-	-	4,930,936	227,645,421	79,715,866	307,361,288
2015	7,682,837	863,482	4,402,161	936,460	13,884,940	6,200,652	557,193	6,757,845	94,691,932	22,764,512	117,456,445	-	-	4,307,964	142,407,193	83,644,869	226,052,062
2016	18,488,616	2,567,377	11,770,719	-	32,826,711	14,036,338	776,203	14,812,541	151,204,027	18,641,745	169,845,772	-	-	3,182,821	220,667,845	83,192,520	303,860,365
2017	19,631,720	2,604,109	11,941,714	-	34,177,543	14,440,993	459,976	14,900,969	156,548,034	12,006,515	168,554,549	-	-	3,154,926	220,787,986	82,981,646	303,769,632
2018	20,702,420	2,652,885	12,200,729	-	35,556,034	14,980,012	205,268	15,185,281	165,093,368	8,088,159	173,181,527	-	-	3,219,206	227,142,048	84,241,155	311,383,203
B - Low-Income	**9,535,455**	**1,591,574**	**7,789,688**	**1,137,010**	**20,053,727**	**7,544,267**	**721,833**	**8,266,100**	**209,478,403**	**26,580,971**	**236,059,375**	**-**	**-**	**5,157,635**	**269,536,837**	**205,052,391**	**474,589,228**
2013	1,039,203	318,061	1,567,751	664,251	3,589,266	1,707,304	283,688	1,990,992	36,922,161	-	36,922,161	-	-	1,419,172	43,921,590	35,283,565	79,205,156
2014	869,671	189,733	1,016,090	208,789	2,284,284	1,072,098	191,245	1,263,344	42,084,518	14,101,879	56,186,398	-	-	1,789,214	61,523,240	39,758,453	101,281,693
2015	1,134,045	229,499	1,193,969	263,970	2,821,484	891,751	130,973	1,022,724	24,368,394	5,260,131	29,628,526	-	-	532,275	34,005,008	25,461,748	59,466,757
2016	2,060,401	283,422	1,326,737	-	3,670,560	1,242,483	61,593	1,304,076	34,607,639	3,419,859	38,027,497	-	-	471,894	43,474,027	34,623,855	78,097,881
2017	2,173,131	284,712	1,338,711	-	3,796,554	1,290,067	37,356	1,327,424	35,369,654	2,236,813	37,606,467	-	-	472,412	43,202,857	34,790,497	77,993,354
2018	2,259,004	286,146	1,346,430	-	3,891,580	1,340,563	16,978	1,357,541	36,126,037	1,562,289	37,688,326	-	-	472,668	43,410,115	35,134,272	78,544,387
C - Commercial & Industrial	**124,731**	**54,489**	**228,343**	**230,495**	**638,058**	**359,681**	**106,429**	**466,110**	**717,949,105**	**115,284,305**	**833,233,410**	**-**	**-**	**41,584,145**	**875,921,723**	**154,022,388**	**1,029,944,111**
2013	122,712	47,319	195,351	229,785	595,167	201,895	71,416	273,311	107,028,348	-	107,028,348	-	-	13,380,442	121,277,268	20,885,094	142,162,362
2014	1,791	6,227	29,040	635	37,693	47,800	17,708	65,509	113,117,989	45,063,337	158,181,326	-	-	13,841,015	172,125,542	28,040,112	200,165,654
2015	227	943	3,953	76	5,198	93,560	16,299	109,859	130,490,308	34,467,340	164,957,647	-	-	6,978,943	172,051,648	22,546,340	194,597,988
2016	-	-	-	-	-	5,618	512	6,130	118,203,717	16,338,246	134,541,963	-	-	2,529,026	137,077,119	27,093,008	164,170,127
2017	-	-	-	-	-	5,729	316	6,046	122,170,199	11,487,316	133,657,515	-	-	2,397,113	136,060,674	27,315,073	163,375,746
2018	-	-	-	-	-	5,079	177	5,255	126,938,545	7,928,066	134,866,611	-	-	2,457,607	137,329,473	28,142,761	165,472,234
Grand Total	**88,360,315**	**12,780,259**	**60,001,971**	**6,396,150**	**167,538,696**	**73,187,566**	**5,386,537**	**78,574,103**	**1,785,992,826**	**256,474,680**	**2,042,467,506**	**-**	**-**	**69,923,026**	**2,358,503,331**	**844,967,598**	**3,203,470,929**
2013	5,593,249	1,447,774	6,975,246	3,339,048	17,355,317	8,853,418	1,480,901	10,334,320	292,718,491	-	292,718,491	-	-	19,185,007	339,593,135	128,285,423	467,878,558
2014	8,634,666	1,559,909	7,501,604	1,856,596	19,552,775	9,801,301	1,642,792	11,444,093	297,462,481	112,273,689	409,736,169	-	-	20,561,165	461,294,203	147,514,432	608,808,635
2015	8,817,109	1,093,924	5,600,082	1,200,506	16,711,621	7,185,963	704,464	7,890,428	249,550,634	62,491,983	312,042,618	-	-	11,819,182	348,463,849	131,652,958	480,116,807
2016	20,549,016	2,850,800	13,097,455	-	36,497,271	15,284,440	838,307	16,122,747	304,015,383	38,399,850	342,415,233	-	-	6,183,740	401,218,991	144,909,383	546,128,374
2017	21,804,850	2,888,822	13,280,424	-	37,974,096	15,736,790	497,648	16,234,438	314,087,887	25,730,644	339,818,531	-	-	6,024,452	400,051,517	145,087,216	545,138,732
2018	22,961,424	2,939,031	13,547,159	-	39,447,615	16,325,654	222,423	16,548,077	328,157,950	17,578,515	345,736,464	-	-	6,149,481	407,881,637	147,518,188	555,399,824

2013-2018 Benefits, Percent of Total TRC Test Benefits

Sector	Electric Benefits – Capacity – Summer Generation	Transmission	Distribution	Capacity DRIPE	Total Capacity Benefits	Electric Energy – Electric Energy	Electric Energy DRIPE	Total Electric Energy Benefits	Natural Gas Benefits – Natural Gas	Natural Gas DRIPE	Total Gas Benefits	Deliverable Fuel Benefits – Oil	Propane	Other Benefits – Water	Total Energy Benefits	Non-Energy Impacts	Total TRC Test Benefits
A - Residential	**4.6%**	**0.7%**	**3.1%**	**0.3%**	**8.6%**	**3.8%**	**0.3%**	**4.1%**	**50.5%**	**6.7%**	**57.3%**	**0.0%**	**0.0%**	**1.4%**	**71.4%**	**28.6%**	**100%**
2013	1.8%	0.4%	2.1%	1.0%	5.3%	2.8%	0.5%	3.3%	60.3%	0.0%	60.3%	0.0%	0.0%	1.8%	70.7%	29.3%	100%
2014	2.5%	0.4%	2.1%	0.5%	5.6%	2.8%	0.5%	3.3%	46.3%	17.3%	63.6%	0.0%	0.0%	1.6%	74.1%	25.9%	100%
2015	3.4%	0.4%	1.9%	0.4%	6.1%	2.7%	0.2%	3.0%	41.9%	10.1%	52.0%	0.0%	0.0%	1.9%	63.0%	37.0%	100%
2016	6.1%	0.8%	3.9%	0.0%	10.8%	4.6%	0.3%	4.9%	49.8%	6.1%	55.9%	0.0%	0.0%	1.0%	72.6%	27.4%	100%
2017	6.5%	0.9%	3.9%	0.0%	11.3%	4.8%	0.2%	4.9%	51.5%	4.0%	55.5%	0.0%	0.0%	1.0%	72.7%	27.3%	100%
2018	6.6%	0.9%	3.9%	0.0%	11.4%	4.8%	0.1%	4.9%	53.0%	2.6%	55.6%	0.0%	0.0%	1.0%	72.9%	27.1%	100%
B - Low-Income	**2.0%**	**0.3%**	**1.6%**	**0.2%**	**4.2%**	**1.6%**	**0.2%**	**1.7%**	**44.1%**	**5.6%**	**49.7%**	**0.0%**	**0.0%**	**1.1%**	**56.8%**	**43.2%**	**100%**
2013	1.3%	0.4%	2.0%	0.8%	4.5%	2.2%	0.4%	2.5%	46.6%	0.0%	46.6%	0.0%	0.0%	1.8%	55.5%	44.5%	100%
2014	0.9%	0.2%	1.0%	0.2%	2.3%	1.1%	0.2%	1.2%	41.6%	13.9%	55.5%	0.0%	0.0%	1.8%	60.7%	39.3%	100%
2015	1.9%	0.4%	2.0%	0.4%	4.7%	1.5%	0.2%	1.7%	41.0%	8.8%	49.8%	0.0%	0.0%	0.9%	57.2%	42.8%	100%
2016	2.6%	0.4%	1.7%	0.0%	4.7%	1.6%	0.1%	1.7%	44.3%	4.4%	48.7%	0.0%	0.0%	0.6%	55.7%	44.3%	100%
2017	2.8%	0.4%	1.7%	0.0%	4.9%	1.7%	0.0%	1.7%	45.3%	2.9%	48.2%	0.0%	0.0%	0.6%	55.4%	44.6%	100%
2018	2.9%	0.4%	1.7%	0.0%	5.0%	1.7%	0.0%	1.7%	46.0%	2.0%	48.0%	0.0%	0.0%	0.6%	55.3%	44.7%	100%
C - Commercial & Industrial	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.1%**	**0.0%**	**0.0%**	**0.0%**	**69.7%**	**11.2%**	**80.9%**	**0.0%**	**0.0%**	**4.0%**	**85.0%**	**15.0%**	**100%**
2013	0.1%	0.0%	0.1%	0.2%	0.4%	0.1%	0.1%	0.2%	75.3%	0.0%	75.3%	0.0%	0.0%	9.4%	85.3%	14.7%	100%
2014	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	56.5%	22.5%	79.0%	0.0%	0.0%	6.9%	86.0%	14.0%	100%
2015	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	67.1%	17.7%	84.8%	0.0%	0.0%	3.6%	88.4%	11.6%	100%
2016	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	72.0%	10.0%	82.0%	0.0%	0.0%	1.5%	83.5%	16.5%	100%
2017	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	74.8%	7.0%	81.8%	0.0%	0.0%	1.5%	83.3%	16.7%	100%
2018	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	76.7%	4.8%	81.5%	0.0%	0.0%	1.5%	83.0%	17.0%	100%
Grand Total	**2.8%**	**0.4%**	**1.9%**	**0.2%**	**5.2%**	**2.3%**	**0.2%**	**2.5%**	**55.8%**	**8.0%**	**63.8%**	**0.0%**	**0.0%**	**2.2%**	**73.6%**	**26.4%**	**100%**
2013	1.2%	0.3%	1.5%	0.7%	3.7%	1.9%	0.3%	2.2%	62.6%	0.0%	62.6%	0.0%	0.0%	4.1%	72.6%	27.4%	100%
2014	1.4%	0.3%	1.2%	0.3%	3.2%	1.6%	0.3%	1.9%	48.9%	18.4%	67.3%	0.0%	0.0%	3.4%	75.8%	24.2%	100%
2015	1.8%	0.2%	1.2%	0.3%	3.5%	1.5%	0.1%	1.6%	52.0%	13.0%	65.0%	0.0%	0.0%	2.5%	72.6%	27.4%	100%
2016	3.8%	0.5%	2.4%	0.0%	6.7%	2.8%	0.2%	3.0%	55.7%	7.0%	62.7%	0.0%	0.0%	1.1%	73.5%	26.5%	100%
2017	4.0%	0.5%	2.4%	0.0%	7.0%	2.9%	0.1%	3.0%	57.6%	4.7%	62.3%	0.0%	0.0%	1.1%	73.4%	26.6%	100%
2018	4.1%	0.5%	2.4%	0.0%	7.1%	2.9%	0.0%	3.0%	59.1%	3.2%	62.3%	0.0%	0.0%	1.1%	73.4%	26.6%	100%

Notes:

2013 values are from the Program Administrator's 2013 Plan Year Report D.P.U. , in 2013$.
2014 values are from the Program Administrator's 2014 Plan Year Report, D.P.U. , in 2013$.
2015 values are from the Program Administrator's 2013-2015 Three-Year Plan, D.P.U. , in 2013$.
For supporting information on the 2016-2018 values, see Table IV.D.3.1.i. The 2016-2018 values are in 2016$.

IV.D. Cost-Effectiveness

D.P.U. 15-160 to D.P.U. 15-169

3.2.i. Savings Summary Table

Exh. 1, Appendix C

Statewide Gas

H.O.s Gold and Sawyer

October 30, 2015

2016 Net Savings

Program	# of Participants	Electric Savings				Natural Gas Savings		Deliverable Fuel Savings				Other Savings	
		Annual Capacity (kW)		Electric Energy (MWh)		(Therms)		Oil (MMBTU)		Propane (MMBTU)		Water (Gallons)	
		Summer	Winter	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime
A - Residential	**612,250**	**5,423**	**2,330**	**9,174**	**161,713**	**15,104,655**	**179,262,960**	**-**	**-**	**-**	**-**	**42,620,144**	**298,341,007**
A1 - Residential Whole House	581,111	4,331	2,331	8,655	153,913	12,498,355	133,560,645	-	-	-	-	42,620,144	298,341,007
A1a - Residential New Construction	4,583	197	304	1,073	20,132	1,185,579	27,993,569	-	-	-	-	-	-
A1b - Residential Multi-Family Retrofit	9,146	254	0	124	3,008	365,893	5,971,468	-	-	-	-	6,522,999	45,660,996
A1c - Residential Home Energy Services - Measures	16,953	3,881	2,026	7,459	130,773	4,915,809	93,564,534	-	-	-	-	36,097,144	252,680,011
A1d - Residential Home Energy Services - RCS	44,711	-	-	-	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	505,718	-	-	-	-	6,031,074	6,031,074	-	-	-	-	-	-
A2 - Residential Products	31,138	1,092	(0)	518	7,800	2,606,301	45,702,315	-	-	-	-	-	-
A2a - Residential Heating & Cooling Equipment	31,138	1,092	(0)	518	7,800	2,606,301	45,702,315	-	-	-	-	-	-
B - Low-Income	**10,596**	**611**	**295**	**750**	**14,865**	**2,054,911**	**40,776,119**	**-**	**-**	**-**	**-**	**6,318,977**	**44,232,841**
B1 - Low-Income Whole House	10,596	611	295	750	14,865	2,054,911	40,776,119	-	-	-	-	6,318,977	44,232,841
B1a - Low-Income Single Family Retrofit	2,840	611	295	750	14,865	760,160	15,071,909	-	-	-	-	107,275	750,925
B1b - Low-Income Multi-Family Retrofit	7,756	-	-	-	-	1,294,751	25,704,210	-	-	-	-	6,211,702	43,481,916
C - Commercial & Industrial	**6,283**	**-**	**0**	**4**	**69**	**10,935,286**	**156,269,870**	**-**	**-**	**-**	**-**	**27,192,197**	**246,376,015**
C1 - C&I New Construction	1,688	-	0	4	69	3,825,609	71,182,537	-	-	-	-	1,056,320	15,066,271
C1a - C&I New Buildings & Major Renovations	330	-	0	1	13	2,701,169	49,073,719	-	-	-	-	-	-
C1b - C&I Initial Purchase & End of Useful Life	1,358	-	0	3	55	1,124,440	22,108,818	-	-	-	-	1,056,320	15,066,271
C2 - C&I Retrofit	4,595	-	-	-	-	7,109,677	85,087,333	-	-	-	-	26,135,877	231,309,743
C2a - C&I Existing Building Retrofit	1,644	-	-	-	-	6,359,669	74,876,940	-	-	-	-	362,759	5,370,994
C2b - C&I Small Business	1,623	-	-	-	-	384,661	4,546,941	-	-	-	-	18,764,066	176,875,387
C2c - C&I Multifamily Retrofit	1,328	-	-	-	-	365,347	5,663,452	-	-	-	-	7,009,052	49,063,363
Grand Total	**629,128**	**6,034**	**2,625**	**9,927**	**176,646**	**28,094,852**	**376,308,950**	**-**	**-**	**-**	**-**	**76,131,318**	**588,949,863**

2017 Net Savings

Program	# of Participants	Electric Savings				Natural Gas Savings		Deliverable Fuel Savings				Other Savings	
		Annual Capacity (kW)		Electric Energy (MWh)		(Therms)		Oil (MMBTU)		Propane (MMBTU)		Water (Gallons)	
		Summer	Winter	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime
A - Residential	**612,552**	**5,492**	**2,385**	**8,981**	**161,045**	**15,185,401**	**181,611,425**	**-**	**-**	**-**	**-**	**43,109,070**	**301,763,489**
A1 - Residential Whole House	581,550	4,362	2,377	8,445	152,977	12,535,935	135,153,107	-	-	-	-	43,109,070	301,763,489
A1a - Residential New Construction	4,215	189	354	1,003	19,312	1,140,061	26,933,469	-	-	-	-	-	-
A1b - Residential Multi-Family Retrofit	9,192	254	0	136	3,311	370,833	6,041,519	-	-	-	-	6,454,393	45,180,754
A1c - Residential Home Energy Services - Measures	17,080	3,919	2,022	7,306	130,354	5,067,505	96,220,583	-	-	-	-	36,654,676	256,582,735
A1d - Residential Home Energy Services - RCS	45,376	-	-	-	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	505,687	-	-	-	-	5,957,536	5,957,536	-	-	-	-	-	-
A2 - Residential Products	31,002	1,130	8	536	8,068	2,649,466	46,458,318	-	-	-	-	-	-
A2a - Residential Heating & Cooling Equipment	31,002	1,130	8	536	8,068	2,649,466	46,458,318	-	-	-	-	-	-
B - Low-Income	**10,625**	**615**	**306**	**756**	**14,989**	**2,061,664**	**40,903,623**	**-**	**-**	**-**	**-**	**6,325,923**	**44,281,463**
B1 - Low-Income Whole House	10,625	615	306	756	14,989	2,061,664	40,903,623	-	-	-	-	6,325,923	44,281,463
B1a - Low-Income Single Family Retrofit	2,870	615	306	756	14,989	769,456	15,253,258	-	-	-	-	122,600	858,200
B1b - Low-Income Multi-Family Retrofit	7,755	-	-	-	-	1,292,208	25,650,365	-	-	-	-	6,203,323	43,423,263
C - Commercial & Industrial	**6,523**	**-**	**2**	**4**	**69**	**11,257,314**	**158,291,766**	**-**	**-**	**-**	**-**	**27,819,488**	**253,057,201**
C1 - C&I New Construction	1,892	-	2	4	69	3,884,614	72,425,374	-	-	-	-	1,056,320	15,066,271
C1a - C&I New Buildings & Major Renovations	416	-	0	1	13	2,727,894	49,872,945	-	-	-	-	-	-
C1b - C&I Initial Purchase & End of Useful Life	1,476	-	2	3	55	1,156,720	22,552,429	-	-	-	-	1,056,320	15,066,271
C2 - C&I Retrofit	4,631	-	-	-	-	7,372,700	85,866,392	-	-	-	-	26,763,168	237,990,929
C2a - C&I Existing Building Retrofit	1,649	-	-	-	-	6,589,409	75,178,780	-	-	-	-	362,759	5,370,994
C2b - C&I Small Business	1,678	-	-	-	-	413,087	4,873,142	-	-	-	-	19,231,897	182,440,351
C2c - C&I Multifamily Retrofit	1,303	-	-	-	-	370,204	5,814,471	-	-	-	-	7,168,512	50,179,585
Grand Total	**629,700**	**6,107**	**2,693**	**9,741**	**176,102**	**28,504,379**	**380,806,813**	**-**	**-**	**-**	**-**	**77,254,481**	**599,102,153**

IV.D. Cost-Effectiveness

3.2.i. Savings Summary Table

Statewide Gas

October 30, 2015

D.P.U. 15-160 to D.P.U. 15-169

Exh. 1, Appendix C

H.O.s Gold and Sawyer

2018 Net Savings

Program	# of Participants	Electric Savings				Natural Gas Savings		Deliverable Fuel Savings				Other Savings	
		Annual Capacity (kW)		Electric Energy (MWh)		(Therms)		Oil (MMBTU)		Propane (MMBTU)		Water (Gallons)	
		Summer	Winter	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime
A - Residential	**597,057**	**5,591**	**2,284**	**8,809**	**161,230**	**15,521,036**	**188,713,984**	**-**	**-**	**-**	**-**	**43,995,287**	**307,967,012**
A1 - Residential Whole House	582,667	4,423	2,285	8,255	152,891	12,812,246	141,270,241	-	-	-	-	43,995,287	307,967,012
A1a - Residential New Construction	4,271	182	288	961	19,241	1,289,022	29,973,009	-	-	-	-	-	-
A1b - Residential Multi-Family Retrofit	9,304	254	0	124	3,013	384,337	6,254,994	-	-	-	-	6,518,055	45,626,385
A1c - Residential Home Energy Services - Measures	17,345	3,986	1,996	7,170	130,637	5,233,742	99,137,093	-	-	-	-	37,477,232	262,340,627
A1d - Residential Home Energy Services - RCS	46,235	-	-	-	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	505,512	-	-	-	-	5,905,145	5,905,145	-	-	-	-	-	-
A2 - Residential Products	14,391	1,168	(0)	554	8,339	2,708,789	47,443,743	-	-	-	-	-	-
A2a - Residential Heating & Cooling Equipment	14,391	1,168	(0)	554	8,339	2,708,789	47,443,743	-	-	-	-	-	-
B - Low-Income	**10,755**	**619**	**300**	**761**	**15,092**	**2,076,231**	**41,199,508**	**-**	**-**	**-**	**-**	**6,329,346**	**44,305,424**
B1 - Low-Income Whole House	10,755	619	300	761	15,092	2,076,231	41,199,508	-	-	-	-	6,329,346	44,305,424
B1a - Low-Income Single Family Retrofit	2,900	619	300	761	15,092	777,704	15,414,492	-	-	-	-	122,600	858,200
B1b - Low-Income Multi-Family Retrofit	7,855	-	-	-	-	1,298,527	25,785,016	-	-	-	-	6,206,746	43,447,224
C - Commercial & Industrial	**6,670**	**-**	**0**	**3**	**59**	**11,613,120**	**162,182,128**	**-**	**-**	**-**	**-**	**28,495,136**	**259,298,925**
C1 - C&I New Construction	2,060	-	0	3	59	3,877,190	72,558,441	-	-	-	-	1,056,320	15,066,271
C1a - C&I New Buildings & Major Renovations	443	-	0	0	4	2,675,670	49,323,499	-	-	-	-	-	-
C1b - C&I Initial Purchase & End of Useful Life	1,617	-	0	3	55	1,201,520	23,234,942	-	-	-	-	1,056,320	15,066,271
C2 - C&I Retrofit	4,610	-	-	-	-	7,735,930	89,623,687	-	-	-	-	27,438,816	244,232,654
C2a - C&I Existing Building Retrofit	1,603	-	-	-	-	6,937,934	78,765,117	-	-	-	-	362,759	5,370,994
C2b - C&I Small Business	1,701	-	-	-	-	421,489	4,943,067	-	-	-	-	19,717,703	187,353,182
C2c - C&I Multifamily Retrofit	1,306	-	-	-	-	376,507	5,915,503	-	-	-	-	7,358,354	51,508,478
Grand Total	**614,482**	**6,209**	**2,584**	**9,574**	**176,382**	**29,210,387**	**392,095,620**	**-**	**-**	**-**	**-**	**78,819,770**	**611,571,361**

2016-2018 Net Savings

Program	# of Participants	Electric Savings				Natural Gas Savings		Deliverable Fuel Savings				Other Savings	
		Annual Capacity (kW)		Electric Energy (MWh)		(Therms)		Oil (MMBTU)		Propane (MMBTU)		Water (Gallons)	
		Summer	Winter	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime
A - Residential	**1,821,859**	**16,506**	**6,999**	**26,965**	**483,988**	**45,811,092**	**549,588,369**	**-**	**-**	**-**	**-**	**129,724,501**	**908,071,507**
A1 - Residential Whole House	1,745,328	13,116	6,992	25,356	459,781	37,846,536	409,983,994	-	-	-	-	129,724,501	908,071,507
A1a - Residential New Construction	13,069	568	947	3,037	58,686	3,614,661	84,900,046	-	-	-	-	-	-
A1b - Residential Multi-Family Retrofit	27,642	762	1	385	9,331	1,121,062	18,267,980	-	-	-	-	19,495,448	136,468,135
A1c - Residential Home Energy Services - Measures	51,378	11,786	6,045	21,935	391,764	15,217,056	288,922,211	-	-	-	-	110,229,053	771,603,372
A1d - Residential Home Energy Services - RCS	136,322	-	-	-	-	-	-	-	-	-	-	-	-
A1e - Residential Behavior/Feedback Program	1,516,917	-	-	-	-	17,893,756	17,893,756	-	-	-	-	-	-
A2 - Residential Products	76,531	3,390	7	1,608	24,207	7,964,556	139,604,375	-	-	-	-	-	-
A2a - Residential Heating & Cooling Equipment	76,531	3,390	7	1,608	24,207	7,964,556	139,604,375	-	-	-	-	-	-
B - Low-Income	**31,976**	**1,845**	**901**	**2,267**	**44,946**	**6,192,807**	**122,879,250**	**-**	**-**	**-**	**-**	**18,974,247**	**132,819,729**
B1 - Low-Income Whole House	31,976	1,845	901	2,267	44,946	6,192,807	122,879,250	-	-	-	-	18,974,247	132,819,729
B1a - Low-Income Single Family Retrofit	8,610	1,845	901	2,267	44,946	2,307,320	45,739,659	-	-	-	-	352,475	2,467,325
B1b - Low-Income Multi-Family Retrofit	23,366	-	-	-	-	3,885,487	77,139,591	-	-	-	-	18,621,772	130,352,404
C - Commercial & Industrial	**19,475**	**-**	**2**	**11**	**197**	**33,805,720**	**476,743,765**	**-**	**-**	**-**	**-**	**83,506,822**	**758,732,140**
C1 - C&I New Construction	5,640	-	2	11	197	11,587,413	216,166,352	-	-	-	-	3,168,961	45,198,814
C1a - C&I New Buildings & Major Renovations	1,189	-	0	2	31	8,104,733	148,270,163	-	-	-	-	-	-
C1b - C&I Initial Purchase & End of Useful Life	4,451	-	2	9	165	3,482,679	67,896,189	-	-	-	-	3,168,961	45,198,814
C2 - C&I Retrofit	13,836	-	-	-	-	22,218,307	260,577,413	-	-	-	-	80,337,861	713,533,326
C2a - C&I Existing Building Retrofit	4,896	-	-	-	-	19,887,012	228,820,836	-	-	-	-	1,088,277	16,112,982
C2b - C&I Small Business	5,003	-	-	-	-	1,219,237	14,363,149	-	-	-	-	57,713,666	546,668,919
C2c - C&I Multifamily Retrofit	3,937	-	-	-	-	1,112,058	17,393,427	-	-	-	-	21,535,918	150,751,425
Grand Total	**1,873,310**	**18,351**	**7,903**	**29,243**	**529,131**	**85,809,618**	**1,149,211,383**	**-**	**-**	**-**	**-**	**232,205,570**	**1,799,623,377**

IV.D. Cost-Effectiveness

3.2.ii. Savings Comparison Table - Three Year Plan vs. Previous Years

Statewide Gas
October 30, 2015

D.P.U. 15-160 to D.P.U. 15-169
Exh. 1, Appendix C
H.O.s Gold and Sawyer

Sector	# of Participants	Electric Net Savings				Natural Gas Net Savings		Deliverable Fuel Net Savings				Other Net Savings	
		Annual Capacity (kW)		Electric Energy (MWh)		Therms		Oil (MMBTU)		Propane (MMBTU)		Water (Gallons)	
		Summer	Winter	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime
A - Residential	**3,508,337**	**24,718**	**10,941**	**39,376**	**738,539**	**87,064,674**	**1,003,415,940**	**-**	**-**	**-**	**-**	**320,286,746**	**1,322,704,457**
2013	556,505	2,695	1,284	4,252	81,567	13,956,596	161,844,604	-	-	-	-	60,788,639	158,078,514
2014	569,411	3,216	1,676	5,155	103,907	15,691,501	176,279,050	-	-	-	-	71,295,810	173,250,904
2015	560,562	2,301	982	3,005	69,076	11,605,485	115,703,917	-	-	-	-	58,477,796	83,303,532
2016	612,250	5,423	2,330	9,174	161,713	15,104,655	179,262,960	-	-	-	-	42,620,144	298,341,007
2017	612,552	5,492	2,385	8,981	161,045	15,185,401	181,611,425	-	-	-	-	43,109,070	301,763,489
2018	597,057	5,591	2,284	8,809	161,230	15,521,036	188,713,984	-	-	-	-	43,995,287	307,967,012
B - Low-Income	**60,249**	**3,246**	**1,873**	**4,493**	**90,147**	**12,349,603**	**244,272,426**	**-**	**-**	**-**	**-**	**68,822,168**	**141,915,027**
2013	10,373	513	377	998	20,672	2,042,010	40,128,901	-	-	-	-	18,205,812	4,618,908
2014	10,891	396	285	676	13,552	2,628,673	51,936,434	-	-	-	-	24,512,264	3,453,100
2015	7,009	492	311	551	10,977	1,486,113	29,327,842	-	-	-	-	7,129,845	1,023,290
2016	10,596	611	295	750	14,865	2,054,911	40,776,119	-	-	-	-	6,318,977	44,232,841
2017	10,625	615	306	756	14,989	2,061,664	40,903,623	-	-	-	-	6,325,923	44,281,463
2018	10,755	619	300	761	15,092	2,076,231	41,199,508	-	-	-	-	6,329,346	44,305,424
C - Commercial & Industrial	**40,321**	**1**	**67**	**400**	**4,962**	**64,657,600**	**928,637,688**	**-**	**-**	**-**	**-**	**738,984,728**	**2,471,082,030**
2013	5,296	0	8	261	2,891	8,669,370	121,301,030	-	-	-	-	263,182,259	621,995,657
2014	10,365	1	46	62	692	10,323,023	154,642,232	-	-	-	-	179,892,058	892,882,876
2015	5,185	0	11	66	1,183	11,859,487	175,950,661	-	-	-	-	212,403,590	197,471,356
2016	6,283	-	0	4	69	10,935,286	156,269,870	-	-	-	-	27,192,197	246,376,015
2017	6,523	-	2	4	69	11,257,314	158,291,766	-	-	-	-	27,819,488	253,057,201
2018	6,670	-	0	3	59	11,613,120	162,182,128	-	-	-	-	28,495,136	259,298,925
Grand Total	**3,608,907**	**27,966**	**12,882**	**44,269**	**833,649**	**164,071,877**	**2,176,326,054**	**-**	**-**	**-**	**-**	**1,128,093,643**	**3,935,701,514**
2013	572,174	3,208	1,669	5,510	105,130	24,667,976	323,274,535	-	-	-	-	342,176,710	784,693,079
2014	590,667	3,613	2,007	5,893	118,152	28,643,197	382,857,716	-	-	-	-	275,700,132	1,069,586,881
2015	572,756	2,794	1,304	3,622	81,236	24,951,085	320,982,420	-	-	-	-	278,011,231	281,798,177
2016	629,128	6,034	2,625	9,927	176,646	28,094,852	376,308,950	-	-	-	-	76,131,318	588,949,863
2017	629,700	6,107	2,693	9,741	176,102	28,504,379	380,806,813	-	-	-	-	77,254,481	599,102,153
2018	614,482	6,209	2,584	9,574	176,382	29,210,387	392,095,620	-	-	-	-	78,819,770	611,571,361

Notes:

2013 values are from the Program Administrator's 2013 Plan Year Report D.P.U. .

2014 values are from the Program Administrator's 2014 Plan Year Report, D.P.U. .

2015 values are from the Program Administrator's 2013-2015 Three-Year Plan, D.P.U. .

For supporting information on the 2016-2018 values, see Table IV.D.3.2.i.

The Progam Administrators have developed new participant definitions through the common assumptions working group for the 2016-2018 Three-Year Plan. Historical participant numbers may not be comparable.

IV.H. Performance Incentive

1. Summary Table

D.P.U. 15-160 to D.P.U. 15-169
Exh. 1, Appendix C
H.O.s Gold and Sawyer

Statewide Gas
October 30, 2015

2016 Performance Incentives				
Sector	**After-Tax Performance Incentives**	**% of Program Costs**	**Pre-Tax Performance Incentives**	**% of Program Costs**
Residential	1,915,099	1.5%	3,150,870	2.5%
Low-Income	491,523	1.1%	808,692	1.8%
Commercial & Industrial	1,221,130	2.8%	2,009,099	4.6%
Grand Total	**3,627,753**	**1.7%**	**5,968,662**	**2.8%**

2017 Performance Incentives				
Sector	**After-Tax Performance Incentives**	**% of Program Costs**	**Pre-Tax Performance Incentives**	**% of Program Costs**
Residential	1,957,861	1.5%	3,221,225	2.5%
Low-Income	507,076	1.1%	834,280	1.9%
Commercial & Industrial	1,245,065	2.8%	2,048,479	4.6%
Grand Total	**3,710,002**	**1.7%**	**6,103,984**	**2.8%**

2018 Performance Incentives				
Sector	**After-Tax Performance Incentives**	**% of Program Costs**	**Pre-Tax Performance Incentives**	**% of Program Costs**
Residential	2,066,942	1.5%	3,400,695	2.5%
Low-Income	527,866	1.2%	868,487	1.9%
Commercial & Industrial	1,289,803	2.8%	2,122,085	4.6%
Grand Total	**3,884,612**	**1.7%**	**6,391,266**	**2.8%**

2016-2018 Performance Incentives				
Sector	**After-Tax Performance Incentives**	**% of Program Costs**	**Pre-Tax Performance Incentives**	**% of Program Costs**
Residential	5,939,902	1.5%	9,772,790	2.5%
Low-Income	1,526,465	1.1%	2,511,460	1.9%
Commercial & Industrial	3,755,999	2.8%	6,179,663	4.6%
Grand Total	**11,222,366**	**1.7%**	**18,463,913**	**2.8%**

Notes:
Performance Incentives for each year in 2016-2018 are represented in nominal dollars (2016$, 2017$, 2018$).
For supporting information on the Performance Incentive, refer to the Performance Incentive Model.
Performance Incentives are not applicable to the Cape Light Compact.

V.B. Allocation of Funds

1. Low-Income Minimum

D.P.U. 15-160 to D.P.U. 15-169
Statewide Gas
Exh. 1, Appendix C
October 30, 2015
H.O.s Gold and Sawyer

2016 Sector Cost Allocation		
Sector	Program Budget	
	($)	(% of Total)
A - Residential	128,380,576	59.2%
B - Low-Income	44,552,694	20.5%
C - Commercial & Industrial	43,935,544	20.3%
Grand Total	**216,868,815**	**100%**

2017 Sector Cost Allocation		
Sector	Program Budget	
	($)	(% of Total)
A - Residential	131,256,509	59.4%
B - Low-Income	44,988,485	20.3%
C - Commercial & Industrial	44,893,412	20.3%
Grand Total	**221,138,405**	**100%**

2018 Sector Cost Allocation		
Sector	Program Budget	
	($)	(% of Total)
A - Residential	135,468,460	59.5%
B - Low-Income	45,635,214	20.1%
C - Commercial & Industrial	46,442,384	20.4%
Grand Total	**227,546,058**	**100%**

2016-2018 Sector Cost Allocation		
Sector	Program Budget	
	($)	(% of Total)
A - Residential	395,105,545	59.4%
B - Low-Income	135,176,393	20.3%
C - Commercial & Industrial	135,271,340	20.3%
Grand Total	**665,553,278**	**100%**

Notes:
General Laws c. 25, § 19(c) requires that at least 10 percent of the amount expended for electric energy efficiency programs and at least 20 percent of the amount expended for gas energy efficiency programs be spent on low-income programs.

V.D. Outsourced/Competitively Procured Services

1. Summary Table

D.P.U. 15-160 to D.P.U. 15-169

Statewide Gas

Exh. 1, Appendix C

October 30, 2015

H.O.s Gold and Sawyer

2016 Competitively Procured Services		
Sector & Cost Categories	**Costs ($)**	**Costs as a Percent of Total Sector Costs (%)**
A - Residential		
Total Cost of Services	36,705,540	100%
In-House Activities	3,839,278	10%
Outsourced Activities	32,866,262	90%
Competitively Procured	31,356,905	85%
Non-Competitively Procured	1,509,358	4%
B - Low-Income		
Total Cost of Services	12,093,670	100%
In-House Activities	1,403,383	12%
Outsourced Activities	10,690,287	88%
Competitively Procured	2,421,080	20%
Non-Competitively Procured	8,269,207	68%
C - Commercial & Industrial		
Total Cost of Services	15,271,413	100%
In-House Activities	5,620,017	37%
Outsourced Activities	9,651,396	63%
Competitively Procured	7,454,264	49%
Non-Competitively Procured	2,197,132	14%
Grand Total		
Total Cost of Services	64,070,623	100%
In-House Activities	10,862,678	17%
Outsourced Activities	53,207,946	83%
Competitively Procured	41,232,249	64%
Non-Competitively Procured	11,975,697	19%

2017 Competitively Procured Services		
Sector & Cost Categories	**Costs ($)**	**Costs as a Percent of Total Sector Costs (%)**
A - Residential		
Total Cost of Services	37,676,447	100%
In-House Activities	3,952,016	10%
Outsourced Activities	33,724,432	90%
Competitively Procured	32,179,465	85%
Non-Competitively Procured	1,544,967	4%
B - Low-Income		
Total Cost of Services	12,140,440	100%
In-House Activities	1,442,476	12%
Outsourced Activities	10,697,964	88%
Competitively Procured	2,410,876	20%
Non-Competitively Procured	8,287,088	68%
C - Commercial & Industrial		
Total Cost of Services	15,426,945	100%
In-House Activities	5,770,802	37%
Outsourced Activities	9,656,143	63%
Competitively Procured	7,448,625	48%
Non-Competitively Procured	2,207,518	14%
Grand Total		
Total Cost of Services	65,243,832	100%
In-House Activities	11,165,294	17%
Outsourced Activities	54,078,538	83%
Competitively Procured	42,038,966	64%
Non-Competitively Procured	12,039,572	18%

V.D. Outsourced/Competitively Procured Services

1. Summary Table

D.P.U. 15-160 to D.P.U. 15-169

Statewide Gas

Exh. 1, Appendix C

October 30, 2015

H.O.s Gold and Sawyer

2018 Competitively Procured Services		
Sector & Cost Categories	**Costs ($)**	**Costs as a Percent of Total Sector Costs (%)**
A - Residential		
Total Cost of Services	38,668,448	100%
In-House Activities	4,175,660	11%
Outsourced Activities	34,492,788	89%
Competitively Procured	32,915,324	85%
Non-Competitively Procured	1,577,464	4%
B - Low-Income		
Total Cost of Services	12,337,156	100%
In-House Activities	1,520,259	12%
Outsourced Activities	10,816,897	88%
Competitively Procured	2,397,071	19%
Non-Competitively Procured	8,419,826	68%
C - Commercial & Industrial		
Total Cost of Services	15,734,976	100%
In-House Activities	6,113,001	39%
Outsourced Activities	9,621,975	61%
Competitively Procured	7,395,673	47%
Non-Competitively Procured	2,226,302	14%
Grand Total		
Total Cost of Services	66,740,580	100%
In-House Activities	11,808,919	18%
Outsourced Activities	54,931,660	82%
Competitively Procured	42,708,069	64%
Non-Competitively Procured	12,223,591	18%

2016-2018 Competitively Procured Services		
Sector & Cost Categories	**Costs ($)**	**Costs as a Percent of Total Sector Costs (%)**
A - Residential		
Total Cost of Services	113,050,436	100%
In-House Activities	11,966,954	11%
Outsourced Activities	101,083,482	89%
Competitively Procured	96,451,694	85%
Non-Competitively Procured	4,631,788	4%
B - Low-Income		
Total Cost of Services	36,571,265	100%
In-House Activities	4,366,118	12%
Outsourced Activities	32,205,148	88%
Competitively Procured	7,229,027	20%
Non-Competitively Procured	24,976,120	68%
C - Commercial & Industrial		
Total Cost of Services	46,433,333	100%
In-House Activities	17,503,819	38%
Outsourced Activities	28,929,514	62%
Competitively Procured	22,298,562	48%
Non-Competitively Procured	6,630,952	14%
Grand Total		
Total Cost of Services	196,055,035	100%
In-House Activities	33,836,891	17%
Outsourced Activities	162,218,144	83%
Competitively Procured	125,979,284	64%
Non-Competitively Procured	36,238,860	18%

Notes:

General Laws c. 25, § 19(b) requires the Department to ensure that energy efficiency programs use competitive procurement processes to the fullest extent practicable.

Costs for the Competitively Procured Services analysis include Program Planning and Administration; Marketing and Advertising; Sales, Technical Assistance & Training; and Evaluation and Market Research.

Costs for each year in 2016-2018 are represented in nominal dollars (2016$, 2017$, 2018$).

V.D. Outsourced/Competitively Procured Services

3. Comparison Table - Three Year Plan vs. Previous Years

D.P.U. 15-160 to D.P.U. 15-169
Exh. 1, Appendix C
H.O.s Gold and Sawyer

Statewide Gas
October 30, 2015

Sector	Competitively Procured Services Costs ($)					Competitively Procured Services Costs as a Percent of Total Sector Costs (%)				
	Total Cost of Services	In-House Activities	Outsourced Activities			Total Cost of Services	In-House Activities	Outsourced Activities		
			Total Outsourced	Competitively Procured	Non-Competitively Procured			Total Outsourced	Competitively Procured	Non-Competitively Procured
A - Residential	**193,604,991**	**31,496,815**	**162,108,177**	**148,562,266**	**13,545,911**	**100%**	**16%**	**84%**	**77%**	**7%**
2013	26,083,230	6,131,337	19,951,893	17,046,204	2,905,689	100%	24%	76%	65%	11%
2014	26,808,472	6,421,709	20,386,763	17,361,177	3,025,586	100%	24%	76%	65%	11%
2015	27,662,854	6,976,815	20,686,039	17,703,191	2,982,848	100%	25%	75%	64%	11%
2016	36,705,540	3,839,278	32,866,262	31,356,905	1,509,358	100%	10%	90%	85%	4%
2017	37,676,447	3,952,016	33,724,432	32,179,465	1,544,967	100%	10%	90%	85%	4%
2018	38,668,448	4,175,660	34,492,788	32,915,324	1,577,464	100%	11%	89%	85%	4%
B - Low-Income	**68,939,078**	**12,365,071**	**56,574,006**	**17,864,773**	**38,709,234**	**100%**	**18%**	**82%**	**26%**	**56%**
2013	9,967,953	2,142,352	7,825,601	3,413,520	4,412,081	100%	21%	79%	34%	44%
2014	10,645,991	2,645,783	8,000,209	3,512,021	4,488,187	100%	25%	75%	33%	42%
2015	11,753,868	3,210,819	8,543,050	3,710,204	4,832,845	100%	27%	73%	32%	41%
2016	12,093,670	1,403,383	10,690,287	2,421,080	8,269,207	100%	12%	88%	20%	68%
2017	12,140,440	1,442,476	10,697,964	2,410,876	8,287,088	100%	12%	88%	20%	68%
2018	12,337,156	1,520,259	10,816,897	2,397,071	8,419,826	100%	12%	88%	19%	68%
C - Commercial & Industrial	**85,686,897**	**36,913,066**	**48,773,831**	**37,005,514**	**11,768,316**	**100%**	**43%**	**57%**	**43%**	**14%**
2013	12,769,727	6,305,843	6,463,884	4,779,413	1,684,471	100%	49%	51%	37%	13%
2014	13,056,102	6,442,520	6,613,582	4,906,149	1,707,433	100%	49%	51%	38%	13%
2015	13,427,734	6,660,884	6,766,850	5,021,390	1,745,460	100%	50%	50%	37%	13%
2016	15,271,413	5,620,017	9,651,396	7,454,264	2,197,132	100%	37%	63%	49%	14%
2017	15,426,945	5,770,802	9,656,143	7,448,625	2,207,518	100%	37%	63%	48%	14%
2018	15,734,976	6,113,001	9,621,975	7,395,673	2,226,302	100%	39%	61%	47%	14%
Grand Total	**348,230,965**	**80,774,952**	**267,456,014**	**203,432,553**	**64,023,461**	**100%**	**23%**	**77%**	**58%**	**18%**
2013	48,820,909	14,579,532	34,241,377	25,239,137	9,002,241	100%	30%	70%	52%	18%
2014	50,510,565	15,510,011	35,000,554	25,779,347	9,221,207	100%	31%	69%	51%	18%
2015	52,844,456	16,848,518	35,995,939	26,434,785	9,561,153	100%	32%	68%	50%	18%
2016	64,070,623	10,862,678	53,207,946	41,232,249	11,975,697	100%	17%	83%	64%	19%
2017	65,243,832	11,165,294	54,078,538	42,038,966	12,039,572	100%	17%	83%	64%	18%
2018	66,740,580	11,808,919	54,931,660	42,708,069	12,223,591	100%	18%	82%	64%	18%

Notes:
General Laws c. 25, § 19(b) requires the Department to ensure that energy efficiency programs use competitive procurement processes to the fullest extent practicable.
Costs for the Competitively Procured Services analysis include Program Planning and Administration; Marketing and Advertising; Sales, Technical Assistance & Training; and Evaluation and Market Research.
The 2013-2015 costs are from the Program Administrator's 2013-2015 Three-Year Plan, D.P.U. , in nominal dollars (2013$, 2014$, 2015$).
For supporting information on the 2016-2018 values, see Table V.D.1. Costs for each year in 2016-2018 are represented in nominal dollars (2016$, 2017$, 2018$).

VII. Appendix

GHG reductions are provided for information purposes only. They are not included in the TRC test.

D.P.U. 15-160 to D.P.U. 15-169
Statewide Gas
Exh. 1, Appendix C
October 30, 2015
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2016 Greenhouse Gas Reductions

Sector	Adjusted Gross Annual Savings			GHG Factors					Annual Emissions Reductions (Short Tons)		
	Electric Energy (MWh)	Natural Gas (Therms)	Oil (MMBTU)	NOX Electric Energy	SO2 Electric Energy	CO2 Electric Energy	CO2 Natural Gas	CO2 Oil	NOX	SO2	CO2
A - Residential	8,579	15,283,428		0.000193548	0.000172043	0.392473	0.00585	0.080693	1.7	1.5	92,775
B - Low-Income	750	2,054,911		0.000193548	0.000172043	0.392473	0.00585	0.080693	0.1	0.1	12,315
C - Commercial & Industrial	6	12,684,976		0.000193548	0.000172043	0.392473	0.00585	0.080693	0.0	0.0	74,209
Grand Total	**9,335**	**30,023,316**		**0.000193548**	**0.000172043**	**0.392473**	**0.00585**	**0.080693**	**1.8**	**1.6**	**179,300**

2017 Greenhouse Gas Reductions

Sector	Adjusted Gross Annual Savings			GHG Factors					Annual Emissions Reductions (Short Tons)		
	Electric Energy (MWh)	Natural Gas (Therms)	Oil (MMBTU)	NOX Electric Energy	SO2 Electric Energy	CO2 Electric Energy	CO2 Natural Gas	CO2 Oil	NOX	SO2	CO2
A - Residential	8,465	15,350,202		0.000193548	0.000172043	0.392473	0.00585	0.080693	1.6	1.5	93,121
B - Low-Income	756	2,061,664		0.000193548	0.000172043	0.392473	0.00585	0.080693	0.1	0.1	12,357
C - Commercial & Industrial	6	13,046,335		0.000193548	0.000172043	0.392473	0.00585	0.080693	0.0	0.0	76,323
Grand Total	**9,227**	**30,458,201**		**0.000193548**	**0.000172043**	**0.392473**	**0.00585**	**0.080693**	**1.8**	**1.6**	**181,802**

2018 Greenhouse Gas Reductions

Sector	Adjusted Gross Annual Savings			GHG Factors					Annual Emissions Reductions (Short Tons)		
	Electric Energy (MWh)	Natural Gas (Therms)	Oil (MMBTU)	NOX Electric Energy	SO2 Electric Energy	CO2 Electric Energy	CO2 Natural Gas	CO2 Oil	NOX	SO2	CO2
A - Residential	8,344	15,670,708		0.000193548	0.000172043	0.392473	0.00585	0.080693	1.6	1.4	94,948
B - Low-Income	761	2,076,231		0.000193548	0.000172043	0.392473	0.00585	0.080693	0.1	0.1	12,445
C - Commercial & Industrial	5	13,448,558		0.000193548	0.000172043	0.392473	0.00585	0.080693	0.0	0.0	78,676
Grand Total	**9,110**	**31,195,497**		**0.000193548**	**0.000172043**	**0.392473**	**0.00585**	**0.080693**	**1.8**	**1.6**	**186,069**

2016-2018 Greenhouse Gas Reductions

Sector	Adjusted Gross Annual Savings			GHG Factors					Annual Emissions Reductions (Short Tons)		
	Electric Energy (MWh)	Natural Gas (Therms)	Oil (MMBTU)	NOX Electric Energy	SO2 Electric Energy	CO2 Electric Energy	CO2 Natural Gas	CO2 Oil	NOX	SO2	CO2
A - Residential	25,388	46,304,339		0.000193548	0.000172043	0.392473	0.00585	0.080693	4.9	4.4	280,845
B - Low-Income	2,267	6,192,807		0.000193548	0.000172043	0.392473	0.00585	0.080693	0.4	0.4	37,118
C - Commercial & Industrial	16	39,179,869		0.000193548	0.000172043	0.392473	0.00585	0.080693	0.0	0.0	229,208
Grand Total	**27,672**	**91,677,014**		**0.000193548**	**0.000172043**	**0.392473**	**0.00585**	**0.080693**	**5.4**	**4.8**	**547,171**

Notes:
The Program Administrators are working with DEP to determine the best method for properly and precisely capturing the full impact of energy efficiency measures on GHG emissions. As part of this process, the Program Administrators have included this additional table on greenhouse gas reductions, based on continuing discussions with the DEP. These reductions are calculated using factors proposed by DEP, which are based on adjusted gross annual electric energy, natural gas, and oil savings. The Program Administrators look forward to discussing these proposed factors with DEP and are committed to ensuring that the full impact of energy efficiency measures on GHG emissions are captured.

Sector	Benefits (2016$)						TRC Costs (2016$)			Cost-Effectiveness	
	Capacity	Electric Energy	Natural Gas	Deliverable Fuels & Other	Non-Energy Impacts	Total Benefits	PA Budget	Participant Costs	Total TRC Test Costs	B/C Ratio	Net Benefits
2016	**36,497,271**	**15,284,440**	**342,415,233**	**6,183,740**	**144,909,383**	**546,128,374**	**222,708,325**	**71,061,198**	**294,567,357**	**1.85**	**251,561,017**
A - Residential	32,826,711	14,036,338	169,845,772	3,182,821	83,192,520	303,860,365	131,402,295	54,175,424	186,055,759	1.63	117,804,606
B - Low-Income	3,670,560	1,242,483	38,027,497	471,894	34,623,855	78,097,881	45,361,386	-	45,539,870	1.71	32,558,011
C - Commercial & Industrial	-	5,618	134,541,963	2,529,026	27,093,008	164,170,127	45,944,644	16,885,775	62,971,727	2.61	101,198,400
2017	**37,974,096**	**15,736,790**	**339,818,531**	**6,024,452**	**145,087,216**	**545,138,732**	**221,613,409**	**73,737,846**	**296,152,668**	**1.84**	**248,986,065**
A - Residential	34,177,543	14,440,993	168,554,549	3,154,926	82,981,646	303,769,632	131,146,610	56,424,721	188,051,515	1.62	115,718,116
B - Low-Income	3,796,554	1,290,067	37,606,467	472,412	34,790,497	77,993,354	44,687,698	-	44,866,982	1.74	33,126,372
C - Commercial & Industrial	-	5,729	133,657,515	2,397,113	27,315,073	163,375,746	45,779,101	17,313,126	63,234,170	2.58	100,141,576
2018	**39,447,615**	**16,325,654**	**345,736,464**	**6,149,481**	**147,518,188**	**555,399,824**	**222,491,228**	**76,429,321**	**299,725,557**	**1.85**	**255,674,268**
A - Residential	35,556,034	14,980,012	173,181,527	3,219,206	84,241,155	311,383,203	132,074,558	58,107,682	190,664,579	1.63	120,718,624
B - Low-Income	3,891,580	1,340,563	37,688,326	472,668	35,134,272	78,544,387	44,228,366	-	44,408,454	1.77	34,135,933
C - Commercial & Industrial	-	5,079	134,866,611	2,457,607	28,142,761	165,472,234	46,188,304	18,321,639	64,652,523	2.56	100,819,711
Grand Total	**113,918,982**	**47,346,883**	**1,027,970,227**	**18,357,672**	**437,514,786**	**1,646,666,930**	**666,812,962**	**221,228,366**	**890,445,581**	**1.85**	**756,221,349**
A - Residential	102,560,289	43,457,344	511,581,848	9,556,953	250,415,320	919,013,200	394,623,463.04	168,707,827	564,771,854	1.63	354,241,346
B - Low-Income	11,358,694	3,873,114	113,322,291	1,416,974	104,548,624	234,635,623	134,277,449.84	-	134,815,307	1.74	99,820,316
C - Commercial & Industrial	-	16,426	403,066,089	7,383,746	82,550,842	493,018,107	137,912,049.08	52,520,539	190,858,420	2.58	302,159,687

Notes:
GHG reductions are provided for information purposes only. They are not included in the TRC test.

Sector	Annual Net Savings						Avg Measure Life (yrs.)	Summer Capacity Cost (TRC$/Annual kW)	Electric Energy Cost (TRC$/Annual MWh)	Gas Costs (TRC$/Annual Therm)	Participants	Annual Emissions Reductions (Short Tons)		
	Summer Capacity (kW)	Electric Energy (MWh)	Gas (Therms)	Oil (MMBTu)	Propane (MMBTu)	Water (Gallons)						NOX	SO2	CO2
2016	**6,034**	**9,927**	**28,094,852**	**-**	**-**	**76,131,318**	**13**	**48,818**	**29,672**	**10**	**629,128**	**1.8**	**1.6**	**179,300**
A - Residential	5,423	9,174	15,104,655	-	-	42,620,144	12	34,308	20,281	12	612,250	1.7	1.5	92,775
B - Low-Income	611	750	2,054,911	-	-	6,318,977	20	74,542	60,740	22	10,596	0.1	0.1	12,315
C - Commercial & Industrial	-	4	10,935,286	-	-	27,192,197	14		16,519,688	6	6,283	0.0	0.0	74,209
2017	**6,107**	**9,741**	**28,504,379**	**-**	**-**	**77,254,481**	**13**	**48,491**	**30,402**	**10**	**629,700**	**1.8**	**1.6**	**181,802**
A - Residential	5,492	8,981	15,185,401	-	-	43,109,070	12	34,240	20,938	12	612,552	1.6	1.5	93,121
B - Low-Income	615	756	2,061,664	-	-	6,325,923	20	72,927	59,339	22	10,625	0.1	0.1	12,357
C - Commercial & Industrial	-	4	11,257,314	-	-	27,819,488	14		16,588,536	6	6,523	0.0	0.0	76,323
2018	**6,209**	**9,574**	**29,210,387**	**-**	**-**	**78,819,770**	**13**	**48,270**	**31,306**	**10**	**614,482**	**1.8**	**1.6**	**186,069**
A - Residential	5,591	8,809	15,521,036	-	-	43,995,287	12	34,103	21,643	12	597,057	1.6	1.4	94,948
B - Low-Income	619	761	2,076,231	-	-	6,329,346	20	71,788	58,321	21	10,755	0.1	0.1	12,445
C - Commercial & Industrial	-	3	11,613,120	-	-	28,495,136	14		19,576,582	6	6,670	0.0	0.0	78,676
Grand Total	**18,351**	**29,243**	**85,809,618**	**-**	**-**	**232,205,570**	**13**	**48,523**	**30,450**	**10**	**1,873,310**	**5.4**	**4.8**	**547,171**
A - Residential	16,506	26,965	45,811,092	-	-	129,724,501	12	34,216	20,945	12	1,821,859	4.9	4.4	280,845
B - Low-Income	1,845	2,267	6,192,807	-	-	18,974,247	20	73,080	59,461	22	31,976	0.4	0.4	37,118
C - Commercial & Industrial	-	11	33,805,720	-	-	83,506,822	14	#DIV/0!	17,467,665	6	19,475	0.0	0.0	229,208

IV.I. Cost Recovery

1. Calculation of LBR

Statewide Gas
October 30, 2015

2016-2018 Lost Base Revenue				
Sector	**2016**	**2017**	**2018**	**2016-2018**
Residential	129,490	114,151	116,037	359,678
Low-Income	13,044	13,044	13,044	39,131
Commercial & Industrial	85,347	85,765	86,188	257,300
Grand Total	**227,881**	**212,960**	**215,268**	**656,109**

This LBR represents Berkshire Gas only, all other PAs are operating under a decoupled rate plan.

D. **Term Sheet**

September 23, 2015 (Supplement 10-26-15)

2016-2018 ENERGY EFFICIENCY PLAN TERM SHEET

Statewide Electric Summary

	Units	2016	2016-2017	2016-2018
Forecasted Annual Retail Energy Sales	*MWh*	46,908,188	93,745,319	140,331,922
Average Annual Savings Over Three Years	*% of sales*		2.93%	
Cumulative Annual Savings Goals	*MWh*	1,371,584	2,744,075	4,117,539
Cumulative Lifetime Savings Goals	*MWh*	12,812,171	26,205,273	40,384,043
Cumulative Budget: Program Costs*	*millions of $*	$ 598.7	$ 1,219.8	$ 1,857.5
Cost per Annual kWh Saved	*$/kWh*		$0.451	
Summer Demand Savings	*MW*	203	404	598
Winter Demand Savings	*MW*	222	440	649
Benefits	*millions of $*	$ 2,055.3	$ 4,132.9	$ 6,249.6
Cumulative Performance Incentive Pool at Design	*$*			$ 100,000,000
Performance Incentive Levels				
Threshold	*%*			75%
Design	*%*			100%
Exemplary - Cap	*%*			125%

Statewide Gas Summary

	Units	2016	2016-2017	2016-2018
Forecasted Annual Retail Energy Sales	*Therms*	2,270,659,323	4,576,164,520	6,915,678,418
Average Annual Savings Over Three Years	*% of sales*		1.24%	
Cumulative Annual Savings Goals	*Therms*	28,094,852	56,599,232	85,809,618
Cumulative Lifetime Savings Goals	*Therms*	376,308,950	757,115,763	1,149,211,383
Cumulative Budget: Program Costs	*millions of $*	$ 216.9	$ 438.0	$ 665.5
Cost per Annual therm Saved	*$/Therm*		$7.76	
Benefits	*millions of $*	$ 562.7	$ 1,125.4	$ 1,698.8
Cumulative Performance Incentive Pool at Design	*$*			$ 18,000,000
Performance Incentive Levels				
Threshold	*%*			75%
Design	*%*			100%
Exemplary - Cap	*%*			125%

These tables represent only PA energy efficiency costs; they do not include additional cost for new demand programs. The PAs will provide an updated set of detailed energy efficiency data tables consistent with and derived from this Term Sheet in the October 30, 2015 final Plan. These data tables provide extensive additional information such as benefits, program-specific budgets, MW savings, etc. Performance incentives are not applicable to Cape Light Compact.

This Term Sheet outlines savings and budget terms that have been negotiated, with supporting details to be provided in the Plan. This framework is designed with an expectation of a detailed review of the full Three-Year Plan. The costs to achieve and other terms in this Term Sheet are negotiated with the understanding that the final Plan will reflect the majority of Council input and recommendations from the July 21, 2015 resolution and that all recommendations adopted by the PAs are able to be accommodated consistent with the overall provisions of this Term Sheet.

Additional Commitments

The following 2016-2018 Plan priorities of the Council will be specifically addressed in the final Plan:

1) **New Demand Reduction/Peak Reduction Efforts**.

The PAs and the Council recognize the growing economic importance of achieving demand reduction goals and mitigating winter and summer peaks. The Term Sheet does not include targets for potential new statewide summer and winter demand peak reduction initiatives, and does not reflect costs, benefits or incentives associated with such initiatives. Subject to open meeting law requirements, PA representatives will work with a small Demand Savings Group that includes the DOER, the Attorney General's Office, the Low-Income Energy Affordability Network, interested expert and qualified stakeholders and the Council's consultants to explore approaches to cost-effective new demand reduction/peak reduction electric and gas initiatives. This Demand Savings Group will be addressing challenging and important matters, and all parties are committed to the successful development and actual implementation in-the-field during the 2016-2018 Plan period of new demand/peak reduction initiatives. To ensure that this in-the-field implementation goal is reached, the PAs will provide a report to the Council setting forth the specific scope, tasks, and detailed timelines for this group by the end of Q1 2016. This report will also provide an anticipated, high-level in-the-field deployment schedule for 2016-2018 based upon the then most current information. Deployment in-the-field will be subject to approval by the Department of Public Utilities and confirmation of cost-effectiveness. The PAs will also provide a report to the Council on the ongoing "super peak" avoided cost study on or before December 31, 2015 (if that study is delayed, this PA deliverable date will be appropriately adjusted).[1]

2) **Continued Commitment to Innovation and Technology**.

The Council and the PAs agree on the importance of implementation of new technologies and program approaches. The PAs are committed to increasingly develop and deploy new technologies, delivery models and business strategies with performance-based results that are appropriate for the customers and that are proven to be cost-effective. The Plan will reflect a continuous commitment by the PAs to exploring and adopting cost-effective innovations and new technologies in the residential, low-income and C&I sectors. In addition to specific efforts identified in the Plan, the PAs commit to continuous collaboration on innovation, including appropriate program updates and evaluation efforts with the Council.

[1] CLC reserves its right to raise issues at any time with either the Demand Savings Group or the EEAC generally regarding its unique role as a municipal aggregator that may affect its ability to fully participate in the development and implementation of demand/peak reduction initiatives.

3) **Contractor Engagement**.

The Council and the PAs recognize that the successful implementation of the Three-Year Plan requires an engaged contractor community. The PAs and the Council will collaborate to identify opportunities to continue to maximize the impact of the contractor community in order to maintain high quality, cost-effective/efficient, high impact programs and increase penetration and success in new sectors. As part of this effort, the PAs will participate in a new Residential Contractor engagement effort to be convened by the DOER. PAs will participate in residential program related topics as appropriate, which may include how residential program contractors can be most effectively engaged in the programs, quality assurance/quality control related topics, appropriate data collection and analysis, and suggestions from the contractor community and the PAs for enhancements and improvements. This DOER effort is not in replacement of the ongoing contractor Best Practices group and does not constitute the formation of a new regulatory or adjudicatory body. The PAs will continue to have the right and responsibility to require contractor engagement and contract terms that protect customers consistent with their corporate/institutional quality and safety standards.

NOTES

- **Core Electric Terms**. Annual savings goal for 2016-2018 of 2.93% of retail sales (based upon April 2015 sales forecast). At least 40.3M MWh lifetime savings goal, with lifetime savings goal showing year-over-year growth from 2016-2018. Annual cost-to-achieve budget for 2016-2018 of $0.453 or below. Performance incentive pool of $100M at design, with threshold of 75% and cap of 125%.[2]
- **Core Gas Terms**. Annual savings goal for 2016-2018 of 1.24% of retail sales (based upon April 2015 sales forecast). At least 1.1B therms lifetime savings goal, with lifetime and annual savings goals showing year-over-year growth for 2016-2018. Annual cost-to-achieve budget for 2016-2018 of $7.81 or below. Performance incentive pool of $18M at design, with threshold of 75% and cap of 125%.[3]
- **Confirmation**. All savings and budget figures are subject to confirmation and quality control checks as the PAs develop detailed tables consistent with this term sheet. Final savings and budget numbers may be slightly higher or lower than these values, but all within a reasonable, non-material bandwidth that does not reduce the overall statewide annual savings target. Retail sales projections reflect forecasts that were available in April 2015 and may not reflect each PA's most up-to-date sales forecast; forecasts are updated periodically.

[2] Performance incentives are not applicable to Cape Light Compact.

[3] National Grid Gas goals and performance incentives incorporate savings and benefits of both the National Grid and Blackstone Gas service areas, consistent with the Council Resolution of March 31, 2015, and are subject to the Department of Public Utilities issuing an order in support of this approach endorsed by the Council, including the Council-supported conditions that there are not separate reporting requirements for the Blackstone and National Grid services areas, and that savings and benefits secured in the Blackstone service area count toward National Grid's performance incentive.

- **Aggressive Goals**. The PAs have utilized an integrated, statewide approach to commit to the increased aggressive statewide savings levels set forth in this term sheet at costs that reflect reductions from those proposed costs presented to the Energy Efficiency Advisory Council in the April 30, 2015 draft 2016-2018 Plan. The individual PA savings levels and costs reflected in Attachment A are appropriate for the 2016-2018 Plan and have been developed through analysis and consideration of evaluation and potential studies.

  Savings goals assume consistent treatment for co-generation facility-related savings as in the past. Consistent with other measures, this includes that new projects installed after the end-of-life of an existing project are given full credit for all cost-effective project savings.

- **Effect of New Legislation or Regulations**. The PAs may be required to offer an Accelerated Rebate Pilot Program ("ARPP") or similar effort by new legislation. Additionally, DOER is currently in the process of issuing new RCS regulations and guidelines. In the event that material impacts occur from an ARPP, a new municipal aggregator program, the RCS regulations or guidelines, or any other new legislation or regulations issued prior to or during the three-year plan term, any affected PA shall have the opportunity to make appropriate adjustments to its costs and savings goals based upon the nature of the impacts, subject to the Council review under G.L. ch. 25, § 21(c) and the approval of the Department of Public Utilities.

- **Performance Incentives**.
  - Statewide performance incentive pool at design level: $100 million (electric); $18 million (gas).
  - Two components of PI mechanism: Savings (dollar value of benefits) and Value (dollar value of net benefits).
  - Incentive component weights: 61.5% Savings, 38.5% Value.
  - The threshold for earning performance incentives shall be 75% of target, with a cap of 125% of design level of performance incentive, each at the at the portfolio level of performance for each PA by component.[4]

[4] Performance incentives are not applicable to Cape Light Compact.

PRIVILEGED AND CONFIDENTIAL

2016-2018 ELECTRIC TERM SHEET

	Units	2016	2016-2017	2016-2018
Forecasted Annual Retail Energy Sales	*MWh*	46,908,188	93,745,319	140,331,922
Average Annual Savings Over Three Years	*% of sales*		2.93%	
Cumulative Annual Savings Goals	*MWh*	1,371,584	2,744,075	4,117,539
Cumulative Lifetime Savings Goals	*MWh*	12,812,171	26,205,273	40,384,043
Cumulative Budget: Program Costs*	*millions of $*	$ 598.7	$ 1,219.8	$ 1,857.5
Cost per Annual kWh Saved	*$/kWh*		$0.451	
Summer Demand Savings	*MW*	203	404	598
Winter Demand Savings	*MW*	222	440	649
Benefits	*millions of $*	$ 2,055.3	$ 4,132.9	$ 6,249.6
Cumulative Performance Incentive Pool at Design	*$*			$ 100,000,000
Performance Incentive Levels				
Threshold	*%*			75%
Design	*%*			100%
Exemplary - Cap	*%*			125%

**Represents only PA energy efficiency costs (i.e., excludes PI, customer cost, and demand reduction specific costs)*

PRIVILEGED AND CONFIDENTIAL

Statewide Electric

As of: Oct 23, 2015

2016	Sales Forecast (MWh)	Budget	Annual Savings (MWh)	Percent of Sales	$/Annual kWh	Lifetime Savings (MWh)	$/Lifetime kWh	Summer kW	Winter kW	Benefits
Residential	15,536,557	$261,996,417	627,236	4.04%	$0.418	4,691,710	$0.0558	83,921	107,209	$ 836,674,492
Low-Income	2,105,459	$67,622,900	40,615	1.93%	$1.665	354,456	$0.1908	4,594	9,311	$ 114,894,978
C&I	29,266,172	$269,073,440	703,733	2.40%	$0.382	7,766,005	$0.0346	98,301	85,677	$ 1,103,686,996
Total	46,908,188	$598,692,757	1,371,584	2.92%	$0.436	12,812,171	$0.0467	186,816	202,197	$ 2,055,256,466

2017	Sales Forecast (MWh)	Budget	Annual Savings (MWh)	Percent of Sales	$/Annual kWh	Lifetime Savings (MWh)	$/Lifetime kWh	Summer kW	Winter kW	Benefits
Residential	15,523,733	$270,373,654	583,876	3.76%	$0.463	4,475,104	$0.0604	79,391	101,218	$ 813,416,230
Low-Income	2,153,913	$68,102,519	39,222	1.82%	$1.736	340,960	$0.1997	4,453	9,009	$ 115,119,786
C&I	29,159,485	$282,611,761	749,393	2.57%	$0.377	8,577,037	$0.0329	104,555	92,275	$ 1,149,087,749
Total	46,837,131	$621,087,935	1,372,491	2.93%	$0.453	13,393,102	$0.0464	188,399	202,501	$ 2,077,623,765

2018	Sales Forecast (MWh)	Budget	Annual Savings (MWh)	Percent of Sales	$/Annual kWh	Lifetime Savings (MWh)	$/Lifetime kWh	Summer kW	Winter kW	Benefits
Residential	15,474,889	$275,322,536	528,881	3.42%	$0.521	4,152,990	$0.0663	73,054	92,994	$ 784,822,034
Low-Income	2,199,889	$67,815,772	38,215	1.74%	$1.775	344,907	$0.1966	4,363	8,807	$ 115,354,581
C&I	28,911,824	$294,583,688	806,368	2.79%	$0.365	9,680,873	$0.0304	110,753	99,274	$ 1,216,505,822
Total	46,586,603	$637,721,996	1,373,464	2.95%	$0.464	14,178,770	$0.0450	188,171	201,075	$ 2,116,682,437

2016-2018	Sales Forecast (MWh)	Budget	Annual Savings (MWh)	Percent of Sales	$/Annual kWh	Lifetime Savings (MWh)	$/Lifetime kWh	Summer kW	Winter kW	Benefits
Residential	46,535,180	$807,692,607	1,739,994	3.74%	$0.464	13,319,805	$0.0606	236,366	301,420	$ 2,434,912,757
Low-Income	6,459,260	$203,541,192	118,051	1.83%	$1.724	1,040,323	$0.1957	13,410	27,127	$ 345,369,345
C&I	87,337,482	$846,268,889	2,259,495	2.59%	$0.375	26,023,915	$0.0325	313,609	277,226	$ 3,469,280,567
Total	140,331,922	$1,857,502,687	4,117,539	2.93%	$0.451	40,384,043	$0.0460	563,385	605,774	$ 6,249,562,668

PRIVILEGED AND CONFIDENTIAL

National Grid Electric

As of: Oct 23, 2015

2016	**Sales Forecast (MWh)**	**Budget**	**Annual Savings (MWh)**	**Percent of Sales**	**$/Annual kWh**	**Lifetime Savings (MWh)**	**$/Lifetime kWh**	**Summer kW**	**Winter kW**	**Benefits**
Residential	7,962,402	$125,228,252	344,163	4.32%	$0.364	2,435,610	$0.051	45,494	59,668	$402,457,438
Low-Income	1,281,545	$32,544,343	20,968	1.64%	$1.552	188,220	$0.173	2,396	4,432	$56,688,814
C&I	12,656,745	$118,663,272	275,912	2.18%	$0.430	3,043,259	$0.039	46,114	40,063	$436,953,027
Total	21,900,693	$276,435,867	641,043	2.93%	$0.431	5,667,089	$0.049	94,003	104,163	896,099,280

2017	**Sales Forecast (MWh)**	**Budget**	**Annual Savings (MWh)**	**Percent of Sales**	**$/Annual kWh**	**Lifetime Savings (MWh)**	**$/Lifetime kWh**	**Summer kW**	**Winter kW**	**Benefits**
Residential	7,983,897	$132,022,746	331,603	4.15%	$0.398	2,455,409	$0.054	44,073	57,894	$402,537,242
Low-Income	1,333,990	$32,875,646	20,608	1.54%	$1.595	179,727	$0.183	2,356	4,373	$56,714,745
C&I	12,677,646	$119,855,549	298,147	2.35%	$0.402	3,220,601	$0.037	50,085	43,399	$457,341,602
Total	21,995,534	$284,753,940	650,358	2.96%	$0.438	5,855,737	$0.049	96,514	105,666	916,593,590

2018	**Sales Forecast (MWh)**	**Budget**	**Annual Savings (MWh)**	**Percent of Sales**	**$/Annual kWh**	**Lifetime Savings (MWh)**	**$/Lifetime kWh**	**Summer kW**	**Winter kW**	**Benefits**
Residential	7,996,210	$134,819,234	309,373	3.87%	$0.436	2,373,069	$0.057	41,536	54,675	$394,622,150
Low-Income	1,386,678	$32,952,695	20,148	1.45%	$1.636	186,853	$0.176	2,296	4,296	$57,457,336
C&I	12,656,314	$121,031,055	318,380	2.52%	$0.380	3,610,935	$0.034	52,968	46,040	$488,136,555
Total	22,039,202	$288,802,985	647,901	2.94%	$0.446	6,170,857	$0.047	96,800	105,011	940,216,041

2016-2018	**Sales Forecast (MWh)**	**Budget**	**Annual Savings (MWh)**	**Percent of Sales**	**$/Annual kWh**	**Lifetime Savings (MWh)**	**$/Lifetime kWh**	**Summer kW**	**Winter kW**	**Benefits**
Residential	23,942,509	$392,070,232	985,139	4.11%	$0.398	7,264,088	$0.054	131,102	172,237	$1,199,616,830
Low-Income	4,002,213	$98,372,684	61,724	1.54%	$1.594	554,799	$0.177	7,048	13,101	$170,860,895
C&I	37,990,705	$359,549,876	892,439	2.35%	$0.403	9,874,795	$0.036	149,167	129,502	$1,382,431,185
Total	65,935,428	$849,992,792	1,939,301	2.94%	$0.438	$ 17,693,682	$0.048	287,317	314,840	$ 2,752,908,910

PRIVILEGED AND CONFIDENTIAL

Eversource Electric

As of: Oct 23, 2015

2016	Sales Forecast (MWh)	Budget	Annual Savings (MWh)	Percent of Sales	$/Annual kWh	Lifetime Savings (MWh)	$/Lifetime kWh	Summer kW	Winter kW	Benefits
Residential	6,390,407	$113,581,668	260,250	4.07%	$0.436	2,026,951	$0.056	35,283	43,281	$369,652,733
Low-Income	699,100	$30,438,637	17,774	2.54%	$1.712	146,996	$0.207	1,920	4,471	$47,311,025
C&I	15,465,152	$135,063,444	385,791	2.49%	$0.350	4,340,494	$0.031	48,934	42,344	$613,975,065
Total	22,554,660	$279,083,748	663,816	2.94%	$0.420	6,514,441	$0.043	86,137	90,096	1,030,938,823

2017	Sales Forecast (MWh)	Budget	Annual Savings (MWh)	Percent of Sales	$/Annual kWh	Lifetime Savings (MWh)	$/Lifetime kWh	Summer kW	Winter kW	Benefits
Residential	6,359,200	$114,235,097	231,622	3.64%	$0.493	1,801,015	$0.063	32,326	39,346	$344,588,259
Low-Income	695,070	$30,143,492	16,628	2.39%	$1.813	140,419	$0.215	1,805	4,194	$46,211,734
C&I	15,341,941	$145,118,976	409,040	2.67%	$0.355	4,978,456	$0.029	50,960	45,573	$637,986,539
Total	22,396,211	$289,497,565	657,290	2.93%	$0.440	6,919,889	$0.042	85,091	89,113	1,028,786,532

2018	Sales Forecast (MWh)	Budget	Annual Savings (MWh)	Percent of Sales	$/Annual kWh	Lifetime Savings (MWh)	$/Lifetime kWh	Summer kW	Winter kW	Benefits
Residential	6,306,686	$115,256,222	200,593	3.18%	$0.575	1,567,203	$0.074	28,709	34,509	$322,168,312
Low-Income	688,489	$29,295,282	15,900	2.31%	$1.842	134,727	$0.217	1,752	4,009	$44,990,193
C&I	15,123,606	$153,435,909	443,640	2.93%	$0.346	5,670,441	$0.027	53,762	49,474	$669,666,510
Total	22,118,781	$297,987,414	660,134	2.98%	$0.451	7,372,371	$0.040	84,224	87,992	1,036,825,015

2016-2018	Sales Forecast (MWh)	Budget	Annual Savings (MWh)	Percent of Sales	$/Annual kWh	Lifetime Savings (MWh)	$/Lifetime kWh	Summer kW	Winter kW	Benefits
Residential	19,056,293	$ 343,072,987	692,465	3.63%	$0.495	5,395,168	$0.064	96,319	117,135	$1,036,409,304
Low-Income	2,082,659	$ 89,877,411	50,302	2.42%	$1.787	422,142	$0.213	5,478	12,674	$138,512,952
C&I	45,930,700	$ 433,618,328	1,238,472	2.70%	$0.350	14,989,391	$0.029	153,656	137,392	$1,921,628,115
Total	67,069,652	$ 866,568,727	1,981,239	2.95%	$0.437	20,806,701	$0.042	255,453	267,201	3,096,550,370

PRIVILEGED AND CONFIDENTIAL

Cape Light Compact

As of: Oct 23, 2015

2016	Sales Forecast (MWh)	Budget	Annual Savings (MWh)	Percent of Sales	$/Annual kWh	Lifetime Savings (MWh)	$/Lifetime kWh	Summer kW	Winter kW	Benefits
Residential	1,064,454	$21,682,579	21,164	1.99%	$1.025	214,736	$0.101	2,909	3,949	$59,028,748
Low-Income	63,879	$4,045,512	1,646	2.58%	$2.457	16,739	$0.242	245	349	$9,582,085
C&I	884,418	$12,672,028	35,664	4.03%	$0.355	304,480	$0.042	2,426	2,433	$40,691,000
Total	2,012,751	$38,400,119	58,474	2.91%	$0.657	535,955	$0.072	5,580	6,732	109,301,833

2017	Sales Forecast (MWh)	Budget	Annual Savings (MWh)	Percent of Sales	$/Annual kWh	Lifetime Savings (MWh)	$/Lifetime kWh	Summer kW	Winter kW	Benefits
Residential	1,060,737	$22,596,621	18,989	1.79%	$1.190	204,061	$0.111	2,746	3,661	$60,510,313
Low-Income	63,607	$4,464,004	1,758	2.76%	$2.539	18,257	$0.245	259	382	$10,870,025
C&I	879,565	$14,936,382	35,764	4.07%	$0.418	302,766	$0.049	2,663	2,438	$42,086,155
Total	2,003,909	$41,997,006	56,511	2.82%	$0.743	525,083	$0.080	5,668	6,481	113,466,493

2018	Sales Forecast (MWh)	Budget	Annual Savings (MWh)	Percent of Sales	$/Annual kWh	Lifetime Savings (MWh)	$/Lifetime kWh	Summer kW	Winter kW	Benefits
Residential	1,051,243	$23,712,462	17,284	1.64%	$1.372	197,549	$0.120	2,556	3,461	$62,316,503
Low-Income	63,042	$4,967,996	1,936	3.07%	$2.567	20,600	$0.241	282	433	$11,585,926
C&I	870,787	$17,390,697	37,792	4.34%	$0.460	322,420	$0.054	3,180	2,901	$46,910,696
Total	1,985,071	$46,071,154	57,012	2.87%	$0.808	540,570	$0.085	6,019	6,796	120,813,125

2016-2018	Sales Forecast (MWh)	Budget	Annual Savings (MWh)	Percent of Sales	$/Annual kWh	Lifetime Savings (MWh)	$/Lifetime kWh	Summer kW	Winter kW	Benefits
Residential	3,176,434	$67,991,662	57,436	1.81%	$1.184	616,346	$0.110	8,212	11,071	$181,855,564
Low-Income	190,527	$13,477,511	5,340	2.80%	$2.524	55,596	$0.242	786	1,165	$32,038,036
C&I	2,634,770	$44,999,106	109,220	4.15%	$0.412	929,666	$0.048	8,270	7,772	$129,687,851
Total	6,001,732	$126,468,280	171,996	2.87%	$0.735	1,601,608	$0.079	17,267	20,008	343,581,451

PRIVILEGED AND CONFIDENTIAL

Unitil Electric

As of: Oct 23, 2015

2016	Sales Forecast (MWh)	Budget	Annual Savings (MWh)	Percent of Sales	$/Annual kWh	Lifetime Savings (MWh)	$/Lifetime kWh	Summer kW	Winter kW	Benefits
Residential	119,294	$1,503,918	1,660	1.39%	$0.906	14,414	$0.104	236	310	$5,535,573
Low-Income	60,935	$594,408	226	0.37%	$2.630	2,501	$0.238	33	59	$1,313,054
C&I	259,856	$2,674,696	6,366	2.45%	$0.420	77,772	$0.034	827	837	$12,067,903
Total	440,085	$4,773,022	8,252	1.88%	$0.578	94,687	$0.050	1,095	1,206	18,916,530

2017	Sales Forecast (MWh)	Budget	Annual Savings (MWh)	Percent of Sales	$/Annual kWh	Lifetime Savings (MWh)	$/Lifetime kWh	Summer kW	Winter kW	Benefits
Residential	119,900	$1,519,191	1,663	1.39%	$0.914	14,620	$0.104	245	317	$5,780,416
Low-Income	61,245	$619,378	228	0.37%	$2.717	2,558	$0.242	33	60	$1,323,282
C&I	260,332	$2,700,855	6,442	2.47%	$0.419	75,214	$0.036	847	865	$11,673,452
Total	441,477	$4,839,424	8,333	1.89%	$0.581	92,392	$0.052	1,125	1,242	18,777,150

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2018	Sales Forecast (MWh)	Budget	Annual Savings (MWh)	Percent of Sales	$/Annual kWh	Lifetime Savings (MWh)	$/Lifetime kWh	Summer kW	Winter kW	Benefits
Residential	120,750	$1,534,617	1,631	1.35%	$0.941	15,170	$0.101	253	350	$5,715,070
Low-Income	61,679	$599,799	232	0.38%	$2.585	2,726	$0.220	32	68	$1,321,126
C&I	261,118	$2,726,027	6,555	2.51%	$0.416	77,077	$0.035	843	859	$11,792,061
Total	443,548	$4,860,443	8,418	1.90%	$0.577	94,973	$0.051	1,127	1,277	18,828,257

2016-2018	Sales Forecast (MWh)	Budget	Annual Savings (MWh)	Percent of Sales	$/Annual kWh	Lifetime Savings (MWh)	$/Lifetime kWh	Summer kW	Winter kW	Benefits
Residential	359,944	$4,557,726	4,954	1.38%	$0.920	44,204	$0.103	734	977	$17,031,059
Low-Income	183,860	$1,813,585	686	0.37%	$2.644	7,785	$0.233	98	187	$3,957,462
C&I	781,306	$8,101,578	19,363	2.48%	$0.418	230,063	$0.035	2,516	2,561	$35,533,416
Total	1,325,110	$14,472,889	25,003	1.89%	$0.579	282,052	$0.051	3,348	3,725	56,521,937

2016-2018 GAS TERM SHEET

	Units	2016	2016-2017	2016-2018
Forecasted Annual Retail Energy Sales	*Therms*	2,270,659,323	4,576,164,520	6,915,678,418
Average Annual Savings Over Three Years	*% of sales*		1.24%	
Cumulative Annual Savings Goals	*Therms*	28,094,852	56,599,232	85,809,618
Cumulative Lifetime Savings Goals	*Therms*	376,308,950	757,115,763	1,149,211,383
Cumulative Budget: Program Costs	*millions of $*	$ 216.9	$ 438.0	$ 665.5
Cost per Annual therm Saved	*$/Therm*		$7.76	
Benefits	*millions of $*	$ 562.7	$ 1,125.4	$ 1,698.8
Cumulative Performance Incentive Pool at Design	*$*			$ 18,000,000
Performance Incentive Levels				
Threshold	*%*			75%
Design	*%*			100%
Exemplary - Cap	*%*			125%

Statewide Gas

As of: October 23, 2015

2016	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	1,121,092,786	$ 128,380,576	15,104,655	1.35%	$8.50	179,262,960	$0.72	$ 315,020,828
Low-Income	110,468,544	$ 44,552,694	2,054,911	1.86%	$21.68	40,776,119	$1.09	$ 77,795,597
C&I	1,039,097,993	$ 43,935,544	10,935,286	1.05%	$4.02	156,269,870	$0.28	$ 169,886,497
Total	2,270,659,323	$ 216,868,814	28,094,852	1.24%	$7.72	376,308,950	$0.58	$ 562,702,922

2017	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	1,136,157,160	$ 131,257,100	15,185,401	1.34%	$8.64	181,611,425	$0.72	$ 315,542,001
Low-Income	111,738,997	$ 44,988,692	2,061,664	1.85%	$21.82	40,903,623	$1.10	$ 77,696,332
C&I	1,057,609,041	$ 44,866,162	11,257,314	1.06%	$3.99	158,291,766	$0.28	$ 169,440,263
Total	2,305,505,197	$ 221,111,954	28,504,379	1.24%	$7.76	380,806,813	$0.58	$ 562,678,596

2018	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	1,151,752,598	$ 135,468,457	15,521,036	1.35%	$8.73	188,713,984	$0.72	$ 323,433,980
Low-Income	113,073,095	$ 45,635,213	2,076,231	1.84%	$21.98	41,199,508	$1.11	$ 78,249,844
C&I	1,074,688,204	$ 46,442,377	11,613,120	1.08%	$4.00	162,182,128	$0.29	$ 171,710,468
Total	2,339,513,897	$ 227,546,047	29,210,387	1.25%	$7.79	392,095,620	$0.58	$ 573,394,293

2016-2018	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	3,409,002,544	$ 395,106,134	45,811,092	1.34%	$8.62	549,588,369	$0.72	$ 953,996,809
Low-Income	335,280,636	$ 135,176,599	6,192,807	1.85%	$21.83	122,879,250	$1.10	$ 233,741,773
C&I	3,171,395,238	$ 135,244,083	33,805,720	1.07%	$4.00	476,743,765	$0.28	$ 511,037,229
Total	6,915,678,418	$ 665,526,816	85,809,618	1.24%	$7.76	1,149,211,383	$0.58	$ 1,698,775,811

National Grid Gas

As of: October 23, 2015

2016	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	652,710,046	$75,816,552	9,889,507	1.52%	$7.67	100,675,764	$0.75	$176,822,592
Low-Income	41,662,343	$25,763,662	1,268,355	3.04%	$20.31	24,472,280	$1.05	$46,346,990
C&I	587,349,817	$22,940,051	5,185,344	0.88%	$4.42	72,208,476	$0.32	$79,481,607
Total	1,281,722,207	$124,520,265	16,343,206	1.28%	$7.62	197,356,520	$0.63	302,651,189

2017	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	666,204,635	$77,639,526	10,045,157	1.51%	$7.73	103,475,602	$0.75	$178,924,055
Low-Income	42,523,700	$25,818,865	1,268,355	2.98%	$20.36	24,472,280	$1.06	$46,084,683
C&I	601,082,125	$23,447,319	5,413,816	0.90%	$4.33	72,657,601	$0.32	$79,516,135
Total	1,309,810,460	$126,905,710	16,727,328	1.28%	$7.59	200,605,484	$0.63	304,524,874

2018	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	679,322,856	$80,247,500	10,305,126	1.52%	$7.79	108,190,149	$0.74	$183,805,985
Low-Income	43,361,033	$25,810,641	1,268,355	2.93%	$20.35	24,472,280	$1.05	$46,022,111
C&I	614,519,090	$24,201,360	5,677,659	0.92%	$4.26	75,082,111	$0.32	$81,440,654
Total	1,337,202,980	$130,259,500	17,251,140	1.29%	$7.55	207,744,539	$0.63	311,268,750

2016-2018	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	1,998,237,537	$233,703,578	30,239,790	1.51%	$7.73	312,341,515	$0.75	$539,552,632
Low-Income	127,547,077	$77,393,168	3,805,066	2.98%	$20.34	73,416,840	$1.05	$138,453,784
C&I	1,802,951,032	$70,588,730	16,276,819	0.90%	$4.34	219,948,188	$0.32	$240,438,396
Total	3,928,735,646	$381,685,476	50,321,675	1.28%	$7.58	605,706,543	$0.63	918,444,812

Eversource Gas

As of: October 23, 2015

2016	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	203,755,403	$26,182,297	2,802,507	1.38%	$9.34	32,460,193	$0.81	$57,816,651
Low-Income	21,512,245	$9,279,054	337,089	1.57%	$27.53	6,991,738	$1.33	$16,835,076
C&I	280,310,571	$10,892,717	3,353,456	1.20%	$3.25	47,938,180	$0.23	$50,443,330
Total	505,578,219	$46,354,069	6,493,052	1.28%	$7.14	87,390,111	$0.53	$125,095,058

2017	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	203,036,917	$27,135,101	2,754,727	1.36%	$9.85	32,607,267	$0.83	$58,010,045
Low-Income	21,434,833	$9,585,378	346,677	1.62%	$27.65	7,180,499	$1.33	$17,139,362
C&I	281,813,521	$11,186,415	3,421,915	1.21%	$3.27	48,915,254	$0.23	$50,249,648
Total	506,285,271	$47,906,894	6,523,319	1.29%	$7.34	88,703,021	$0.54	$125,399,054

2018	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	203,094,284	$28,347,055	2,777,038	1.37%	$10.21	33,867,477	$0.84	$59,587,313
Low-Income	21,438,188	$10,047,053	360,868	1.68%	$27.84	7,468,637	$1.35	$17,757,997
C&I	283,726,843	$11,840,183	3,494,342	1.23%	$3.39	49,960,314	$0.24	$50,705,817
Total	508,259,314	$50,234,290	6,632,247	1.30%	$7.57	91,296,428	$0.55	$128,051,127

2016-2018	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	609,886,604	$81,664,453	8,334,272	1.37%	$9.80	98,934,938	$0.83	$175,414,009
Low-Income	64,385,265	$28,911,485	1,044,634	1.62%	$27.68	21,640,875	$1.34	$51,732,435
C&I	845,850,935	$33,919,315	10,269,713	1.21%	$3.30	146,813,748	$0.23	$151,398,795
Total	1,520,122,804	$144,495,254	19,648,619	1.29%	$7.35	267,389,560	$0.54	$378,545,239

Columbia Gas of Massachusetts

As of: October 23, 2015

2016	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	200,339,969	$20,492,285	1,908,612	0.95%	$10.74	37,781,956	$0.54	$66,575,024
Low-Income	31,746,990	$7,175,793	356,228	1.12%	$20.14	7,381,851	$0.97	$11,051,359
C&I	90,089,117	$7,585,896	1,876,083	2.08%	$4.04	26,674,639	$0.28	$29,958,031
Total	322,176,076	$35,253,974	4,140,924	1.29%	$8.51	71,838,445	$0.49	$107,584,414

2017	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	201,462,047	$20,842,296	1,915,879	0.95%	$10.88	37,994,448	$0.55	$66,704,532
Low-Income	31,924,801	$7,250,204	352,557	1.10%	$20.56	7,304,702	$0.99	$10,884,164
C&I	92,342,897	$7,682,577	1,883,361	2.04%	$4.08	27,012,615	$0.28	$29,491,100
Total	325,729,745	$35,775,077	4,151,797	1.27%	$8.62	72,311,764	$0.49	$107,079,796

2018	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	202,971,669	$21,119,323	1,956,638	0.96%	$10.79	38,869,815	$0.54	$67,837,626
Low-Income	32,164,024	$7,426,432	352,557	1.10%	$21.06	7,304,702	$1.02	$10,871,350
C&I	94,022,084	$7,812,102	1,899,078	2.02%	$4.11	27,341,728	$0.29	$29,394,753
Total	329,157,777	$36,357,857	4,208,274	1.28%	$8.64	73,516,245	$0.49	$108,103,729

2016-2018	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	604,773,685	$62,453,904	5,781,129	0.96%	$10.80	114,646,219	$0.54	$201,117,182
Low-Income	95,835,815	$21,852,430	1,061,343	1.11%	$20.59	21,991,254	$0.99	$32,806,874
C&I	276,454,098	$23,080,574	5,658,522	2.05%	$4.08	81,028,981	$0.28	$88,843,884
Total	977,063,598	$107,386,907	12,500,994	1.28%	$8.59	217,666,454	$0.49	$322,767,940

Liberty Utilities

As of: October 23, 2015

2016	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	30,098,005	$1,970,215	163,238	0.54%	$12.07	3,240,038	$0.61	$4,677,290
Low-Income	8,000,735	$912,683	33,820	0.42%	$26.99	724,936	$1.26	$1,279,006
C&I	26,239,590	$815,935	141,166	0.54%	$5.78	2,053,239	$0.40	$2,554,176
Total	64,338,330	$3,698,833	338,224	0.53%	$10.94	6,018,213	$0.61	$8,510,473

2017	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	30,420,467	$1,964,297	162,085	0.53%	$12.12	3,219,280	$0.61	$4,622,384
Low-Income	8,086,453	$898,928	33,820	0.42%	$26.58	724,936	$1.24	$1,270,801
C&I	26,620,950	$830,399	153,450	0.58%	$5.41	2,227,415	$0.37	$2,683,625
Total	65,127,870	$3,693,624	349,355	0.54%	$10.57	6,171,632	$0.60	$8,576,810

2018	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	30,634,480	$1,978,553	166,738	0.54%	$11.87	3,312,340	$0.60	$4,697,753
Low-Income	8,143,370	$903,782	33,774	0.41%	$26.76	724,240	$1.25	$1,264,648
C&I	26,598,060	$850,522	154,769	0.58%	$5.50	2,252,719	$0.38	$2,647,650
Total	65,375,910	$3,732,857	355,281	0.54%	$10.51	6,289,299	$0.59	$8,610,050

2016-2018	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	91,152,952	$5,913,065	492,061	0.54%	$12.02	9,771,659	$0.61	$13,997,426
Low-Income	24,230,558	$2,715,394	101,414	0.42%	$26.78	2,174,112	$1.25	$3,814,455
C&I	79,458,600	$2,496,856	449,385	0.57%	$5.56	6,533,374	$0.38	$7,885,451
Total	194,842,110	$11,125,314	1,042,860	0.54%	$10.67	18,479,144	$0.60	$25,697,332

Berkshire Gas

As of: October 23, 2015

2016	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	26,297,849	$2,845,848	273,178	1.04%	$10.42	3,802,763	$0.75	$6,596,210
Low-Income	4,897,701	$950,752	37,658	0.77%	$25.25	788,995	$1.21	$1,475,886
C&I	41,779,017	$1,108,803	253,104	0.61%	$4.38	4,928,440	$0.22	$5,140,619
Total	72,974,568	$4,905,403	563,940	0.77%	$8.70	9,520,197	$0.52	$13,212,714

2017	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	27,067,390	$2,581,350	240,818	0.89%	$10.72	3,024,132	$0.85	$4,755,556
Low-Income	5,041,021	$954,355	37,658	0.75%	$25.34	788,995	$1.21	$1,469,324
C&I	42,367,002	$1,115,088	254,391	0.60%	$4.38	4,954,185	$0.23	$5,092,897
Total	74,475,413	$4,650,794	532,868	0.72%	$8.73	8,767,312	$0.53	$11,317,777

2018	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	27,683,288	$2,658,627	244,795	0.88%	$10.86	3,099,357	$0.86	$4,812,779
Low-Income	5,155,725	$957,232	37,658	0.73%	$25.42	788,995	$1.21	$1,467,793
C&I	42,363,025	$1,120,804	255,696	0.60%	$4.38	4,980,297	$0.23	$5,090,684
Total	75,202,039	$4,736,664	538,150	0.72%	$8.80	8,868,648	$0.53	$11,371,255

2016-2018	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	81,048,528	$8,085,826	758,792	0.94%	$10.66	9,926,252	$0.81	$16,164,545
Low-Income	15,094,447	$2,862,339	112,975	0.75%	$25.34	2,366,984	$1.21	$4,413,002
C&I	126,509,044	$3,344,695	763,191	0.60%	$4.38	14,862,921	$0.23	$15,324,199
Total	222,652,019	$14,292,860	1,634,958	0.73%	$8.74	27,156,157	$0.53	$35,901,746

Unitil Gas

As of: October 23, 2015

2016	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	7,891,513	$1,073,378	67,613	0.86%	$15.88	1,302,246	$0.82	$2,533,061
Low-Income	2,648,529	$470,750	21,760	0.82%	$21.63	416,320	$1.13	$807,280
C&I	13,329,881	$592,142	126,134	0.95%	$4.69	2,466,897	$0.24	$2,308,733
Total	23,869,923	$2,136,270	215,506	0.90%	$9.91	4,185,463	$0.51	$5,649,074

2017	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	7,965,704	$1,094,530	66,735	0.84%	$16.40	1,290,695	$0.85	$2,525,428
Low-Income	2,728,190	$480,960	22,596	0.83%	$21.28	432,211	$1.11	$847,998
C&I	13,382,545	$604,365	130,381	0.97%	$4.64	2,524,696	$0.24	$2,406,859
Total	24,076,439	$2,179,855	219,712	0.91%	$9.92	4,247,602	$0.51	$5,780,285

2018	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	8,046,021	$1,117,400	70,700	0.88%	$15.80	1,374,845	$0.81	$2,692,526
Low-Income	2,810,755	$490,073	23,019	0.82%	$21.29	440,655	$1.11	$865,946
C&I	13,459,102	$617,406	131,575	0.98%	$4.69	2,564,960	$0.24	$2,430,911
Total	24,315,878	$2,224,879	225,294	0.93%	$9.88	4,380,460	$0.51	$5,989,382

2016-2018	Sales Forecast (therms)	Budget	Annual Savings (therms)	Percent of Sales	$/Annual therms	Lifetime Savings (therms)	$/Lifetime therms	Total Benefits (2016$)
Residential	23,903,238	$3,285,308	205,048	0.86%	$16.02	3,967,787	$0.83	$7,751,015
Low-Income	8,187,474	$1,441,783	67,375	0.82%	$21.40	1,289,185	$1.12	$2,521,223
C&I	40,171,528	$1,813,913	388,090	0.97%	$4.67	7,556,553	$0.24	$7,146,504
Total	72,262,240	$6,541,004	660,512	0.91%	$9.90	12,813,524	$0.51	$17,418,742

E. **<u>Council's Resolution of March 31, 2015</u>**

MA ENERGY EFFICIENCY ADVISORY COUNCIL

EEAC Resolution Concerning Its Priorities for the Development, Implementation, and Evaluation of the 2016-2018 Three-Year Energy Efficiency Plans

Adopted March 31, 2015

Part 1: Introduction

Under the Green Communities Act ("GCA"), the Energy Efficiency Advisory Council ("EEAC" or "Council") is charged with reviewing the Massachusetts Program Administrators ("PAs") energy efficiency investment plans and budgets, which are prepared in coordination with the EEAC. The EEAC has worked with, and will continue to collaborate with, the PAs to develop and deliver nation leading energy efficiency and demand reduction programs.

In this resolution, the EEAC again re-affirms its understanding that the GCA requires bold action to acquire all available cost effective energy efficiency and demand resources. In addition, the emission reduction targets established by the Global Warming Solutions Act ("GWSA") and the Commonwealth's Clean Energy and Climate Plan to implement the GWSA include a key role for energy efficiency and demand reduction programs. Given these statutory commitments, the economic and energy benefits that energy efficiency is providing to Massachusetts consumers, and the precedent that the PAs have established in leading the nation in developing comprehensive energy efficiency programs, the Council has great expectations for the development of a third balanced, cost-effective, robust, and innovative statewide electric and natural gas plan, inclusive of individual PA efficiency investment plans (i.e., "Three-Year Plans").

This resolution articulates the EEAC's priorities for program planning, analysis, implementation, and evaluation. It represents input from councilors, gathered through workshops and meetings. The Council also highlights for the PAs the importance of considering public comment and other stakeholder input. Developing the 2016-2018 Plans will be an iterative process between the Council, the PAs, and the EEAC's Consultant, as well as interested stakeholders. The Council looks forward to continuing collaboration with the PAs and interested stakeholders to plan and implement creative, effective approaches that meet or exceed the intended impact of this resolution.

Part 2: Priorities

The Green Communities Act mandates the acquisition of "all available cost-effective energy efficiency". The EEAC affirms this goal and, in striving to meet this statutory requirement, shall only approve 2016-2018 Plans that include savings that build on the achievement of the prior Three-Year Plans and conform with, and support the successful attainment of all available cost-effective energy efficiency.

The Council prioritizes continuous improvement in lifetime savings, benefits, and customer experience for the energy efficiency programs set forth in the 2016-2018 Plans, in order to ensure delivery of cost-effective programs that:

- Achieve all cost effective energy efficiency and demand reduction in accordance with the Green Communities Act.
- Align with the greenhouse gas reduction targets of the Global Warming Solutions Act and Clean Energy and Climate Plan.
- Deliver consistent and equitable service to all segments of businesses and residents statewide.
- Prioritize lifetime savings and benefits.
- Realize electric demand savings to significantly mitigate peak demand costs to the electric sector.
- Achieve data transparency and enable robust planning and analysis of the available energy efficiency resource through a comprehensive and detailed statewide database.
- Effectively communicate program and initiative successes, effectiveness, and progress to ratepayers.
- Continue to improve the cost efficiency of program delivery, with due regard for comprehensiveness, changes in avoided costs, and changes in technologies.

Part 3: Recommendations

Consistent with the priorities articulated above, the Council, PAs, and Council consultants conducted and participated in a collaborative planning process from December 2014 through March 2015. Seven workshops were held during which Voting and Non-voting councilors received briefing materials on prioritized topics, engaged in discussions, and developed the following informed recommendations for the PAs to consider when developing the 2016-2018 Plans. The Council appreciates that the cost-effectiveness, budgeting, and bill impact implications of each of these recommendations individually and in total will be considered by the PAs. The PAs shall provide updates to the Council on progress and implementation timeline of adopted recommendations as part of the PAs' quarterly reports. The Council looks forward to reviewing the draft 2016-2018 Plans and the PAs' written response to these recommendations, as well as to continuing collaborative discussions.

Cross-Cutting

1. The PAs, in coordination with the Council, shall develop a methodology and report accurate program penetration and participation numbers that are linked to individual account holders as opposed to participation in various programs.
2. The PAs shall support products and practices that reduce winter and summer peak demand by taking the following actions:
    a. Design, implement, and evaluate a demand reduction or demand response offering in each PA's service territory.
    b. Present to the EEAC a joint report with EEAC consultants on the impacts, opportunities and challenges of time varying rates on the energy efficiency programs, within 3 months of the Department's order approving such rates. Such report shall also include an analysis of incorporation of technologies like advanced metering in the efficiency programs, including potential adverse impacts on particular customer segments, such as low-income.
    c. Support the EEAC consultants in investigating the potential impact on efficiency savings if the Council were to place more emphasis on demand savings or peak demand savings.
3. The PAs shall proactively promote efficient renewable thermal technologies.
    a. Develop and implement a methodology in coordination with DOER and the EEAC Consultants to claim savings associated with the installation of renewable thermal equipment and fully account for savings associated with the reduction in use of the prior fuel source.
    b. Provide rebates and incentives for renewable thermal technologies, where deemed appropriate and cost-effective at the program level pursuant to the above methodology, not later than Q3 2016.
    c. Coordinate with the Massachusetts Clean Energy Center and DOER to provide information to customers and promote rebates and incentives for renewable thermal technologies.

Commercial & Industrial (C&I)

C&I Reporting

4. The PAs shall report on the following as separate initiatives within the C&I New Construction Program:
    a. Upstream
    b. End of life replacement
    c. New Construction/Major Modifications
5. The PAs shall report on the following as separate initiatives within the C&I Retrofit Program:
    d. Combined Heat and Power
    e. Retrofit Programs
    f. Control systems (including retro-commissioning, control upgrades, sub-metering and performance metrics)
    g. Engagement programs (continuous energy improvement, strategic energy management, behavioral programs)

Segment Specific Approaches

6. The PAs shall continue to improve their delivery of efficiency services via C&I market segment specific approaches using the following strategies:
    a. Provide more targeted communication materials to different market segments, explaining the benefits from, and availability of, energy savings opportunities to drive participation.
    b. Improve of the Mass Save® website to provide these sector-specific materials, including PA-specific materials, such as marketing materials, case studies and educational opportunities.
    c. Leverage partnerships with trade associations and other sector-specific partners to tailor efficiency program implementation to address sector-specific barriers and opportunities.
    d. Inform the EEAC in semi-annual reports about sector specific approaches (e.g., municipal, health care, commercial real estate, education, non-profits, hospitality, mid-size and small C&I), including:
        i. The impacts of sector specific strategies being implemented across the state.
        ii. How the results of EM&V studies and market research are being incorporated in program design.

Commercial Real Estate

7. The PAs shall continue to improve the efficiency programs targeted to the commercial real estate sector through the following strategies.
    a. Implement recommendations from Commercial Real Estate Working Group Roadmap, Massachusetts Commercial Real Estate Survey Analysis and Office Market profile report.
    b. Expand the Sustainable Office Design program features, including streamlined review of incentives to technologies beyond lighting. Implement pre-packaged offerings to address multiple end-uses.
    c. Use a whole building approach to target mid-size office buildings.
    d. Leverage energy reporting and disclosure ordinances to identify commercial real estate participants and explore the use of low-cost, streamlined whole building audits to support multi-year engagements on energy efficiency with interested property managers.

e. Explore market transformation opportunities, including updated advanced building operator training, sub-metering, wireless controls and better financing opportunities.
f. Investigate the main drivers for commercial real estate energy efficiency investment opportunities.

Small Businesses

8. The PAs shall continue to improve their delivery of efficiency services to small businesses through the following strategies.
    a. Provide deeper savings to each participating customer.
        i. Expand the menu of prescriptive services to better advance natural gas energy efficiency opportunities and non-lighting electric measures;
        ii. Use more comprehensive (e.g. integrated gas/electric) marketing programs for small businesses.
    b. Increase participation in the program.
        i. Use building analytics and benchmarking to target small business customers;
        ii. Increase outreach and awareness programs;
        iii. Continue to work with trade groups and associations.
    c. Continue to customize services based upon customer size and type.
        i. Investigate the potential for varied program implementation approaches to better serve the various strata of Small Business customers.
        ii. Determine which implementation strategies, technologies and building diagnostic capabilities employed in other programs are transferable and effective for serving Small Business customers.
        iii. Explore a Home Energy Services-type approach for the smallest business customers.

Combined Heat and Power

9. The PAs shall increase the overall number of Combined Heat and Power (CHP) installations.
    a. Provide additional education and outreach on CHP technology, including cost-effectiveness and other implementation barriers.
    b. Deliver a report on CHP by the end of 2016 that:
        i. Provides a statewide, bottom-up analysis of potential for custom, pre-packaged and third-party CHP projects;
        ii. Identifies technical, policy, financial, legislative, and market barriers and potential solutions, including, but not limited to, custom, pre-packaged and third-party CHP;
        iii. Determines the costs and feasibility of the PAs' implementing the identified solutions;
        iv. Investigates the challenges for installing CHP systems posed by natural gas availability and volatility in fuel prices, and potential programmatic approaches to mitigating those risks; and
        v. Assesses the interconnection challenges in area networks and how these challenges have been addressed in other cities, states or countries.
    c. Implement cost effective CHP program enhancements according to the findings of the report.

Continuous Technology Improvements

10. Given the importance of ongoing research and development of energy efficiency technologies, the Council recommends the PAs fully utilize all pilot funds.
11. The PAs shall develop a piloting or demonstration process and guidelines to facilitate and incentivize a more rapid and nimble adoption of emerging technologies, products, services, and strategies that enable energy efficiency savings. To that end, the PAs shall:
    a. Assess products that reflect rapid innovations in the marketplace, are of high customer interest, and/or have dependence on the customer for persistent savings (not limited to: data analytics, advances in sub metering, and advanced controls). As appropriate, adopt these measures into the C&I Programs.
    b. Examine combinations of products, services and strategies that enable energy efficiency savings or measurement of savings to assess their effectiveness.
    c. Report to the EEAC semi-annually on program selection, design, key performance indicators, and results.
    d. Complement the existing Massachusetts Technical Assessment Committee (MTAC). However, unlike the MTAC, the PAs will take the lead to identify and pilot these new technologies, services, and strategies.

Retro-Commissioning, Building Controls and Sub-metering

12. The PAs shall increase participation in retro-commissioning, building controls and sub-metering initiatives by enhancing the current offerings and incentives.
    a. Use data analytics and benchmarking processes to identify ideal retro-commissioning candidate projects.
    b. Promote continuous commissioning projects for retrofit and new construction projects by changing incentive structure to promote program participation, offering appropriate incentives, sponsoring new technologies, and training system operators.
    c. Where appropriate, incentivize the replacement of legacy building controls and open architecture in control systems to facilitate simpler system upgrading.
    d. Educate customers and vendors about new technologies and education opportunities, including regularly posting webinars, case studies, and videos on the Mass Save® website.
    e. Update and expand building operator training offerings, with input from customers, and explore the impact of combining these trainings with peer-to-peer based group learning.
    f. Expand training to increase the number of vendors who provide retro-commissioning and building controls in the marketplace.

Behavioral and Engagement

13. In recognition of the significance of C&I customer behavior on energy efficiency, the PAs shall:
    a. Deliver a report by the end of 2016 on Strategic Energy Management (SEM)/ Continuous Energy Improvement (CEI) programs for large commercial and industrial customers that:
        i. Researches SEM/ CEI programs to determine their applicability, cost effectiveness, and feasibility of implementation in Massachusetts;
        ii. Evaluates the potential savings from SEM/CEI programs;

   iii. Develops guidelines for how energy savings from SEM/CEI programs can cost-effectively be measured and verified; and
   iv. Explores leveraging such programs for dispatchable load control.
b. Based on the reports, if appropriate, implement SEM/CEI with large commercial and industrial customers, including providing technical assistance to identify opportunities and/or project management support for implementation.
c. Deliver a report by the end of 2016 on behavioral programs for small and mid-size commercial customers that:
   i. Investigates successful commercial behavioral programs to determine the critical elements for success and their cost-effectiveness;
   ii. Evaluates the potential savings from commercial behavioral programs;
   iii. Develops guidelines for how energy savings from commercial behavioral programs can cost-effectively be measured and verified; and
   iv. Explores leveraging such programs for dispatchable load control.
d. Assess and, if appropriate, implement upfront incentives for building operators and owners for behavior-based and operational savings, building operator training around behavioral strategies, and support for peer-to-peer cohorts.

LED Streetlights

14. The PAs shall:
    a. Retrofit the majority of utility-owned street lights with LED technology statewide by 2018 and create a plan to retrofit the remainder by 2020, or sooner if possible.
    b. Work with municipalities to retrofit the remainder of municipally-owned street lights to LED technology by 2018.
    c. Enable and incentivize advanced controls for LED street lights for both municipally and utility-owned street lights.

Delivered Fuels and Thermal Efficiency

15. The PAs shall promote non-gas customers' ability to self-fund the thermal portion of a comprehensive energy assessment using a PA auditor.

Hockey Stick Pattern

16. To address the uneven distribution of C&I savings occurring primarily at the end of the calendar year, the PAs shall:
    a. Improve C&I pipeline forecasting and reporting to the Council to increase visibility and predictability.
    b. Avoid offering incentives that create inequities or unintended consequences of delay and deferral.

Net Zero Energy Ready Buildings

17. The PAs shall assess offering a tier within the C&I New Construction initiative to enable net zero energy readiness.

Residential

New Initiatives

18. The PAs shall develop and implement by Q2 2016, a moderate income specific initiative designed to increase participation from this specific customer sector.
    a. Assess and determine appropriate population (within the 60-120% Area Median Income range) to serve and ensure that there is continuity with the low-income programs.
    b. Consider proxy means of income qualification (e.g. by zip code, rent costs), with protocols to assure that households eligible for low-income services are referred to the low-income programs.
    c. Develop and leverage partnerships with community groups to help with marketing and education, and coordinate with municipal efforts, that yield savings.
19. The PAs shall develop and implement by Q2 2016, a separate renter specific initiative, designed to address the split incentive and increase participation from this specific customer sector.
    a. Develop and leverage partnerships with community groups to help with marketing and education and coordinate with municipal efforts and/or consider alternative program models to better serve renters.

Home Energy Services Initiative

20. The PAs shall achieve deeper savings per household in the Home Energy Services (HES) Initiative through the following strategies.
    a. Increase the closure rate for weatherization jobs:
        i. Assess why home energy assessments are not resulting in installation of recommended weatherization
        ii. As soon as practicable, use findings to implement changes to increase the close rate
        iii. Report findings and progress in the quarterly reports to the EEAC.
    b. Assess the potential impacts of adjusting the insulation incentive, including maximum dollar value and percentage, and consider eliminating the cap on these incentives. Assess offering different tiers for market rate vs. moderate income households, while allowing for broad awareness marketing.
    c. Provide customized approaches, technical assistance, and offerings to specific customer types/segments (e.g., homes doing remodeling work, high energy users and electric heat resistance customers).
    d. Track all measures implemented at the household level where technically feasible to provide the Council with more comprehensive information on the penetration rates, and the depth of savings achieved when multiple measures are implemented.
    e. Continue to create incentives for lead vendors, Home Performance Contractors (HPCs), and contractors to achieve overall savings targets through a whole building approach.
    f. Reassess the structure of the Best Practices Working Group to ensure HPCs have an equitable role in decisions.
    g. Integrate renewable thermal technologies into the HES delivery model, building on the success of the early boiler/early furnace replacement offering.
21. The PAs shall optimize the effectiveness of the Home Energy Assessment (HEA) and the HEA delivery channel.

a. Improve the integrated "one-stop shop" customer experience:
    i. Provide the customer with comprehensive information about Mass Save®, state and federal incentives for HVAC, hot water, and renewable thermal technologies, regardless of the customer's existing fuel source.
    ii. Direct lead vendors and HPCs to provide customers with comprehensive HVAC/hot water and renewable thermal technology options, regardless of the customer's fuel source, when recommendations to upgrade are made.
b. Identify, assess, and, where appropriate, implement ways to streamline and better customize the offer and information presented at the HEA through strategies such as pre-screening customers and additional customer follow-up protocols.
c. By Q1 2016, collaborate with DOER and EEAC Consultants on a report that:
    a. Identifies actions needed to provide customers with an asset-based "home energy scorecard", similar to the one implemented in the Home MPG initiative and;
    b. Quantifies costs and benefits associated with providing customers with such a scorecard.

Products Program

22. The PAs shall fully incorporate LEDs in both the Products and Whole House programs, and phase out CFLs, as follows:
    a. As soon as pricing allows, and no later than Q4 2016, offer only LEDs in the Whole House program and specialty lighting in the Products program.
    b. As part of ongoing assessment activities conducted in conjunction with EEAC consultants, progress towards providing only LEDs for general lighting in the Products program, and report on such assessments and progress in the quarterly reports to the EEAC.
    c. To support and maintain Massachusetts' position as a leader in accelerating the adoption and installation of new technologies and practices, the PAs, in conjunction with the EEAC consultants, shall assess upstream program designs for HVAC and DHW-related technologies no later than Q3 2016.

HEAT loan/financing

23. The PAs shall, by Q2 2016, evaluate the following proposed changes to the HEAT loan program. The PAs shall report findings to the EEAC no later than Q2 2016:
    a. Provide low interest (e.g. 2%) loans for market rate customers, and maintain 0% for moderate income customers.
    b. PAs fund a loan loss reserve for moderate income customers and customers with marginal (e.g. 600-650) credit scores.
24. The PAs shall coordinate with DOER to expand the HEAT loan-eligible measures to include those currently funded by DOER under the Expanded HEAT Loan program.
25. The PAs shall identify and implement appropriate ways to simplify and accelerate the HEAT Loan application and approval process.

New Construction Initiative

26. The PAs shall enhance the New Construction Initiative:
    a. By Q1 2016, implement a "renewable ready" requirement in the highest two performance-based tiers and the top prescriptive incentive tier.
    b. By Q2 2016, deliver a report to the EEAC that assesses:
        i. Creating a Zero Net Energy (ZNE) incentive top performance tier.
        ii. Adding a performance path for multi-family housing (4+ stories).
        iii. Increasing incentives for rental housing new construction as a way of mitigating rental split-incentives.

Behavior Initiative

27. The PAs shall expand savings from behavior programs and explore the incorporation of home automation technology into their behavior initiative and report to the EEAC on the results of their findings.

Multi-Family Retrofit Initiative

28. The PAs shall increase savings from, and improve the customer experience in, the multi-family retrofit initiative:
    a. Provide weatherization incentives and HVAC and hot water equipment rebates to multi-family buildings that heat with unregulated fuels (e.g., oil or propane) to the same extent provided to gas or electric resistance-heated multi-family buildings.
    b. By Q2 2016, for buildings that benchmark, use benchmarking to:
        i. Institute or demonstrate a "pay for performance" approach to retrofits using pre- and post-retrofit baselines for evaluation.
        ii. Customize incentives to facilitate participation and deeper savings per building.
    c. By Q2 2016, develop and implement a plan or initiative for benchmarking in the multi-family sector.
    d. Seamlessly deliver services, rebates and incentives to the customer, regardless of whether such services, rebates or incentives are supported by the commercial or residential program.
        i. Provide customers with a single point of contact to act as a project manager offering whole building services for both residential and commercially metered buildings, including overseeing energy efficiency installations and coordinating with the PAs and their vendors.
        ii. For each building, link all services, rebates and incentives provided, regardless of whether such services, rebates or incentives are supported by the commercial or residential program, to provide a comprehensive view of commercially- and residentially-metered energy use and savings.
        iii. For each building, track and report both commercially-metered energy use and savings, and residentially-metered energy use and savings.
    e. Segment the sector (e.g. according to ownership patterns, building types, or meter configurations) and implement tailored approaches to facilitate increased participation and savings per building within such segments.
    f. Prioritize comprehensive whole building based performance.
    g. By Q2 2016, implement an initiative, in partnership with housing finance institutions, to integrate efficiency work into opportunities such as refinancing or retrofitting of larger multi-family buildings.

Low Income Programs

29. The Low Income Energy Affordability Network (LEAN) shall expand their eligible scope of services:
    a. Provide weatherization, HVAC, and hot water technology services to low income multi-family buildings that heat with unregulated fuels (e.g., oil or propane).
    b. Define low-income multi-family buildings as those with at least 50% of tenants earning up to 80% of Area Median Income (AMI).
    c. Assess and report to the Council on expanding 1-4 family program to serve customers up to 80% AMI.
    d. Evaluate and, if appropriate, serve non-profit organizations that primarily serve low income customers, provided that:
        i. Such services are clearly defined, and synched with Mass Save® C&I sector non-profit initiatives;
        ii. There is adequate funding such that providing such services does not reduce services to pre-existing LEAN markets or exacerbate the low income residential program queue;
        iii. The PAs and LEAN report annually to the EEAC on which non-profits are served, what services are provided, and the cost per building.

F. **<u>PA Response Matrix to March Resolution</u>**

#	DESCRIPTION	STATUS 1 Plan to implement & in Plan 2 = Plan to implement, not in plan 3 = Still under consideration 4 = Not in plan, not being implemented	COMMENTS	REFERENCES
Recommendations				
Cross-Cutting				
1	**The PAs, in coordination with the Council, shall develop a methodology and report accurate program penetration and participation numbers that are linked to individual account holders as opposed to participation in various programs.**	**4**	The PAs work to create common participant definitions for each program and initiative. The definitions are designed to most accurately reflect unique participants and are constantly being refined over time. Appendix G has draft participant definitions for 2016-2018. Accurately assessing program penetration and the number of unique customers participating in energy efficiency programs across the Commonwealth is a more complicated process. It is a difficult number to derive for two reasons: 1) because of customer overlap between PA territories and 2) because certain program delivery models, such as upstream, work through manufacturers and distributors rather than customers. For example, lighting incentives through the products program are delivered by hundreds of retailers across Massachusetts. It is not practical to ask every customer that buys an incentivized light bulb to provide enough information to track individual customer participation for that extensive initiative. The PAs use periodic Residential and C&I Customer Profile Studies to accurately determine penetration and an approximate count of customers being served across the Commonwealth. The first Residential Customer Profile Study will be complete in summer 2015. The 2013 C&I Customer Profile Study was completed in April 2015. A 2014 C&I Customer Profile Study will be complete in Spring 2016.	Section III.A.5.b, page 179 Appendix G, page 258
2	**The PAs shall support products and practices that reduce winter and summer peak demand by taking the following actions:**	**1**	The PAs recognize the special value of products and practices that can reduce winter and summer peak demand. The PAs have not fully developed all of their strategies for addressing these issues in the April 30 draft, but the discussions are active; the PAs expect to provide further detail as the Plan is refined. This draft of the 2016-2018 Plan projects electric demand savings of 514,175 kW (summer) and 617,294 kW (winter). In 2010-2014, the PAs achieved over 650,000 kW of summer capacity savings. Current 2016-2018 Plan expectations for demand savings are included in Table 3.2.i., Savings Summary. Issues relating to demand savings can be complex. The PAs have formed an *ad hoc* group to discuss these matters informally with the Council's consulting team. The PAs are sensitive to designing efforts that take into account unintended negative consequences, such as increased energy usage (which, for example, can be an unintended result of subsidizing ice storage plants that reduce demand). The *ad hoc* group is also exploring demand response, load-shifting and geo-targeting. Efforts like time-varying rates and advanced metering are also recognized by the PAs as an important part of our energy future and are being addressed by many PAs under	Section II.H.3.a, page 153
a	Design, implement, and evaluate a demand reduction or demand response offering in each PA's service territory.	3		
b	Present to the EEAC a joint report with EEAC consultants on the impacts, opportunities and challenges of time varying rates on the energy efficiency programs, within 3 months of the Department's order approving such rates. Such report shall also include an analysis of incorporation of technologies like advanced metering in the efficiency programs, including potential adverse impacts on particular customer segments, such as low-income.	4		
c	Support the EEAC consultants in investigating the potential impact on efficiency savings if the Council were to place more emphasis on demand savings or peak demand savings.	4		

			their Grid Modernization efforts. With respect to reports or investigations requested of the EEAC consultants in the Council recommendations, the PAs believe that is a matter for the Council and its consultants to develop and implement directly between themselves. The PAs will remain actively engaged with the Council, but any reports requested of the consulting team should be the responsibility of the consultants, at the direction of the Council, and not a responsibility of the PAs.	
3	**The PAs shall proactively promote efficient renewable thermal technologies.**	**3**	The PAs have not fully developed plans for renewable thermal technologies at this time, but are carefully examining these exciting technologies. At the heart of the PAs process are four questions 1) Are there cost-effective energy efficiency renewable thermal options, as opposed to renewable supply side measures? 2) Which renewable thermal technologies should be prioritized (if any) 3) What are the quantifiable energy savings and benefits?, and 4) What funding sources would be available for renewable thermal strategies under consideration? The PAs currently work with the Massachusetts Clean Energy Center and DOER to promote rebates and incentives for renewable thermal that work under current program design and delivery.	Section II.H.3.b, pages 154-155
a	Develop and implement a methodology in coordination with DOER and the EEAC Consultants to claim savings associated with the installation of renewable thermal equipment and fully account for savings associated with the reduction in use of the prior fuel source.	3		
b	Provide rebates and incentives for renewable thermal technologies, where deemed appropriate and cost-effective at the program level pursuant to the above methodology, not later than Q3 2016.	3		
c	Coordinate with the Massachusetts Clean Energy Center and DOER to provide information to customers and promote rebates and incentives for renewable thermal technologies.	3		
Commercial & Industrial (C&I)				
C&I Reporting				
4	**The PAs shall report on the following as separate initiatives within the C&I New Construction Program:**	**1**	The PAs share the Council's desire for increased transparency. Following a review of the C&I programs, the PAs have decided to separate out elements of those programs for budget/planning/reporting purposes. Within the New Construction Program, the PAs have created a Core Initiative for “New Buildings & Major Renovations” and another for “Initial Purchase & End of Useful Life” thereby increasing the granularity with which the Program, and its component elements, will be tracked during the course of the 2016-2018 Plan period. In summary, the PAs New Construction Program will consist of two Core Initiatives: - New Buildings & Major Renovations - Initial Purchase & End of Useful Life	Section II.G.2.a, page 100
a	Upstream	1		
b	End of Life Replacement	1		
c	New Construction/Major Modifications	1		
5	**The PAs shall report on the following as separate initiatives within the C&I Retrofit Program:**	**1**	Similar to New Construction, the PAs reviewed the Retrofit Program and, to facilitate increased transparency and granularity and clarity of reporting, have decided to include two new stand-alone core initiatives -- Multifamily Retrofit and Upstream Lighting. C&I Multifamily Retrofit aligns with the parallel Residential Multifamily Retrofit Core Initiative. Together, these two initiatives present a seamless approach to all elements of multi-family housing and represent the PAs’ commitment to harmonizing these important offerings across both sectors. Upstream Lighting has been moved from New Construction to Retrofit based on a determination that the vast majority of upstream lighting purchases have been, and will continue to be, for purposes of retrofitting existing equipment. After careful consideration, the PAs have decided not to separately plan for and report on CHP, control systems, or engagement programs as separate core initiatives. CHP results are, by nature of the complexity, relative risk, and long lead times of projects, highly variable and exhibit large fluctuations year to year, usually due to both the size and unpredictability of individual projects. It should be noted, however, that CHP measure level information is available in the electric PAs BCR screening models.	Section II.G.2.b, page 116
d	Combined Heat and Power	4		
e	Retrofit Programs	1		
f	Control systems (including retro-commissioning, control upgrades, sub-metering and performance metrics)	4		
g	Engagement programs (continuous energy improvement, strategic energy management, behavioral programs)	4		

			Controls related offerings, as well as engagement initiatives, have been and will continue to be important components of the PAs portfolio of C&I offerings and are often effectively included in the context of an MOU/SEMP. However, in light of their narrow applicability and relatively small (lifetime) savings relative to other parts of the portfolio, the PAs have concluded they do not warrant the level of attention of a separate Core Initiative. In Summary, the PAs Retrofit Program will consist of four Core Initiatives: - Existing Building Retrofit - Small Business - Multifamily Retrofit - Upstream Lighting	
			Segment Specific Approaches	
6	**The PAs shall continue to improve their delivery of efficiency services via C&I market segment specific approaches using the following strategies:**	**1**	The PAs have been early and longstanding proponents and practitioners of segment-based approaches to serving C&I customers and are pleased that the Council appreciates and supports that those efforts are key to achieving both broad and deep savings. The PAs will continue to develop additional customized approaches for specific segments of their C&I customers, making use of local EM&V studies, the experience of peer programs around the country, and data reported in studies and program evaluations from Massachusetts and other jurisdictions. The PA's Draft Plan specifically addresses a number of segments -- large customers, municipalities and water/wastewater treatment, commercial real estate, industrial, and non-profits, etc. -- and the PAs have or will develop customized approaches to serve additional segments within their unique customer bases and across the state. The PAs have and will continue to address evaluation recommendations in their Plan Year Reports in detail. In order to avoid redundancy and manage costs, the PAs will continue to emphasize EM&V and the impacts of EM&V on program design and delivery in Plan-Year and Term Reports, and will not provide separate reports on these efforts. As they have historically done, the PAs will continue to provide periodic presentations/reports to the EEAC on segment-specific activities and associated results and lessons learned. The PAs feel that reports presented closer to real time activity is more effective and impactful than reporting that is dependent on a rigid calendar schedule. Accordingly, while the PAs are not adopting a semi-annual approach, they do fully embrace continued and timely reporting related to incorporation of EM&V recommendations into program design and delivery.	Section II.G.2.b, pages 130-131 and 134-141
a	Provide more targeted communication materials to different market segments, explaining the benefits from, and availability of, energy savings opportunities to drive participation.	1		
b	Improve of the Mass Save® website to provide these sector-specific materials, including PA-specific materials, such as marketing materials, case studies and educational opportunities.	2		
c	Leverage partnerships with trade associations and other sector-specific partners to tailor efficiency program implementation to address sector-specific barriers and opportunities.	1		
d	Inform the EEAC in semi-annual reports about sector specific approaches (e.g., municipal, health care, commercial real estate, education, non-profits, hospitality, mid-size and small C&I), including:	4		
i	The impacts of sector specific strategies being implemented across the state.	4		
ii	How the results of EM&V studies and market research are being incorporated in program design.	4		
			Commercial Real Estate	
7	**The PAs shall continue to improve the efficiency programs targeted to the commercial real estate sector through the following strategies.**	**1**	As described in the PA's Draft Plan, once available, the results of the CRE Working Group will be reviewed and used to develop strategies for more effectively engaging with commercial real estate customers. In the interim, the PAs have and will continue to utilize a number of approaches specifically targeted to CRE customers -- sustainable office design (SOD), whole building approach, and MOU/SEMPs with large CRE customers across their portfolio of properties.	Section II.G.2.a, pages 105-106 Section II.G.2.b, pages 127 and 139
a	Implement recommendations from Commercial Real Estate Working Group Roadmap, Massachusetts Commercial Real Estate Survey Analysis and Office Market profile report.	1		
b	Expand the Sustainable Office Design program features, including streamlined review of incentives to technologies beyond lighting. Implement pre-packaged offerings to address multiple end-uses.	3		
c	Use a whole building approach to target mid-size office buildings.	3		

d	Leverage energy reporting and disclosure ordinances to identify commercial real estate participants and explore the use of low-cost, streamlined whole building audits to support multi-year engagements on energy efficiency with interested property managers.	3		
e	Explore market transformation opportunities, including updated advanced building operator training, sub-metering, wireless controls and better financing opportunities.	3		
f	Investigate the main drivers for commercial real estate energy efficiency investment opportunities.	3		
	Small Businesses			
8	**The PAs shall continue to improve their delivery of efficiency services to small businesses through the following strategies.**	**1**	The PAs have included a lengthy description of Small Business in their Draft Plan including plans to thoroughly review every aspect of the Small Business Core Initiative – administration and delivery, target markets, measures, marketing, etc. -- in order to develop the next generation version of this already extremely successful model. Examples of the options under consideration include: addition of more gas measures, including thermal measures; better and more referral follow-up services for measures not amenable to the direct install delivery model (such as thermal measures and heating systems so that deeper treatments can be undertaken); further segmentation to reach the smallest of the small customers through consideration of web portals, self-service delivery concepts, further development of the "Main Streets" or other geographically-focused delivery models, adaptation of successful residential delivery models such as HES, etc.; and more targeted marketing and measure mixes by business type.	Section II.G.2.b, pages 118, 125-127 Section II.G.2.b.ii, pages 147-148
a	Provide deeper savings to each participating customer.	1		
i	Expand the menu of prescriptive services to better advance natural gas energy efficiency opportunities and non-lighting electric measures;	1		
ii	Use more comprehensive (e.g. integrated gas/electric) marketing programs for small businesses.	1		
b	Increase participation in the program.	1		
i	Use building analytics and benchmarking to target small business customers;	3		
ii	Increase outreach and awareness programs;	1		
iii	Continue to work with trade groups and associations.	1		
c	Continue to customize services based upon customer size and type.	1		
i	Investigate the potential for varied program implementation approaches to better serve the various strata of Small Business customers.	1		
ii	Determine which implementation strategies, technologies and building diagnostic capabilities employed in other programs are transferable and effective for serving Small Business customers.	1		
iii	Explore a Home Energy Services-type approach for the smallest business customers.	1		
	Combined Heat and Power			
9	**The PAs shall increase the overall number of Combined Heat and Power (CHP) installations.**	**1**	The PAs have included a lengthy description of CHP in their Draft Plan and plan to aggressively target CHP opportunities during the 2016-2018 period including a commitment to increase education and outreach as well as the commissioning of a best practices review of CHP programs nationally and a reassessment of CHP potential in Massachusetts. While sharing the Council's strategic commitment to excellence with regard to CHP delivery and the undertaking of research to enhance performance, the PAs do not feel it appropriate to adopt a specific time line for reporting on CHP activities or the results of any related research.	Section II.G.2.b, pages 132, 141-143
a	Provide additional education and outreach on CHP technology, including cost-effectiveness and other implementation barriers.	1		
b	Deliver a report on CHP by the end of 2016 that:	1		
i	Provides a statewide, bottom-up analysis of potential for custom, pre-packaged and third-party CHP projects;	3		
ii	Identifies technical, policy, financial, legislative, and market barriers and potential solutions, including, but not limited to, custom, pre-packaged and third-party CHP;	3		
iii	Determines the costs and feasibility of the PAs' implementing the identified solutions;	3		
iv	Investigates the challenges for installing CHP systems posed by natural gas availability and volatility in fuel	3		

	prices, and potential programmatic approaches to mitigating those risks; and			
v	Assesses the interconnection challenges in area networks and how these challenges have been addressed in other cities, states or countries.	3		
c	Implement cost effective CHP program enhancements according to the findings of the report.	1		
	Continuous Technology Improvements			
10	**Given the importance of ongoing research and development of energy efficiency technologies, the Council recommends the PAs fully utilize all pilot funds.**	**1**	There are no budgeted funds for pilots in the PAs Draft Plan, but the PAs plan to continue their long-standing practice of regularly evaluating and field testing new/emerging technologies.	N/A
11	**The PAs shall develop a piloting or demonstration process and guidelines to facilitate and incentivize a more rapid and nimble adoption of emerging technologies, products, services, and strategies that enable energy efficiency savings. To that end, the PAs shall:**	**1**	The PAs plan to continue assessing new, market ready, technologies and determine their eligibility for incorporation in program offerings, as well as technologies that are on the near horizon for marker-readiness. MTAC, a group comprised of PA technical and engineering representatives, provides a consistent statewide approach for identifying and evaluating new efficiency technologies. In furtherance of this work, MTAC communicates and cooperates with similar emerging technology assessment groups around the country. MTAC, with assistance as necessary from other C&I Subcommittees, will continue to maintain summaries of the results of all such technology reviews and make available information regarding approved technologies on the Mass Save website. Additionally, the C&IMC and other related subcommittees will continue to discuss the programmatic structures that best serve the introduction of emerging technologies and associated strategies. To support these efforts, the PAs have specifically budgeted R&D funds in the hard-to-measure line item to pursue technologies of interest.	N/A
a	Assess products that reflect rapid innovations in the marketplace, are of high customer interest, and/or have dependence on the customer for persistent savings (not limited to: data analytics, advances in sub metering, and advanced controls). As appropriate, adopt these measures into the C&I Programs.	3		
b	Examine combinations of products, services and strategies that enable energy efficiency savings or measurement of savings to assess their effectiveness.	3		
c	Report to the EEAC semi-annually on program selection, design, key performance indicators, and results.	3		
d	Complement the existing Massachusetts Technical Assessment Committee (MTAC). However, unlike the MTAC, the PAs will take the lead to identify and pilot these new technologies, services, and strategies.	2		
	Retro-Commissioning, Building Controls and Sub-metering			
12	**The PAs shall increase participation in retro-commissioning, building controls and sub-metering initiatives by enhancing the current offerings and incentives.**	**1**	The PAs will continue to support and facilitate the implementation of RCx strategies, building systems optimization, and advanced controls operations wherever appropriate and consistent with energy efficiency program guidelines. To this end, the PAs will proactively implement the recommendations of the recently completed Retro-Commissioning Best Practice Study to streamline the RCx offerings and to achieve greater implementation of these strategies. For example, the PAs have already tested some of the RCx Best Practices recommendations by developing and implementing customized approaches to providing targeted RCx services to hospitals with a similar approach for labs currently in development. In addition, the PAs are committed to developing a common tool for RCx measures and expanding training for RCx for providers.	Section II.G.2.b, pages 118 and 120-121
a	Use data analytics and benchmarking processes to identify ideal retro-commissioning candidate projects.	1		
b	Promote continuous commissioning projects for retrofit and new construction projects by changing incentive structure to promote program participation, offering appropriate incentives, sponsoring new technologies, and training system operators.	3		
c	Where appropriate, incentivize the replacement of legacy building controls and open architecture in control systems to facilitate simpler system upgrading.	3		
d	Educate customers and vendors about new technologies and education opportunities, including regularly posting webinars, case studies, and videos on the Mass Save® website.	3		

e	Update and expand building operator training offerings, with input from customers, and explore the impact of combining these trainings with peer-to-peer based group learning.	3		
f	Expand training to increase the number of vendors who provide retro- commissioning and building controls in the marketplace.	3		
	Behavioral and Engagement			
13	**In recognition of the significance of C&I customer behavior on energy efficiency, the PAs shall:**	**4**	There is a significant investment in staff time and expense required of both customer and the PA to implement successful Strategic Energy Management (SEM) initiatives. For that reason SEM has only been applied successfully to a very small universe of the largest, primarily industrial and large commercial customers in a few parts of the country. Additionally, SEM approaches are generally designed to provide incremental savings over and above the traditional capital investments, which typically provide substantially greater and more predictable and sustainable savings. Many experts in the field also believe the results of SEM and related behavioral efforts remain inconclusive in terms of their ability to produce significant savings and whether those savings can be produced and sustained cost effectively. At this juncture, the PAs believe SEM remains a narrowly applicable approach to energy efficiency that does not warrant significant investment of time and resources. However, the PAs do understand the value of SEM to specific subsets of customers, and will be refining and expanding existing approaches to better serve those customers. The PAs also examine methods to expand SEM approaches to a broader market as the concept becomes a more familiar model in the business community, and as various emerging models demonstrate a record of success. Activities that the PAs have supported and will continue to support include retro-commissioning, an array of training and education opportunities, and customized process and behavioral approaches within the broader context of a customer-specific Memorandum of Understanding (MOU)/Strategic Energy Management Plan (SEMP). It should also be noted that behavioral approaches will also be considered as part of the PAs reexamination of approaches to serving small business customers	Section II.G.2.b, pages 120-125, 129-130, and 136
a	Deliver a report by the end of 2016 on Strategic Energy Management (SEM)/ Continuous Energy Improvement (CEI) programs for large commercial and industrial customers that:	4		
i	Researches SEM/ CEI programs to determine their applicability, cost effectiveness, and feasibility of implementation in Massachusetts;	3		
ii	Evaluates the potential savings from SEM/CEI programs;	3		
iii	Develops guidelines for how energy savings from SEM/CEI programs can cost-effectively be measured and verified; and	3		
iv	Explores leveraging such programs for dispatchable load control.	3		
b	Based on the reports, if appropriate, implement SEM/CEI with large commercial and industrial customers, including providing technical assistance to identify opportunities and/or project management support for implementation.	4		
c	Deliver a report by the end of 2016 on behavioral programs for small and mid-size commercial customers that:	4		
i	Investigates successful commercial behavioral programs to determine the critical elements for success and their cost-effectiveness;	3		
ii	Evaluates the potential savings from commercial behavioral programs;	3		
iii	Develops guidelines for how energy savings from commercial behavioral programs can cost effectively be measured and verified; and	3		
iv	Explores leveraging such programs for dispatchable load control.	3		
d	Assess and, if appropriate, implement upfront incentives for building operators and owners for behavior-based and operational savings, building operator training around behavioral strategies, and support for peer-to-peer cohorts.	3		
	LED Streetlights			
14	**The PAs shall [support LED street lighting technologies]:**	**1**	The PAs remain committed to providing their municipal customers with the most up-to-date street lighting technology options -- including lighting and controls -- as well as providing options for them to assume ownership and maintenance of lighting where it is cost-effective and they so desire. The PAs remain committed to working with any community wishing to explore the process of conversion to municipal ownership. Local conditions and priorities of the local governing body in each unique city or town will control the rate at which the conversion can be accomplished.	Section II.G.2.b, page 143
a	Retrofit the majority of utility-owned street lights with LED technology statewide by 2018 and create a plan to retrofit the remainder by 2020, or sooner if possible.	4		
b	Work with municipalities to retrofit the remainder of municipally-owned street lights to LED technology by 2018.	4		

c	Enable and incentivize advanced controls for LED street lights for both municipally and utility-owned street lights	3	The PAs have to date successfully supported the conversion of a very large number of customer-owned streetlights to LED technology. For example, in the eastern portion of Eversource's territory where roughly 90% of the streetlights are already customer-owned, over 60% of those streetlights have been converted to LED. Somewhat by contrast, in National Grid's territory, less than 20% of municipalities have purchased their streetlights thereby limiting the opportunity to convert to LED technology. Cape Light Compact has also completed a large number of street lighting conversions spanning a number of communities during the current 2013-2015 Plan period. The PAs are also committed to supporting the conversion of utility-owned streetlights to LED technology once the electric utilities in the state have developed, filed, and had approved the necessary tariffs.	
	Delivered Fuels and Thermal Efficiency			
15	**The PAs shall promote non-gas customers' ability to self-fund the thermal portion of a comprehensive energy assessment using a PA auditor.**	**2**	When working with customers whose heating fuel is neither electricity nor natural gas, the PAs have and will continue to make those customers aware of the efficiency opportunities that may nonetheless exist to reduce energy consumption related to space heating, and direct them to other funding sources that may be available to help them do so. The PAs always explain to these customers that, due to regulatory constraints, the PAs are not able to provide financial support for any engineering assessment of those opportunities, but that the customer should consider undertaking that analysis on their own behalf and, should the customer so desire, the PAs can direct them to qualified engineer firms with whom they work regularly on such projects.	N/A
	Hockey Stick Pattern			
16	**To address the uneven distribution of C&I savings occurring primarily at the end of the calendar year, the PAs shall:**	**2**	The so-called "Hockey Stick Pattern" is a reliably predictable phenomenon, which the PAs factor into their forecasting efforts. The PAs will continue to provide reasonable and accurate forecasts of expected year-end results and increased visibility regarding those forecasts to the Council. The PAs assist their business customers in understanding, evaluating, and implementing the energy efficiency opportunities that maximize the benefits of those efforts. In so doing, the PAs must be aware of and adapt to the financial and operating constraints that influence customer decision-making -- both in terms of the projects they may undertake and the timing of those projects.	N/A
a	Improve C&I pipeline forecasting and reporting to the Council to increase visibility and predictability.	2		
b	Avoid offering incentives that create inequities or unintended consequences of delay and deferral.	2		
	Net Zero Energy Ready Buildings			
17	**The PAs shall assess offering a tier within the C&I New Construction initiative to enable net zero energy readiness.**	**3**	The PAs have an interest in staying closely engaged in the Net Zero movement. This may take a number of forms including participation in research and development efforts, particularly where Massachusetts participation can be used to leverage resources from program administrators in other jurisdictions and/or government research investments. It may also take the form of support for demonstration projects in partnership with developers or owners who are motivated to have a Net Zero building, or a building along the continuum to Net Zero: e.g., "Net Zero Ready" (highly efficient but renewables not yet in place) or "Near Net Zero" (highly efficient). The ZNE market remains very immature and as such it would be premature to design and implement a separate tier within the C&I New Construction Program; however, as the market develops in the future, a variety of options for enabling this market will be considered including perhaps a tier within the New Construction Program.	Section II.G.2.a, pages 102-103

Residential & Low-Income

New Initiatives

18	**The PAs shall develop and implement by Q2 2016, a moderate income specific initiative designed to increase participation from this specific customer sector.**	**1**	The PAs are exploring a moderate income offer. PAs are committed to ensuring moderate income customers are able to successfully access and participate in all Mass Save® efficiency opportunities in 2016-2018. The 2016-2018 Plan includes the strategic commitment to ensuring designs effectively serve moderate income customers. The PAs will be addressing this within the first year of the three-year plan. Some of the details of implementation are not included, both because they are evolving and because they may be inappropriate to the Plan level. PAs must maintain the ability to be nimble and flexible in delivery, allowing the program's design to adapt to learning, especially as PA's trial new offerings. We have provided detail on some of the areas PAs are exploring to provide context and depth to our strategic commitment. As these efforts evolve they will be tested and refined and may begin to take different design direction. In addition to a moderate income specific offering, PAs recognize that approaches focused on renters and 2-3 family properties will have overlap with moderate income populations. Therefore while PAs discuss a renter specific offer in the comments under recommendation 19, PAs consider the renter-specific efforts to be part of our holistic design to reach all customers and specifically moderate income customers. It is also important to note the whole house program is not the only opportunity to serve moderate income customers. The products program also reaches moderate income customers. PAs are very mindful of this in our program and will explore how to leverage locations or special promotions to ensure access for moderate income consumers. This is noted in the plan. PAs initial planning of the moderate income offer has focused on concerns raised during the workshop discussions and in the recommendations regarding the need for continuity with the low-income programs and "simplification" of entry for customers to weatherization. In response, and in consideration of other program factors, PAs have focused on an offer that: 1) targets the 61-80% state median income, i.e., moderate income, population just above "low-income" service definition, and 2) preserves the Mass Save brand awareness and current penetration success of the HEA channel. The preliminary exploration has focused on entry and service through HES –HEA. Customers with identified weatherization opportunities, uncovered as part of an HEA, can be offered an opportunity to be "qualified" for an increased incentive where income is a barrier. This has the advantages of maintaining the ability to market the Mass Save® initiative broadly, being fair and available to all customers, and allowing customers to decide if they want to be "income qualified". It further limits the pool of participants for increased support to customers with realizable weatherization opportunities, increasing the balance of funds expended for customer's direct incentive and energy savings, while controlling the growth in program administration overhead from adding a unique "offer" to a targeted sub-segment. PAs are still examining methods and costs for the income verification element of this more prescribed offering. Using the same scale for income qualification as is currently used by the low-income program will allow customers who enter through the low-income portal to be more easily transitioned into this offer. Customers who have completed income verification	Section I.A.2, page 11 Section II.E.2, pages 34 and 37 Section II.E.3, pages 39-40 Section II.E.4.c, pages 54 and 60 Section II.E.4.h, page 85
a	Assess and determine appropriate population (within the 60-120% Area Median Income range) to serve and ensure that there is continuity with the low-income programs.	1		
b	Consider proxy means of income qualification (e.g. by zip code, rent costs), with protocols to assure that households eligible for low-income services are referred to the low-income programs.	3		

c	Develop and leverage partnerships with community groups to help with marketing and education, and coordinate with municipal efforts, that yield savings.	2	prior to assessment through the low-income program and are over income for low-income services can be triaged into HES for an HEA and the existing low-income qualification will go with the customer into the HES program. Details on this process will be developed in close partnership with LEAN. • Learning from Efficient Neighborhoods+® (EN+) and Renew Boston is still on-going in evaluations. There may be more information coming in that can help inform an approach to moderate income. Our review and incorporation of this information is part of how we approach "assess and determine appropriate population." PAs initial focus on 61-80% state median income is to respond to the need for continuity of services with low-income programs. • A primary concern PAs have with proxy methods of income verification is that they restrict the ability of PAs to broadly market the program through traditional, low cost, effective marketing mediums. Proxy methods also can cause customer confusion and result in poor customer perception of the program. Finally there is no evidence that such proxy methods would actually have lower overhead costs relative to direct income verification. So far, we have indications from the EN+ evaluation that at least one proxy method of targeting paired with targeted outreach has a very high cost per opportunity secured. PAs are interested in exploring opportunities that can put more of the program dollars directly to work benefiting customers and securing weatherization opportunities. • One advantage of the opt-in design is the continuity with the low-income programs, achieved by utilizing the same "qualification" scale and maintaining the two program structure. Details on how to refer customers and methods and costs to income verification for "opt-in" customers all need and will receive further examination. • PAs are very enthusiastic about the ideas discussed in workshops regarding existing municipal efforts and local community organizations that currently serve this target market of moderate income customers. PAs have noted in the Plan their commitment to learn more and leverage opportunities to use such connections to increase access for moderate income customers to Mass Save® opportunities, with an emphasis on increasing installations. As these opportunities and relationships are inherently service area based, more detail and differing specific implementation opportunities are likely for each PA.	
19	**The PAs shall develop and implement by Q2 2016, a separate renter specific initiative, designed to address the split incentive and increase participation from this specific customer sector.**	1	PAs have begun planning for the introduction of a renter-specific initiative within the first year of the 2016-2018 Plan. The PAs are currently exploring program enhancements that provide effective screening and direction of renters to a specially designed visit that responds to renter opportunities and constraints. PAs see the potential for a well-designed special renter visit to increase participation in HES offerings, both by renters and landlords. The visit will focus on installation of instant savings measures such as efficient lighting, water saving devices and advanced power strips and will inform the customer of other appropriate opportunities for renters. Given the potential overlap of renters and moderate-income households, this effort	Section I.A.2, page 11 Section II.E, pages 37-38 Section II.E.4.c, page 57

a	Develop and leverage partnerships with community groups to help with marketing and education and coordinate with municipal efforts and/or consider alternative program models to better serve renters.	2	may simultaneously increase access and participation by moderate-income households, a high priority for the PAs, LEAN, and the Council (Council recommendation #18). Deployment of a special renter visit may also help to increase cost-effective program delivery by providing the right level of service at a reduced delivery time and cost. Triaging customers in this way may also help vendors providing HEAs to effectively serve renters while garnering information on landlord interest, thus increasing the opportunity to convert to deeper measures, consistent with the shared goal of increasing closure rates (Council recommendation #20). PAs are very enthusiastic about the ideas discussed in workshops regarding leveraging existing municipal efforts and local community organization that currently serve this target market of rental housing (renters and landlords). PAs have noted in the plan their commitment to learn more and leverage opportunities to use such connections to increase access for renters and moderate income customers to Mass Save® opportunities, with an emphasis on increasing installations. As these opportunities and relationships are inherently service area based, more detail and differing specific implementation opportunities are likely for each PA.	
		Home Energy Services Initiative		
20	**The PAs shall achieve deeper savings per household in the Home Energy Services (HES) Initiative through the following strategies.**	**1**	PAs plan to conduct an extensive review of the customer experience to identify opportunities for increased streamlining, simplifying and better targeting time and content of customer information to maximize our opportunity to influence customers taking action. This will include investigating digital and online options that improve the customer experience, and exploration of enhanced customer follow-up strategies that continue to track and reach out to customers at key moments, helping them pursue deeper measures and stay on track with open recommendations from their HEA. This holistic assessment process is fundamental to PA program design and implementation. It includes continuous review of cost effective incentive levels, for customers and vendors within the context of all elements of the program as a system to maximize savings realization. Most PAs have adopted a reporting/rating system to help contractors understand their performance in a holistic manner. These systems award work and/or financial bonuses based on performance. This is an ongoing effort and is discussed in the Plan Mass Save® Data, www.masssavedata.com, updated quarterly, already provides information on weatherization jobs, closure rates and savings. PAs are conscious of redundant reporting and the attendant overhead costs and do not plan to add new layers to the existing robust tracking and reporting in place. Tracking data at the customer or household level is an outstanding issue in an open docket with the DPU. Based on the Council recommendation, PAs reviewed the current composition of the best practices working group and determined it currently provides a higher representation of HPCs as a proportion of participating contractors statewide. HPCs hold 45% of the contractor seats while representing approximately 18% of the contractors in the program. The current structure is working well, and PAs have not included adjustments in the plan. PAs are open to discussing balancing the representation to better reflect proportionate representation (i.e., increase proportionate representation of IICs) if this remains a critical concern to the Council. PAs currently provide incentives for heat pump technologies and are continuously reviewing /screening heat pump technology in specific applications in the residential sector. To date, heat pumps have not screened as being cost effective as a whole house heating system replacement for any heat source, including electric resistance heat (baseboard). The technology is rapidly evolving along with complementary technologies, which may, in time, support optimizing heat pumps as primary heating	Section II.E.1, page 33 Section II.E.2, page 34 Section II.E.2.c, page 36 Section II.E.3, pages 38 and 40 Section II.E.4.c, pages 52-54, 56, and 60 Section II.E.4.f, page 73
a	Increase the closure rate for weatherization jobs:	1		
i	Assess why home energy assessments are not resulting in installation of recommended weatherization	1		
ii	As soon as practicable, use findings to implement changes to increase the close rate	1		
iii	Report findings and progress in the quarterly reports to the EEAC.	4		
b	Assess the potential impacts of adjusting the insulation incentive, including maximum dollar value and percentage, and consider eliminating the cap on these incentives. Assess offering different tiers for market rate vs. moderate income households, while allowing for broad awareness marketing.	3		
c	Provide customized approaches, technical assistance, and offerings to specific customer types/segments (e.g., homes doing remodeling work, high energy users and electric heat resistance customers).	3		
d	Track all measures implemented at the household level where technically feasible to provide the Council with more comprehensive information on the penetration rates, and the depth of savings achieved when multiple measures are implemented.	4		
e	Continue to create incentives for lead vendors, Home Performance Contractors (HPCs), and contractors to achieve overall savings targets through a whole building approach.	1		
f	Reassess the structure of the Best Practices Working Group to ensure HPCs have an equitable role in decisions.	4		
g	Integrate renewable thermal technologies into the HES delivery model, building on the success of the early boiler/early furnace replacement offering	3		

			systems. As cost effective implementation opportunities ripen, PAs will adjust program offers to respond. The early boiler/furnace model may or may not represent an optimal mechanism for deployment.	
21	**The PAs shall optimize the effectiveness of the Home Energy Assessment (HEA) and the HEA delivery channel.**	**1**	Massachusetts' HES is a mature initiative with over 20 years of program delivery experience, including many refinements and expansions. The core initiative consistently delivers strong energy savings while reaching over 80,000 participants statewide in 2014 and continues to grow. The Massachusetts HES core initiative has the greatest reach of any whole home program in the nation. Nevertheless, PAs remain committed to continuous improvement and this 2016-2018 Plan focuses strongly on optimizing all aspects of the HES-HEA delivery channel. As discussed above in response to Recommendation #20, PAs plan to conduct an extensive review of the customer experience to identify opportunities for increased streamlining, simplifying and better targeting to maximize opportunities to influence customers to take action. The current design and implementation of the initiative includes a one stop shop approach and provides comprehensive information to customers on Mass Save® opportunities with a fuel blind approach. The Mass Save® website has become a critical focal point in the comprehensive marketing program, providing a consolidated one stop shop for residents and businesses to learn about energy efficiency, program offerings, and opportunities. The Mass Save® website and strategies that drive customers to the website will continue to be refined to ensure the highest quality customer experience. A majority of residential customers are aware of the website and 30% report using the website more than once in the past year. The Mass Save® assessment collateral links customers to a federal website with updated information on tax credits and additional incentives. If the Commonwealth would like to provide a link to a static URL that is updated on a regular basis and encompasses all available state incentives, the PAs would be pleased to link to that as well. Under current RCS regulations the PA's Lead Vendors and HPCs are providing comprehensive HVAC and hot water recommendations in a fuel blind manner during the HEA. Modifications may be necessary based on anticipated RCS regulation changes and will be made when RCS regulations become final. Recommendation of renewable thermal technologies may expand based on RCS regulation changes but will also need to be screened for cost effectiveness. The deployment of the online assessment tool, speaks to the on-going commitment of PAs to reach out broadly and provide an effective and creative entry point for customers. The on-line assessment tool is beginning to offer what the Council has highlighted in their recommendation as a desire to "optimize" the effectiveness of the HEA and the HEA delivery channel. The on-line assessment effectively provides customers with a no–cost home energy score card, tied directly to customer-specific actionable Mass Save® energy efficiency opportunities based on the resident's unique circumstances, all from the comfort of their keyboard and at their leisure. Each user can be tracked and followed up with, regardless of whether they move on to an HEA or are better suited to another Mass Save® opportunity. PAs look forward to exploring how our existing on-line assessment tool and resultant score card, a cost effective customer centric approach, already addresses the Council's interest in ensuring customers have access to actionable home energy score cards. PAs will also continue to monitor DOEs ongoing research in neighboring states on alternative score cards. The plan will not be including artificial deadlines or additional reporting or research requirements. This level of design detail is not appropriate to the plan and runs the risk of distracting effort and effectiveness from providing customers with the highest quality information and greatest access to efficiency opportunities, a strategic commitment shared by both the PAs and the Council. PAs are particularly concerned with	Section II.E.2, page 35 Section II.E.4.c, page 54 Section II.I.1, page 156
a	Improve the integrated "one-stop shop" customer experience:	1		
i	Provide the customer with comprehensive information about Mass Save®, state and federal incentives for HVAC, hot water, and renewable thermal technologies, regardless of the customer's existing fuel source.	2		
ii	Direct lead vendors and HPCs to provide customers with comprehensive HVAC/hot water and renewable thermal technology options, regardless of the customer's fuel source, when recommendations to upgrade are made.	1		
b	Identify, assess, and, where appropriate, implement ways to streamline and better customize the offer and information presented at the HEA through strategies such as pre-screening customers and additional customer follow-up protocols.	1		
c	By Q1 2016, collaborate with DOER and EEAC Consultants on a report that:	4		
i	Identifies actions needed to provide customers with an asset-based "home energy scorecard", similar to the one implemented in the Home MPG initiative and;	1		
ii	Quantifies costs and benefits associated with providing customers with such a scorecard.	4		

			explorations of offerings, such as review of alternative score cards which are already being studied by neighboring jurisdiction, that increase administrative overhead without connecting to energy savings.	
		Products Program		
22	**The PAs shall fully incorporate LEDs in both the Products and Whole House programs, and phase out CFLs, as follows:**	**1**	The Plan clearly commits to fully incorporating LEDs and phasing out CFLs, as market factors allow, and with attention to ensuring the highest value investment and benefits for ratepayers over the 2016-2018 Plan period. PAs have shown their commitment over the 2013-2015 period with major advancement in this arena – driven entirely by PA long term research efforts, professional program design, and effective procurement strategies that have allowed the program to lead the nation and market in technology deployment and cost effective savings. PAs remain committed to sharing information through quarterly reports with the Council and using the existing EMV and research frameworks to continue their success in this area. The Plan will not be including artificial deadlines for the phase out or additional reporting or research requirements that are a level of design detail not appropriate to the Plan and run the risk of distracting effort and effectiveness in achieving the shared strategic commitment of the PAs and the Council to fully incorporate LEDs in both the Products and Whole House programs, and phase out CFLs.	Section II.E.1, pages 33-34 Section II.E.2, page 34 Section II.E.2.a, page 36 Section II.E.3, page 40 Section II.E.4.h, pages 80 and 85
a	As soon as pricing allows, and no later than Q4 2016, offer only LEDs in the Whole House program and specialty lighting in the Products program.	1		
b	As part of ongoing assessment activities conducted in conjunction with EEAC consultants, progress towards providing only LEDs for general lighting in the Products program, and report on such assessments and progress in the quarterly reports to the EEAC.	4		
c	To support and maintain Massachusetts' position as a leader in accelerating the adoption and installation of new technologies and practices, the PAs, in conjunction with the EEAC consultants, shall assess upstream program designs for HVAC and DHW-related technologies no later than Q3 2016.	4		
		HEAT loan/financing		
23	**The PAs shall, by Q2 2016, evaluate the following proposed changes to the HEAT loan program. The PAs shall report findings to the EEAC no later than Q2 2016:**	**4**	The Mass Save® HEAT Loan initiative is the most successful initiative of its kind in the nation, growing from 532 loans in 2006 to over 11,000 loans in 2014 (annual). Since inception, the Mass Save® HEAT Loan has made over $200,000,000 available to thousands of homeowners implementing home energy efficiency improvements. With over $250 million financed (residential) - more than other leading states, combined- the Mass Save® HEAT Loan initiative has the largest volume of loans. It also has the broadest lender participation with over 60 local Banks and Credit Unions across the Commonwealth offering this product. Since 2011, the initiative has incorporated a broad FICO score acceptance, well into the sub-prime category. Approximately 45% of households taking the HEAT Loan in 2014 had incomes between $40 and $80 K, and banks indicate that income is not a major barrier for HEAT loan approval (detail found on page 229 of the DRAFT 2016-2018 Plan). The current HEAT Loan developed, deployed, and offered to customers by the PAs in conjunction with the Massachusetts Bankers Association and Credit Unions, has low costs to the Programs, a very attractive interest rate, no credit enhancements, no loan administrative costs passed back to PAs, and lenders bear the principal risks. All customers of electric PAs receive the HEAT Loan application. Gas PAs that have municipal electric companies within their territories will offer the HEAT Loan to those natural gas/municipal electric customers. In this way, all customers that pay into the funds are able to access the HEAT Loan. This universal access and common 0% interest rate has tremendous marketing and brand value for energy efficiency and the PAs' energy efficiency programs. The Mass Save® HEAT Loan is a major success story. The PAs have given the Council's recommendation serious attention. At this time the value of the current structure, including the single 0% interest rate, is working effectively both in terms of costs to administer and results in broadly serving the Massachusetts market place by	Section II.E.2.a, pages 35-36 Section II.E.4.b, pages 47-48 Section II.E.4.c, page 55 Section II.E.4.e, page 66 Section II.H.2, page 152 Section V.B.5, pages 228-230
a	Provide low interest (e.g. 2%) loans for market rate customers, and maintain 0% for moderate income customers.	4		
b	PAs fund a loan loss reserve for moderate income customers and customers with marginal (e.g. 600-	4		

24	**The PAs shall coordinate with DOER to expand the HEAT loan-eligible measures to include those currently funded by DOER under the Expanded HEAT Loan program.**	**3**	leveraging the expertise and capital of the existing lending community. Similarly it does not appear at this time that there is reasonable justification for a loan loss reserve given the programs current success in serving moderate income customers and current broad FICO score acceptance. The PAs will continue their efforts to understand the nature of barriers for different customer segments, which may be related to accessing capital, and to explore financing products/solutions to address them. The PAs will also continue to review the cost to administer the HEAT Loan offer and seek out efficiencies and cost savings.	Section II.E.4.a, pages 47-48 Section II.H.3.b, page 155
25	**The PAs shall identify and implement appropriate ways to simplify and accelerate the HEAT Loan application and approval process.**	**2**	PAs have not fully developed strategies for addressing all possible technologies. PAs are reviewing these matters, while also seeking to ensure that each technology is addressed in the most appropriate forum. The outcomes of the anticipated RCS regulation changes and cost effectiveness screening will be critical to understanding which technologies may be eligible for a HEAT Loan and whether efficiency resources may be appropriately applied. PAs are open to leveraging their highly successful HEAT Loan infrastructure to support additional related energy technologies but only if additional funding is available. It is contemplated that HEAT Loan expansion will require additional funding sources that could vary by measure. The current HEAT Loan offering was developed, deployed, and offered to customers in conjunction with the Massachusetts Bankers Association and Credit Unions. PAs will continue this successful partnership working closely with our partners in the lending community who are best positioned to offer advice on loan application and approval processes. The current loan volume is a strong indication that the current process is well designed and administered. PAs remain ever vigilant to ensure the best possible customer experience across all customer/program touch points and work continuously to simplify and accelerate the process.	Section V.B.5, page 230
		New Construction Initiative		
26	**The PAs shall enhance the New Construction Initiative:**	**1**	The PAs are enthusiastic about continuing to enhance the new construction initiative in ways that motivate builders to use the most energy efficient technologies and building practices for Massachusetts homes. PAs are committed to promoting the value of net zero and renewable ready measures to builders in the New Construction Initiative. Currently, multiple builders in the highest performance tier are including renewable ready elements along with super-efficient designs and construction resulting in homes that achieve net zero or renewable ready status. PAs have already begun to share these success stories and promote the approaches used in training and educational offerings and through marketing. In this way, PAs support the industry in achieving increased numbers of high performance homes and support customer understanding of their value within the market. For 2016-2018 the PAs will be increasing their education and marketing on how builders can use the existing initiative to reach net zero or net zero ready in the current new construction training programs. The High Rise path (serving buildings that are 4+ stories) offers a custom option, which is prescriptive based. The Joint Management Committee ("JMC"), including residential and commercial new construction technical experts from the PAs staff and the lead vendor, will continue to assist in defining performance targets, establishing incentive structures, recruiting developers, completing energy analysis, and providing technical guidance on energy efficiency construction practices. A more detailed or clearer articulation of how the custom path reflects a "performance path" will be considered.	Section II.E.2.c, page 37 Section II.E.3, page 39 Section II.E.4.a, pages 41 and 45
a	By Q1 2016, implement a "renewable ready" requirement in the highest two performance-based tiers and the top prescriptive incentive tier.	4		
b	By Q2 2016, deliver a report to the EEAC that assesses:	4		
i	Creating a Zero Net Energy (ZNE) incentive top performance tier.	3		

ii	Adding a performance path for multi-family housing (4+ stories).	3	The plan will not be including artificial deadlines or additional reporting or research requirements that are a level of design detail not appropriate to the plan and run the risk of distracting effort and effectiveness in achieving the shared strategic commitment of the PAs and the Council to achieving the deepest savings possible in the New Construction Initiative.	
iii	Increasing incentives for rental housing new construction as a way of mitigating rental split-incentives.	4	The PAs are unable to include increased incentives for rental housing in the plan. The New Construction Incentives are not stratified by housing type, and incentives are provided to the builder. Savings are calculated based on the unit level savings above an agreed upon baseline. PAs cannot currently claim different savings based on planned occupancy. The new construction initiative experiences some difficulty in maintaining cost effectiveness, leaving no room for incentive increases without some corresponding increased savings. This is also a concern for adding new incentives for non-energy savings items such requiring renewable ready, net zero, or achievement of these elements. Incentives and requirements of the program shall remain focused on maximizing energy efficiency savings. Although not specifically recommended by the Council, the PAs will be exploring the savings opportunities home automation technologies can provide to the new construction initiative. The PAs feel home automation could be an exciting advancement in new construction market that could also help make the initiative more cost effective.	
		Behavior Initiative		
27	**The PAs shall expand savings from behavior programs and explore the incorporation of home automation technology into their behavior initiative and report to the EEAC on the results of their findings.**	**1**	The PAs are actively deploying behavioral programming, specifically through the Home Energy Report initiatives that the majority of PAs intend to continue. Two gas PAs have been unable to secure a reasonable cost for the HER deployment in their service areas, though given the broad reach of the electric PA programs, many of these customers may already have been treated, thus a spillover effect is in play. PAs intend to continue to monitor opportunities for amendments to the current HER model and new behavioral initiatives. The field of behavioral energy efficiency is evolving, with new product offers from vendors as well as new opportunities created by technology and engagement tools. PAs share the Council's enthusiasm for supporting cost-effective emerging technologies and will continue exploration of how home automation technology can be woven into initiatives, including exploring its use in combination with behavioral elements. There is considerable discussion in the Plan on this topic (see narrative under New Construction Initiative above). PAs are also continuing to evaluate and explore opportunities to leverage home automation technologies including eligible wireless enabled thermostats and their associated communication tools as well as other custom engagement tools for behavioral savings. The Plan further notes that some PAs may explore offering behavior initiatives that have the ability to provide near real time electric consumption feedback, and have the ability to offer a mobile based application in addition to traditional web based or paper reporting. Some PAs may also look to see what potential exists to tie in home automation, smart appliances, and other controls where applicable. Some electric PAs may leverage funding from their Grid Modernization Plan in areas where energy efficiency and grid modernization cross over.	Section II.E.2.b, page 36 Section II.E.3, page 38 Section II.E.4.d, pages 62-64
		Multi-Family Retrofit Initiative		
28	**The PAs shall increase savings from, and improve the customer experience in, the multi-family retrofit initiative:**	**1**	PAs remain committed to continuous improvement of the multi-family program to increase savings and improve the customer experience. PAs expressly commit in the Plan to continued improvement of the customer's single point of contact experience,	Section I.A.2, page 11 Section II.E.1, page 33 Section II.E.2.a, page 35

a	Provide weatherization incentives and HVAC and hot water equipment rebates to multi-family buildings that heat with unregulated fuels (e.g., oil or propane) to the same extent provided to gas or electric resistance-heated multi-family buildings.	1	leveraging and expanding from the success of the MMI model to further support customers. PAs also commit to seamless program delivery, linking rebates, incentives and services to the customer in a way that provides a comprehensive energy efficiency offer and maximizes savings. PAs are committed to coordinating the residential multi-family and commercial initiatives through the joint participation of the Multi-Family Working Group of Residential and C&I program management staff and vendors, working together to streamline delivery of packaged, comprehensive energy efficiency services to the multi-family sector. PAs are also committed in the Plan to tracking and reporting residential and commercial meter savings separately. PAs have planned for expansion of weatherization, HVAC, and water heating to multi-family customers utilizing oil and propane, pending (and dependent on) finalization of RCS regulations. PAs currently offer and will continue to offer support for Multi-Family properties to benchmark their properties through the EPA Benchmarking tool (Portfolio Manager). The link to this nationally recognized tool is included on the website page(s) associated with the Multi-Family Retrofit core initiative. EPA Portfolio Manager is a publicly available and free tool accessible to all property owners. PAs have supported data upload through the Green Button Initiative and have extensively coordinated with disclosure efforts such as the Boston Energy Reporting and Disclosure Ordinance to support customers' ease of access to benchmarking and compliance with reporting requirements.	Section II.E.2.c, page 37 Section II.E.3, pages 39-40 Section II.E.4.b, pages 47 and 51-52
b	By Q2 2016, for buildings that benchmark, use benchmarking to:	NA		
i	Institute or demonstrate a "pay for performance" approach to retrofits using pre- and post-retrofit baselines for evaluation.	4		
ii	Customize incentives to facilitate participation and deeper savings per building.	1		
c	By Q2 2016, develop and implement a plan or initiative for benchmarking in the multi-family sector.	1		
d	Seamlessly deliver services, rebates and incentives to the customer, regardless of whether such services, rebates or incentives are supported by the commercial or residential program.	1		
i	Provide customers with a single point of contact to act as a project manager offering whole building services for both residential and commercially metered buildings, including overseeing energy efficiency installations and coordinating with the PAs and their vendors.	1		
ii	For each building, link all services, rebates and incentives provided, regardless of whether such services, rebates or incentives are supported by the commercial or residential program, to provide a comprehensive view of commercially- and residentially-metered energy use and savings.	1		
iii	For each building, track and report both commercially-metered energy use and savings, and residentially-metered energy use and savings.	1		
e	Segment the sector (e.g. according to ownership patterns, building types, or meter configurations) and implement tailored approaches to facilitate increased participation and savings per building within such segments.	1		
f	Prioritize comprehensive whole building based performance.	1		
g	By Q2 2016, implement an initiative, in partnership with housing finance institutions, to integrate efficiency work into opportunities such as refinancing or retrofitting of larger multi-family buildings.	3		
	Low-Income Programs			
29	**The Low-Income Energy Affordability Network (LEAN) shall expand their eligible scope of services:**	**1**	PAs have planned for expansion of weatherization, HVAC and water heating for eligible participants in the low – income multi-family program utilizing oil and propane, pending finalization of the anticipated revised RCS regulations. PAs will work with their partners at LEAN to ensure any efforts designed to serve moderate income customers up to 80% of state median income are coordinated. This is discussed above in response to Council recommendation # 18. With respect to recommendation #29.b, the PAs believe that changing the 60% state median income standard used with consistency at the DPU for low-income EE matters is beyond the scope of these current program design efforts.	Section II.E.2, page 11 Section II.E.3, page 38-39 Section II.E.4.a, page 85 Section II.E.4.b, page 90
a	Provide weatherization, HVAC, and hot water technology services to low-income multi-family buildings that heat with unregulated fuels (e.g., oil or propane).	1		
b	Define low-income multi-family buildings as those with at least 50% of tenants earning up to 80% of Area Median Income (AMI).	4		
c	Assess and report to the Council on expanding 1-4 family program to serve customers up to 80% AMI.	Refer to #18		

d	Evaluate and, if appropriate, serve non-profit organizations that primarily serve low-income customers, provided that:	3	It should be noted that non-profits are served as commercial entities and therefore any program or initiative activity will be the province of the C&I programs, regardless of delivery vendor.	
e	Such services are clearly defined, and synched with Mass Save® C&I sector non-profit initiatives;	NA		
i	There is adequate funding such that providing such services does not reduce services to preexisting LEAN markets or exacerbate the low-income residential program queue;	NA		
ii	The PAs and LEAN report annually to the EEAC on which non-profits are served, what services are provided, and the cost per building	NA		

G. **<u>Council's Resolution of July 21, 2015</u>**

Massachusetts Energy Efficiency Advisory Council

Comments regarding the April 30th Draft 2016-2018 Energy Efficiency Plan

Resolution approved July 21, 2015

I. <u>Introduction</u>

Under the Green Communities Act ("GCA"), the Energy Efficiency Advisory Council ("EEAC" or "Council") is charged with reviewing the Massachusetts Program Administrators' ("PAs") draft Statewide Electric and Gas Energy Efficiency Plan ("the Draft Plan"), submitted to the EEAC on April 30, 2015. Having reviewed the Draft Plan, the EEAC provides the following comments to the Department of Public Utilities ("the Department") and the PAs.[1]The EEAC recognizes and commends the PAs on the significant achievements made during the first two years of the current 2013-2015 Plan, in particular surpassing the 2014 Plan savings goals on a state-wide level. The Council looks forward to building on that success by leveraging the collective experiences and shared commitment to design and deliver programs to achieve all available, cost-effective energy efficiency savings consistent with the GCA goals. The EEAC also recognizes and appreciates the significant hard work that the PAs have put into the development of the Draft Plan, and encourage the continuing cooperation among PAs, the EEAC and its consultants, and interested stakeholders through the planning process.

The following comments represent input from councilors, stakeholders, legislators, and EEAC consultants, gathered through EEAC meetings, two public comment sessions and nine workshops to engage councilors and PAs in discussion. The EEAC notes and appreciates the PAs' contributions to engage fully in these workshops.The Council looks forward to continuing collaboration and the exchange of information among the PAs, the EEAC and its consultants, and interested stakeholders throughout the summer and fall. It is the EEAC's expectation that the PAs will work with the EEAC and its consultants to continue to refine and improve the Draft Plan, through timely interim updates on program design that respond to this resolution with a Revised Plan to the Council no later than September 18th , leading to filing a Final Plan with the Department in October. In this spirit of collaboration, the Council provides the following comments on the Draft Plan as the next step in its role in shaping the 2016-2018 Final Plan.

A. Savings Goals and Program Costs

The EEAC's first priority in evaluating the Draft Plan is to consider the level of targeted lifetime savings

and benefits achieved by the programs. The EEAC resolved on March 31, 2015 that it "shall only approve 2016-2018 Plans that include savings goals that build on the achievement of the prior Three-Year Plans and conform with and support the successful attainment of all available cost-effective energy efficiency." The Draft Plan falls short of both objectives: to build on the programs' prior savings and

[1] Only voting members of the EEAC may vote to approve this resolution, therefore this resolution does not necessarily represent the views of the all parties who have participated in the 2016-2018 Draft Plan development.

benefits achievement and to meet the GCA's mandate to achieve all available cost-effective energy efficiency. The PAs' proposed savings goals for gas and electric in the Draft Plan are too low and are below the level of current achieved savings. Consistent with the GCA, the PAs must take advantage of all cost-effective innovations on the demand side, especially at a time when other energy sources are constrained.

The EEAC supports savings goals higher than proposed in the Draft Plan and in line with the Consultants' estimate of savings, as updated July 13th, in which they recommended savings goals (on average across the 3 years of the 2016-2018 Plan) of 3.09% of annual savings as a percentage of retail sales for electric; 1.44% of annual savings as a percentage of retail sales for gas; with 44,696,836 megawatt hours (MWh) of lifetime electric savings and 1,321,607,043 therms of lifetime gas savings.

The EEAC sees many indications that the PAs can pursue and achieve additional energy savings and benefits, beyond those reflected in the Draft Plan. Among the more significant indications are:

- The historical PA achievements, including the evaluated level of savings in 2014 (for electric: 2.76% of annual savings as a percentage of retail sales, and 13,554,964 MWh of lifetime savings; and for gas: 1.35% of annual savings as a percentage of retail sales, and 382,857,716 therms of lifetime savings);
- The EEAC Consultants' March 10th Assessment of Potential for energy efficiency savings (3% of annual sales for electric and 1.5% for gas);
- The energy efficiency savings goals in line with the Massachusetts Clean Energy and Climate Plan for 2020; and
- The robust benefit/cost ratios for the electric programs in the PAs' Draft Plan (2.38 overall and increasing across the three years).

Given the differences in savings goals and program costs between the Council's consultants and the Draft Plan, it is clear that some of the planning assumptions made by the PAs in the Draft Plan differ from those assumptions made by the EEAC consultants in their April 30th recommendation, and updated recommendations from July 13th. The EEAC appreciates the collaborative effort that the PAs and Consultants have expended in recent weeks exploring the main assumptions that account for these differences and expects that the results of this "key drivers" analysis will be reported to the EEAC for consideration at its August EEAC meeting.

The EEAC also notes that, in 2014, the PAs achieved savings significantly above plan year goals while spending close to budgeted costs. The PAs hard work in overcoming sector level challenges to achieve these nation-leading levels of savings is appreciated. Notwithstanding the potential for assumptions to change through the "key drivers" analysis, the PAs' most recent results indicate that the steep increase in levels of program costs in the Draft Plan is not merited without a commensurate increase in savings. Where budget increases are proposed above 2014 actual levels, the EEAC requires a detailed and reasonable justification of any higher costs in the Revised Plan, with factual support linked to program redesign, specific baseline changes, new initiatives, deeper savings, incorporation of the EEAC's informed recommendations, or other rationale(s).

The EEAC expects that the Revised Plan will provide significantly higher savings goals at similar or lower program costs, while clearly demonstrating that the PAs seek to achieve all available cost-effective energy efficiency consistent with GCA. The EEAC requires that the next draft provide more specificity and back-up data for the proposed goals in general, and, more specifically, complete and updated cost-benefit screening tool data by PA. If any PAs propose goals below 2014 evaluated levels of lifetime savings in MWh, therms, gallons of oil, or British thermal units (BTUs) of propane achieved by any sector for any year within 2016-2018, the Revised Plan must include detailed and specific relevant data that informed the decision to reduce the savings goal, including any independent market assessments of achievable savings goals.

B. Other EEAC Priorities

The EEAC reiterates its priority of continuous improvement in lifetime savings, benefits, and customer experience for the 2016-2018 Plan expressed in the March 31, 2015 Resolution. In refining the plan, the EEAC encourages the PAs to maintain an emphasis on lifetime savings and benefits. The Council further supports greater integration of gas and electric programs and additional winter and summer peak demand savings. Although there are line items in the EEAC reviewed term sheet template for summer and winter electric demand savings, the EEAC does not see much emphasis in the Draft Plan on demand reduction. The Council encourages additional efforts to realize electric demand savings.

The EEAC also appreciates the PAs' creation in the Draft Plan of offerings that target historically underserved segments of businesses and residents statewide, such as renters, moderate income customers, and small businesses. These efforts are the type of market segmentation and targeting that will enable the programs to continue to grow, capture further savings, and equitably serve ratepayers throughout the Commonwealth. The Council expects the PAs to include much more detail in the Revised Plan about these offerings and additional offerings that target other customer segments.

The EEAC thinks that the Mass Save Data website is a useful tool and greatly appreciates the PAs' continual improvement to this website. However, the Council continues to request a comprehensive statewide database with sufficiently granular inputs and this website should not be framed as such. Instead, the Revised Plan should more accurately reference the status of the EEAC stakeholder process, including the Department's December 2014 decision. A comprehensive database is still seen by the Council as a significant aid in: identifying untapped opportunities for savings, enabling better comparisons between PAs and incorporating best practices across territories, streamlining and reducing costs of EM&V, and addressing many of the EEAC's requests for additional reporting.

Finally, the EEAC recognizes that performance incentives are an integral part of the planning process and of program implementation. The Council does not provide any comments on the performance incentives proposed in the Draft Plan at this stage. Before October, the EEAC will review the overall framework of the current performance incentive model with the PAs and EEAC consultants, in order to optimize and calibrate the performance incentive structure to reflect the priorities of the EEAC and ensure the best results.

C. Major Overarching Comments

The Draft Plan describes in detail the existing programs already established and underway, but provides little specificity regarding changes or enhancements proposed by the PAs to these programs for 2016-2018. The EEAC requires that the Revised Plan include additional detail and clarity regarding the program elements being newly introduced for the 2016-2018 timeframe, elements being continued from previous years, and elements the PAs propose to continue with specific improvements. The Council expects additional details in the Revised Plan including implementation strategies, budgets, and timelines for all substantial changes the PAs plan to introduce relative to the 2013-2015 Plan.

The Draft Plan provides few firm commitments, specifics, or dates by which program enhancements and new initiatives will be introduced. Similarly there are only rarely descriptions of action plans or timeframes for deciding on and implementing the various options the PAs are exploring. Taken as a whole, the lack of specificity in the Draft Plan is such that the EEAC cannot, at this stage, determine whether it can support the programmatic changes the PAs propose. The EEAC requests that dates, milestones and additional detail for all changes to programs and initiatives be included in the Revised Plan.

The EEAC encourages more innovation by the PAs through pilots and/or demonstration projects, as well as through programmatic changes. The Council urges the PAs to take advantage of opportunities to introduce new approaches to advance the energy efficiency market further. In particular, the PAs have the opportunity to continue driving the light emitting diode (LED lighting) market and the related phase-out of compact fluorescent lightbulbs (CFLs), rather than simply reacting to current market trends as described in the Draft Plan.

The EEAC recognizes that lighting baselines and certain building code provisions are changing in the coming years, and that these changes will affect the level of claimed savings. However, the EEAC remains confident that the PAs can deliver new and improved programs that continue to grow cost-effective and deeper savings by leveraging increasing customer awareness, reaching historically underserved sectors, and taking advantage of rapid changes in technologies such as lighting, controls, and heat pumps, aligned with decreasing capital and installation costs of these and other technologies.

Finally, the EEAC has prepared detailed comments regarding the PAs' responses to the informed recommendations the Council provided in its March 31, 2015 resolution. The Council's more specific comments on the Draft Plan are included below in Section II.

The EEAC re-emphasizes its appreciation for the hard work and efforts of the PAs in developing the Draft Plan and implementing the current nation-leading and award-winning programs. The EEAC recognizes that the planning process is an ongoing one and the PAs are continually working on further refinements. The Council is ready and willing to work with the PAs, prior to the October filing with the Department, to improve the Draft Plan and align the details of the Revised and Final Plan with the GCA and the Council comments and recommendations.

II. EEAC Recommendations

In support of the priorities articulated above, and in order to achieve the high levels of benefits, lifetime electric and natural gas savings, and demand reduction consistent with the GCA, the Council makes the following recommendations. The recommendations in this section may not represent the opinion or position of every Councilor on certain issues, but on the whole, the EEAC has determined that the recommendations should be considered and addressed in the Revised Plan. The EEAC appreciates that some of these recommendations have cost-effectiveness, budgeting, and bill impact implications that the PAs will consider alongside benefits. At the same time the EEAC thinks that the Revised Plan must innovate in order to set the stage for future plans where lighting is expected to contribute a lower percentage of overall savings and benefits.

Cross-Cutting Recommendations

a. The PAs, in coordination with the EEAC, should develop a methodology for reporting accurate program penetration and participation numbers that will be reported regularly to the EEAC. The EEAC appreciates the difficulty of reporting on upstream programs. As such, it is appropriate for the PAs to develop building-level tracking with zip-code level reporting[2] for building level measures and to report on upstream programs at a measure level by PA territory.
b. The PAs should support products and practices that reduce winter and summer peak demand by taking the following actions:
    i. Design, implement, and evaluate a demand reduction or demand response offering in each PA's service territory.
    ii. Detail the results of the PAs' ad hoc group that is exploring demand reduction strategies, including a description of subsequent actions to be taken, and a timeline for implementation of such strategies in the Revised Plan.
    iii. Collaborate with the EEAC consultants in investigating the potential impact on efficiency savings from a greater emphasis in program design on demand savings or peak demand savings, including reviewing whether changes to the cost-benefit screening tools are appropriate.
c. The PAs should work with the Department of Energy Resources (DOER) to identify appropriate incentives in the Mass Save programs for renewable thermal technologies.
    i. DOER and the PAs shall jointly develop a methodology to claim savings associated with the installation of renewable thermal equipment and fully account for savings where appropriate associated with the reduction in use of the prior fuel source.
    ii. The PAs should provide rebates and incentives for renewable thermal technologies, where deemed appropriate and cost-effective at the sector level pursuant to the above methodology, not later than Q3 2016.
    iii. The PAs should continue to coordinate with the Massachusetts Clean Energy Center and DOER to provide information to customers and promote coordinated rebates and incentives for renewable thermal technologies.

[2] Reporting at higher aggregations than a single zip-code may be warranted on a case-by-case basis for certain C&I measures, but the default should be to provide geographic information while maintaining client confidentiality.

Commercial and Industrial (C&I) Recommendations

A. Segment Specific Approaches

The Draft Plan includes several examples of existing segment-specific approaches such as coordination with municipalities, and it is clear that these are an important part of the PAs' C&I strategies.

a. The PAs should provide more specifics about segment-specific approaches in the Revised Plan, including:
    i. Which segments will be and are being served with segment-specific approaches, and the timeframes and strategies for introducing new approaches.
    ii. The PAs' forthcoming on-line application and energy conservation measure portal.
    iii. How the PAs are leveraging industry, professional and Councilor associations and networks.
    iv. More details and timeframes on staff and vendor training to better communicate with customers the value proposition of energy efficiency, address concerns, and stimulate interest in moving forward with recommendations.
    v. How the PAs are addressing demand and peak load reduction through segment-specific approaches.
    vi. How the PAs are addressing the topic of statewide consistency and best practice sharing for segment-specific approaches.
    vii. More information about targeted communication materials for sectors as well as improvements to the Mass Save website to provide these materials
b. The EEAC requests that the PAs report regularly on progress and innovations with respect to how the PAs are implementing segment specific approaches. The PAs should propose a format and schedule in the Revised Plan for these less formal updates.
c. *Healthcare* - The PAs shall provide information about how recommendations from the joint PA/EEAC Consultant Healthcare Best Practices study, or other segment strategy, will be implemented, including commitments to specific timelines for adoption.
d. *Mid-Size Customers* - The PAs shall provide a timeline and details for new mid-size customer strategies.
e. *Non-Profits* – The PAs shall provide a timeline and details of strategic outreach, for serving non-profits beyond what is included in the Draft Plan.
f. *Commercial Real Estate (CRE)* - The CRE sections were not included in the Draft Plan. The EEAC requests that the PAs develop a CRE section of the Plan, informed by the findings of the CRE Working Group before August 1st, if not sooner.
    i. This section should include the following information:
        1. Plans for evaluating sub-metering for the CRE sector, including whether it will be considered as part of PAs' offerings, and a date by which that determination will be made or implementation will occur.
        2. An assessment of all recommendations for CRE from the EEAC's March resolution, and a specific response to each.

B. Continuous Technology Improvement

The PAs did not propose in the Draft Plan any pilot programs, as the EEAC recommended in March, but note that they will undertake a "consolidated research and development ('R&D') effort to (a) support the work of the Massachusetts Technology Assessment Committee (MTAC), and (b) pursue technologies of interest in order to remain at the top of the 'innovation curve.'" However, there is little detail on how this work will be undertaken. New for the Draft Plan is the PA inclusion of a budget line item for "C&I R&D and Demonstration". The Revised Plan should include:

a. More details about the scope and operation of R&D projects, including work performed at the MTAC and PA innovations outside the MTAC.
b. Commitment to implement demonstration projects that advance innovation, especially as it relates to products that reflect rapid innovations in the marketplace, are of high customer interest, and/or have dependence on the customer for persistent savings.
c. Regular updates to the EEAC on R&D and demonstration projects. The PAs should propose a format and schedule for these less formal updates in the Revised Plan.

C. C&I Reporting

The PA Draft Plan has included more initiatives in the C&I programs, largely in line with the Council recommendations. These initiatives will have their own goals and budgets associated with them and will be part of the regular PA tracking data. In the Revised Plan, the PAs should:

a. Establish a three-year Combined Heat and Power (CHP) goal (not necessarily as a separate initiative in C&I Retrofit) and track/report on this CHP-specific goal as part of the PAs' annual reports to the EEAC/Department.
b. Consider adding an Upstream Products break-out for New Construction that includes products beyond lighting, such as water heaters.
c. Commit to continuing to report annually on C&I segment-specific approaches (e.g. CRE, healthcare, mid-size, industrial, etc.).
d. Increase goals for LED lighting, and C&I Retrofit in accordance with the results of the key drivers analysis.
e. Commit to semi-annual reporting to the EEAC on LED streetlight conversions.

D. C&I Updates

The PAs deliver significant energy savings and benefits through the programs through hard work and innovation. Updates from the PAs help inform the EEAC of these efforts and innovations. In the March 31, 2015 resolution, the EEAC asked for regular PA updates on a number of topics. For some topics, like the CHP potential analysis, these requests will require formal reports. Other areas, like the updates on sector-specific approaches or small business program innovations, will not necessarily require regular formal written reports. For topics not needing a formal written report, the EEAC would like the PAs to commit to a less formal reporting method to keep the Council informed of these and other efforts through means such as presentations to the EEAC or periodic (quarterly) PA C&I webinars. The PAs should propose a format and schedule for these updates in the

Revised Plan. The Council thinks these less formal program updates will also provide checkpoints for the PAs to share program success.

E. Retro-Commissioning, Building Controls, and Sub-metering

The Draft Plan notes that the PAs will align the PAs' retro-commissioning (RCx) programs with the recommendations from the "Retro-commissioning Best Practices Study" completed by the PAs and the EEAC Consultants. Existing building operator training programs are discussed, but no new training programs are proposed. The Draft Plan does not address benchmarking in the context of commissioning or legacy controls. In the Revised Plan, the PAs should:

a. Address issues of persistence of savings from RCx projects. Monitoring-based commissioning can increase and ensure persistence of savings and should be further explored and demonstrated.
b. Address how legacy controls will be included in the PAs' retrofit and RCx programs.
c. Address how the use of benchmarking, sub-metering and pre/post metering will be integrated into programs.
d. Commit to a strategy that expands building operator training programs, beyond the Draft Plan and traditional Building Operator Certification (BOC) offerings, including soliciting input from customers.
e. Commit to specific program enhancements and timelines for adoption of best practices identified in the RCx Best Practices Study.
f. Commit to increasing the availability of qualified RCx providers.

F. Behavioral and Engagement

The PAs note that they engage in Strategic Energy Management (SEM) in the context of existing programs and will consider expanding SEM offerings by engaging with early SEM adopters from the Pacific Northwest. The Draft Plan contains little information about behavioral programs and does not commit to deliver reports on either SEM or behavioral programs as requested by the Council. The PAs should include the following information in the Revised Plan:

a. Commitment to assess cost effectiveness of SEM projects in line with the EEAC March 31, 2015 Resolution and, if deemed cost-effective at the sector level, a commitment to develop and evaluate an SEM demonstration project.
b. More detail on behavior approaches outside of memoranda of understanding (MOUs) and on whether and how savings are claimed from customer behavior changes.
c. More detail on direct load control and methods for how the PAs could engage customers in demand response.
d. Commitment to using the Consortium for Energy Efficiency (CEE) Minimum Elements document as a reference when discussing SEM programs, in order to ensure a common understanding of what is included.
e. Commitment to implement and evaluate behavioral demonstration projects for small and medium C&I customers.

G. Small Business

The Council appreciates the PAs' commitment to the Small Business program. The Draft Plan addresses a number of Council recommendations including realizing deeper savings, expanding gas measures, and expanded sector-specific approaches. The PAs intend to make program enhancements though a series of incremental improvements. Using building analytics is under consideration by the PAs and web-based customer engagement portals will be implemented by the PAs. The PAs should include the following information in the Revised Plan:

a. Specific commitments to program enhancements for the Small Business program, and a timeline for these enhancements. Some of the enhancements the EEAC thinks are important include: expanding offerings for gas measures, more comprehensive marketing/outreach/awareness programs, and more customized approaches for Small Business customers (by size and segment).
b. A timeline for evaluating potential and cost effectiveness of building analytics and portals for small business customers (EEAC Councilors discussed a Q3 2016 deadline).
c. An action plan, including timelines, for using the data collected by online portals to analyze and benchmark energy use to effectively target small businesses.

H. Combined Heat and Power

The PA Commitment to CHP is clear and the PAs largely incorporated the Council's recommendations. The PAs should include the following information in the Revised Plan:

a. A firm commitment to complete the CHP potential report and implement findings including:
    i. Deliverable dates for a best practices review and potential study (EEAC suggested end of 2016)
    ii. Specific mention of pre-packaged and third party CHP options
b. A clear CHP goal and a schedule for annual reporting on the progress toward the three-year goal, even if this is not a separate initiative outside of C&I Retrofit.
c. Higher goals for CHP, in accordance with the results of the key drivers analysis.

I. LED Streetlights

LED Streetlights represent a significant source of savings in the Commonwealth. The Draft Plan notes success with streetlight retrofits by Cape Light Compact and other PAs. However the Draft Plan does not commit to any innovations around streetlights, or to the EEAC-requested goal of retrofitting the majority of utility owned streetlights and all municipal owned streetlights by 2018. The PAs should include the following information in the Revised Plan:

a. An action plan for stimulating rapid conversion for municipally-owned street lights; for example:
    i. Cape Light Compact managed a joint conversion process for all of its municipalities, providing technical assistance and project management through the entire process.
    ii. Upstream or bulk purchase pricing for municipalities.
b. A strategy and timeline to retrofit the majority of utility-owned street lights to LEDs within this Plan's timeframe (including a timeframe and commitment for filing of an appropriate

tariff for utility-owned LED streetlights at the Department). The EEAC intends to support such a tariff at the Department, to aid in removing this barrier for the PAs.

c. Higher savings goals attributable to LED streetlights in accordance with the results of the key drivers analysis.

J. Zero Net Energy (ZNE) Ready Buildings

In the Draft Plan, the PAs propose to establish a basis of technical knowledge and expertise, and a framework for program support for ZNE ready buildings. However there is no timeline or commitment to implement a Zero Net Energy Buildings (ZNEB) program. The PAs should commit to assessing a ZNE ready building tier and include a timeline for a new construction offering in the Revised Plan.

K. Delivered Fuels and Thermal Efficiency

There is no mention of the PAs' marketing comprehensive assessments to non-gas C&I customers. The PAs should include the following information in the Revised Plan:

a. A strategic plan for marketing, in-print, online, and in-person, a non-gas customer's ability to self-fund the thermal portion of a comprehensive energy assessment using a PA auditor.
b. A timeline for assessing any barriers or limitations to implementing the strategic plan, and a commitment to work with the EEAC to seek ways to address any barriers/limitations.

Residential Recommendations

A. New Initiatives

Moderate Income Initiative

The EEAC supports the Draft Plan proposals to develop a new moderate income offering within the Home Energy Services (HES) core initiative and the PAs' proposal to initially focus on households earning 61-80% of state median income (SMI). This initial offering should be developed further into an initiative to attract new participants to the HES and multi-family retrofit programs, as well as support follow-through of existing customers with deeper savings opportunities. Therefore, the Revised Plan should include:

a. Detail on the proposed scope of measures and program marketing plan, including plans to leverage partnerships with community groups, possible points of entry, and qualification for eligible customers.
b. Detail about the customers in this income range, including number and proportion of residential customers in the 61-80% SMI in each PA territory and the number of those customers that the PAs expect to serve.
c. Commitment to provide and incorporate, as appropriate, lessons learned from the Efficient Neighborhoods +® (EN+) evaluation and other pilots, demonstrations, or applicable programs by Q1 2016.
d. Commitment to assess by Q2 2017 the potential for serving customers at 81-100% and 101-120% of state median income as part of an expanded moderate income offering.

Renter-Specific Initiative

The EEAC supports the PAs' inclusion of a renter-specific initiative in the Draft Plan that recognizes a large and relatively underserved customer base. In order for the EEAC to fully comment on and understand this initiative, the PAs should include the following clarifying details in the Revised Plan:

a. The implementation strategy and schedule for the renter-specific offering, providing dates, milestones, and a date in 2016 by which the offering will be available to qualified HES and multi-family customers. The PAs should provide details on program marketing, including plans to leverage partnerships with community groups.
b. The PAs' proposed engagement strategy to ensure immediate benefits to renters, with a plan for securing landlord buy-in and follow-through with whole-house/building measures.
c. The savings measures that will be offered to renters and how such measures compare to the measures currently provided under the HES and multi-family retrofit initiatives.

B. Whole House Program

The Council recognizes the great need for deeper and diversified savings in the Whole House Program, which was not fully addressed in the Draft Plan. The EEAC supports the PAs' plan to conduct an extensive review of the customer experience through HES, to streamline, simplify and maximize opportunities to influence customers to pursue deeper savings. The Revised Plan should include:

a. A commitment to household-level tracking of all non-upstream measures, where technically feasible.
    i. Include a proposal, with dates and milestones, for linking rebates and incentives provided to the same household across programs and PAs, together with a plan for reporting this whole house coordinated information at a zip-code level.
b. Dates for: completion of the extensive review of the HES program, development of a plan for implementation of identified opportunities, and a report back to Council.
c. Details, dates, and milestones regarding improvement of the integrated "one-stop shop" customer experience, including providing customers with both Mass Save and non-Mass Save incentive/rebate information, regardless of heating fuel source, consistent with the proposed Residential Conservation Services (RCS) regulations.
d. Details of the expected oil and propane savings by PA, based on an analysis of their service territory.
e. Commitment to collaborating with DOER and the EEAC consultants to identify the actions and implementation steps needed to provide customers with an asset-based "home energy scorecard", including cost estimates for each step.
f. Strategies (including continuation of existing strategies) tailored to specific customer groups or segments, such as targeted approaches, technical assistance, or offerings (e.g., homes undergoing remodeling work, high energy users, and customers using electric resistance heat).
g. A description of efforts to ensure equitable treatment of Home Performance Contractors (HPCs) compared to lead vendors, including 3rd party quality control inspections and regular opportunities to engage and present to the Residential Management Committee (RMC).

C. HEAT Loans and Financing

The Council appreciates the success of the HEAT Loan program to date. The Draft Plan proposes no changes to the HEAT loan or other financing initiatives. In the Revised Plan, the PAs should include:

a. Strategy, dates, and milestones to assess how moderate income customers are currently served and could be better served by the HEAT Loan program, including assessment of the cost and effectiveness of a loan loss reserve, taking due account for the economic vulnerability of some customers.
b. A date by which the PAs will finalize additional measures to be financed through the HEAT loan, including those currently funded through DOER's Expanded HEAT Loan Program.

D. Multifamily Retrofit

The EEAC understands the complexity of the multifamily sector, including the dual residential-commercial meters that may serve them, the diversity of building types, ownership entities, and resident profiles. The Council is supportive of improving the customer experience through the PAs' proposed single point of contact for multifamily projects. The PA C&I team should be engaged in refinements to the multi-family program. In the Revised Plan, the PAs should:

a. Provide detail on the PAs' proposed single point of contact and commit to assessing what changes are necessary to integrate commercial and residential rate codes into a whole building approach.
b. Commit to developing and providing targeted offerings to different segments of the multifamily building market.
c. Provide plans for improving the integration of efficiency into refinancing events, such as through a proposed partnership with the state's housing finance agencies or commercial lending institutions.
d. Commit to providing multi-family customers with user-friendly benchmarking tools to track unit-level energy usage and comparisons against peers.
e. Implement a pay-for-performance demonstration program.

E. Behavior

The PAs include consideration of positive additions to behavior programs in the Draft Plan, including home automation, near real-time feedback, smart appliances and controls. In addition to these enhancements, in the Revised Plan the PAs should:

a. Commit to expand behavior program participation and include dates and milestones to implement this expansion. PAs not implementing behavior programs should document why these measures are not cost-effective and why the PA is not partnering with other PAs that are implementing behavior programs.

F. New Construction

The Draft Plan does not address the initial Council recommendations on New Construction. The Council supports the Draft Plan's inclusion of marketing and education efforts around zero net energy (ZNE) homes. In the Revised Plan, the PAs should:

a. By Q4 2016, commit to working with the EEAC consultants to explore how to claim savings for renewable energy systems in the cost/benefit analysis.
b. Add a performance path for multi-family housing.
c. Implement a renewable-ready requirement in the highest two performance tiers and the top prescriptive tier.
d. By Q4 2016, commit to working with the EEAC consultants to assess the impact of creating a ZNE incentive top performance tier and report findings to the Council. Use findings to inform implementation of a ZNE top performance tier.

G. Renewable Thermal

The Draft Plan does not explicitly address the growing market for renewable thermal technologies, though it references the expected updates to the RCS regulations that allow fuel switching away from pre-existing heating fuels.

a. The PAs should actively collaborate with DOER on the development and implementation of RCS guidelines, and by Q4 2016, update and maintain the cost-benefit screening tools for renewable thermal technologies.

H. Products Program

Lighting

The EEAC supports the commitment in the Draft Plan to phase out incentives for specialty CFLs by 2016. However, the Draft Plan does not fully address the Council's recommendations on LEDs and appears to use inconsistent and overly conservative volume and cost projections for 2016-2018. In the Revised Plan, the PAs should:

a. Increase savings projections to reflect a growing market share of LEDs and increasing sales volumes for retail lighting.
b. Commit to quarterly reporting to the EEAC on progress of LEDs during Plan implementation.

Heating and Hot Water

The PAs did not propose residential upstream incentives for hot water heaters in the Draft Plan, although this is being implemented for C&I customers. The Council recognizes that the PAs need to understand the market potential for this incentive and the effects of implementing an upstream program on savings. In the Revised Plan, the PAs should:

a. Include an assessment of implementing upstream incentives for residential tankless water heaters and other potential HVAC measures and report back to the Council by Q3 2016.

Low-Income Recommendations

The EEAC acknowledges the establishment of the income guideline for Low Income programs at 60% of state median income (SMI) in the Green Communities Act, and the PAs' inclusion of a moderate income offering within the residential Whole House programs in the Draft Plan. The Council recognizes the need for flexibility in programs that serve buildings with high tenant turnover or families living on the margin of eligibility in the Low Income programs. In addition, the Council recognizes the variety of organizations that hold nonprofit status and that some of those organizations own buildings that serve low income populations and may have opportunities for energy savings. The Revised Plan should commit to:

a. Explore ways to flexibly serve low-income multi-family buildings with at least 50% of residents earning up to 80% SMI.
b. Explore alternative incentives or service approaches for non-profit organizations that primarily serve low income customers.

H. **PA Response Matrix to July Resolution**

Submitted: September 23, 2015

PA RESPONSE TO EEAC RESOLUTION ADOPTED ON 7-21-15

	Resolution Language	PA Response	Plan Section
	Introduction		
1.	It is the EEAC's expectation that the PAs will work with the EEAC and its consultants to continue to refine and improve the Draft Plan, through timely interim updates on program design that respond to this resolution with a Revised Plan to the Council no later than September 18th, leading to filing a Final Plan with the Department in October.	The PAs have worked intensively with EEAC members (with a special focus on work with DOER and the Attorney General) and the Council's consultants during the summer and into this month to refine and improve the 2016-2018 Plan in response to the Council's July resolution. In addition, the PAs, the Council's consultants, DOER, and the AG have engaged in extensive discussions, data sharing and analysis to refine assumptions, close the gaps, and come to agreement on appropriate budget, savings, and performance incentive levels for 2016-2018. These discussions have resulted in the Term Sheet being filed herewith, which provides for the highest savings goals ever put forward in the Commonwealth (and, to the PAs' knowledge, in the United States), at costs-to-achieve that are materially lower than the costs in the April 30, 2015 draft plan. To finalize productive discussions, the parties agreed that the PAs should push back submission of the September 18 draft until the week of September 21. The PAs express their appreciation and respect for the extensive efforts of DOER, the Attorney General, the Council's consultants and the EEA in developing and finalizing the historic commitment to energy efficiency. The PAs hope the Council will support unanimously the Term Sheet and the 2016-2018 Plan and look forward to reviewing the Plan with Councilors.	Appendix (Term Sheet)
	Savings Goals and Program Costs		
2.	The EEAC supports savings goals higher than proposed in the Draft Plan and in line with the Consultants' estimate of savings, as updated July 13th, in which they recommended savings goals (on average across the 3 years of the 2016 - 2018 Plan) of 3.09% of annual savings as a percentage of retail sales for electric; 1.44% of annual savings as a percentage of retail sales for gas; with 44,696,836 megawatt hours (MWh) of lifetime electric savings and 1,321,607,043 therms of lifetime gas savings. The EEAC sees many indications that the PAs can pursue and achieve additional energy savings and benefits, beyond those reflected in the Draft Plan. Among the more significant indications are:	The PAs engage in a collaborative and iterative planning process for setting savings goals and budgets. As part of this process, the PAs engaged in extensive, productive, and collaborative discussions with the Council's consultants, as well as DOER and the Attorney General, in an effort to resolve differences and narrow gaps. These discussions resulted in adjustments on the part of both PAs and other parties as they shared, reviewed and analyzed different data sets and assumptions. The PAs necessarily employ a multi-faceted approach and consider and weigh multiple reference points, including the following three distinct analyses: (1) bottom-up; (2) evaluation; and (3) top-down. The bottom-up process involves building plan goals and budgets from the measure level up whereas the top-down process looks at the portfolio as a whole, evaluating the potential for achieving higher goals given markets in which the programs are operating . The impact of evaluation results are considered in both bottom-up and top-down planning and may drive other adjustments. The process to determine goals must be and is fluid, flexible and iterative because PAs receive information throughout the planning process relating to program design, evaluation, costs, and other factors. As discussed in more detail in the Plan, in developing goals for 2016-2018, the PAs conducted a comprehensive assessment of the energy efficiency landscape, including considering changes in baselines, codes, and standards, evaluation studies, PA potential studies, consultant assessments, and other market factors. As a result, the 2016-2018 Plan takes into account many competing considerations to set goals that	II.D; IV; V

Submitted: September 23, 2015

	Resolution Language	PA Response	Plan Section
		satisfy the GCA's mandate to achieve all available cost-effective energy efficiency and the Department's directive to do so at a sustainable pace. As a result of this process, the PAs are submitting savings goals for 2016-2018 that are at the highest level ever for the Commonwealth, and to the PAs' knowledge, in the United States. See Term Sheet being filed herewith.	
3.	• The historical PA achievements, including the evaluated level of savings in 2014 (for electric: 2.76% of annual savings as a percentage of retail sales, and 13,554,964 MWh of lifetime savings; and for gas: 1.35% of annual savings as a percentage of retail sales, and 382,857,716 therms of lifetime savings);	See above response. The 2016-2018 Plan is expected to deliver more lifetime MWh and therm savings than the 2013-2015 Plan. Looking at the PAs' performance in terms of percent of sales does not always provide an accurate comparison of actual savings levels because forecasted sales change from one three-year plan to the next based on factors including weather, economic activity and other factors outside the PAs' control. For example, if savings levels stayed the same or increased, the percent of sales could decline if sales increased. Additionally, other factors outside the PAs' control affect the PAs' ability to achieve savings, including updates to codes, baselines, and standards.	II.D; IV; V
4.	• The EEAC Consultants' March 10th Assessment of Potential for energy efficiency savings (3% of annual sales for electric and 1.5% for gas);	See above two responses.	II.D; IV; V
5.	• The energy efficiency savings goals in line with the Massachusetts Clean Energy and Climate Plan for 2020; and	The 2016-2018 Plan delivers more GHG emissions reductions than prior plans, and has major environmental benefits for the Commonwealth that support the goals of the GWSA. In order to maximize environmental benefits, a goal of the GCA, the PAs, with the support of the Council's independent EM&V expert, propose to conduct a new EM&V study to better quantify the full suite of GHG reductions and benefits that result from energy efficiency efforts.	IV.G.4.d.
6.	• The robust benefit/cost ratios for the electric programs in the PAs' Draft Plan (2.38 overall and increasing across the three years).	In accordance with the GCA and the directives of the Department, the PAs seek to acquire all available cost-effective energy efficiency through a sustained statewide effort. The 2016-2018 Plan provides a strategic plan for acquiring all cost-effective energy efficiency resources at a reasonable pace during this three-year period.	II.B; II.D; IV; V.A
7.	Where budget increases are proposed above 2014 actual levels, the EEAC requires a detailed and reasonable justification of any higher costs in the Revised Plan, with factual support linked to program redesign, specific baseline changes, new initiatives, deeper savings, incorporation of the EEAC's informed recommendations, or other rationale(s).	As discussed above, the PAs engage in a collaborative and iterative planning process for setting budgets. As part of this process, the PAs engaged in extensive, productive, and collaborative discussions with the Council's consultants, as well as DOER and the Attorney General, in an effort to resolve differences and narrow gaps. These discussions resulted in adjustments on the part of both PAs and other parties as they shared, reviewed and analyzed different data sets and assumptions. In developing budgets, the PAs took into account changes in the cost of program delivery, baselines, codes, and standards, evaluation studies, potential studies, consultant assessments, and other market factors.	II.D; III, IV; V
8.	The EEAC expects that the Revised Plan will provide significantly higher savings goals at similar or lower program costs, while clearly demonstrating that the PAs seek to achieve all available cost - effective energy efficiency consistent with GCA.	As noted above, the Plan adopts higher savings goals than the April 30, 2015 draft at reduced costs, consistent with the EEAC's recommendations in the July Resolution.	IV, Appendix (Data Tables)

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9.	The EEAC requires that the next draft provide more specificity and back - up data for the proposed goals in general, and, more specifically, complete and updated cost-benefit screening tool data by PA.	As they did with the April draft, PAs will provide benefit cost screening tools, with detailed assumptions on costs, savings, and benefits (with measure level data) to the DOER, Attorney General and the Council's consultants for the September draft Plan. Final BCR models will be provided to the EEAC and the DPU at the time of the PAs' final October Plan filing. The September Plan includes significant discussion of key drivers of the savings and costs proposed in the Plan.	IV; Appendix (Data Tables)
10.	If any PAs propose goals below 2014 evaluated levels of lifetime savings in MWh, therms, gallons of oil, or British thermal units (BTUs) of propane achieved by any sector for any year within 2016 - 2018, the Revised Plan must include detailed and specific relevant data that informed the decision to reduce the savings goal, including any independent market assessments of achievable savings goals.	See Term Sheet for individual PA goals. All goals have been calibrated based upon Term Sheet negotiations supported by an extensive array of data and associated analysis. Please also refer to the potential studies discussed in the Plan and included as an Appendix, as well as discussion on unique service area characteristics in the Plan and in the Appendices.	IV.A.5.f, V.A.4, Appendices (Term Sheet, Potential Studies, Unique PA Materials)
	Other EEAC Priorities		
11.	In refining the plan, the EEAC encourages the PAs to maintain an emphasis on lifetime savings and benefits.	The PAs report both annual and lifetime savings and benefits.	
12.	The Council further supports greater integration of gas and electric programs and additional winter and summer peak demand savings.	The PAs have integrated electric and gas programs throughout the program design process. For example, the Residential Heating and Cooling - Electric core initiative will continue to work with the Residential Heating and Cooling – Natural Gas core initiative (GasNetworks®) on joint offerings, and co-promote through marketing, contractor training, and trade ally outreach including circuit rider. By collaborating, the PAs offer a near seamless integration of the gas and electric energy efficiency programs. PAs explore electric and gas technologies through MTAC, participate in management committees, and cross-promote between programs and initiatives.	III
13.	The Council encourages additional efforts to realize electric demand savings.	Achievement of demand savings in 2016-2018 is a key goal shared by the PAs and the Council. PA representatives will work with a small Demand Savings Group that includes the DOER, the Attorney General's Office, the Low-Income Energy Affordability Network, and the Council's consultants to explore demand savings opportunities such as demand savings from traditional energy efficiency, demand response, load shifting, and geo-targeting.	III.H.3
14.	The EEAC also appreciates the PAs' creation in the Draft Plan of offerings that target historically underserved segments of businesses and residents statewide, such as renters, moderate income customers, and small businesses. These efforts are the type of market segmentation and targeting that will enable the programs to continue to grow, capture further savings, and equitably serve ratepayers throughout the Commonwealth. The Council expects the PAs to include much	Please refer to the program specific recommendations and Plan sections for additional detail on new and improved efforts, such as the renter-specific visit, moderate income customer enhancements, and optimization of the Multi-Family Initiative. Like its predecessors, the 2016-2018 Plan includes multiple parts that taken together as an integrated whole describe the PAs' strategy for acquiring all cost-effective energy efficiency resources through a sustained effort. While detailed, a Three-Year Plan is a statewide strategic plan and not a detailed implementation guideline. A statewide strategic plan provides the PAs with the flexibility necessary to make implementation changes to meet changing circumstances in order to deliver on their Plan goals and satisfy the GCA.	II.D.1, III

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	more detail in the Revised Plan about these offerings and additional offerings that target other customer segments.		
15.	The EEAC thinks that the Mass Save Data website is a useful tool and greatly appreciates the PAs' continual improvement to this website. However, the Council continues to request a comprehensive statewide database with sufficiently granular inputs and this website should not be framed as such. Instead, the Revised Plan should more accurately reference the status of the EEAC stakeholder process, including the Department's December 2014 decision. A comprehensive database is still seen by the Council as a significant aid in: identifying untapped opportunities for savings, enabling better comparisons between PAs and incorporating best practices across territories, streamlining and reducing costs of EM&V, and addressing many of the EEAC's requests for additional reporting.	The PAs appreciate the Council's positive comment on Mass Save Data and know that access to data is important to all. In addition, the PAs recognize that competing needs to protect confidential customer data, manage costs, and provide detailed and transparent information must be considered and weighed. The PAs submit that they have developed a publicly accessible statewide energy efficiency database with Mass Save Data, but appreciate that even more information and enhancements may be appropriate. In this spirit and as part of ongoing improvements to Mass Save Data, the PAs are working to provide geographic information, with appropriate aggregation to protect customer privacy. The PAs are also working on providing measure level information on Mass Save Data for 2016-2018. These important new enhancements, which are directly responsive to specific Councilor requests, are under development by the PAs. The PAs remain willing to engage in discussions and review other requests for data and/or enhancements to Mass Save Data, understanding the shared goals of transparency, cost-effectiveness, and protection of confidential information. The PAs have also updated the plan narrative to accurately reference the status of the EEAC stakeholder process, including the Department's December 2014 decision and different stakeholder views during the EEAC process. Finally, the PAs will also carefully review and follow up on any directives of the Department of Public Utilities on the database matters currently pending before it.	VII.C and related appendices.
	Major Overarching Comments		
16.	The Draft Plan describes in detail the existing programs already established and underway, but provides little specificity regarding changes or enhancements proposed by the PAs to these programs for 2016 - 2018. The EEAC requires that the Revised Plan include additional detail and clarity regarding the program elements being newly introduced for the 2016 - 2018 timeframe, elements being continued from previous years, and elements the PAs propose to continue with specific improvements. The Council expects additional details in the Revised Plan including implementation strategies, budgets, and timelines for all substantial changes the PAs plan to introduce relative to the 2013 - 2015 Plan.	Please refer to the program specific recommendations below and program descriptions in the plan for additional detail. This 2016-2018 Plan builds on many successful and nationally emulated programs that the PAs have developed over years of implementing energy efficiency in the Commonwealth. The PAs seek continued innovation, but also seek to continue implementing successful strategies. The program specific materials detail many new innovations for 2016-2018, such as providing a streamlined customer experience, increased use of technology (and automation), leveraging and protecting the energy efficiency workforce, a single-point-of-contact experience for the multi-family customer, increased adoption of LEDs, continued review and expansion of upstream market models, encouragement of net-zero buildings, a renter initiative, enhanced services for moderate income customers, expanded segment-based delivery approaches, and many more. Like its predecessors, the 2016-2018 Plan includes multiple parts that taken together as an integrated whole describe the PAs' strategy for acquiring all cost-effective energy efficiency resources through a sustained effort. While detailed, a Three-Year Plan is a statewide strategic plan and not a detailed implementation guideline. A statewide strategic plan provides the PAs with the flexibility necessary to make implementation changes to meet changing circumstances in order to deliver on their Plan goals and satisfy the GCA.	II.D.1; III.E.3 (details Residential new and innovative); III.G.4. (Highlights C&I enhancements)

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17.	The Draft Plan provides few firm commitments, specifics, or dates by which program enhancements and new initiatives will be introduced. Similarly there are only rarely descriptions of action plans or timeframes for deciding on and implementing the various options the PAs are exploring. Taken as a whole, the lack of specificity in the Draft Plan is such that the EEAC cannot, at this stage, determine whether it can support the programmatic changes the PAs propose. The EEAC requests that dates, milestones and additional detail for all changes to programs and initiatives be included in the Revised Plan.		See above response.	II.D.1
18.	The EEAC encourages more innovation by the PAs through pilots and/or demonstration projects, as well as through programmatic changes. The Council urges the PAs to take advantage of opportunities to introduce new approaches to advance the energy efficiency market further. In particular, the PAs have the opportunity to continue driving the light emitting diode (LED lighting) market and the related phase-out of compact fluorescent lightbulbs (CFLs), rather than simply reacting to current market trends as described in the Draft Plan.		The PAs actively seek innovation and consistently work on demonstration projects within different programs. The PAs have also included separate budgets for R&D and Demonstration Projects in both residential and C&I sectors. The PAs are committed to technology innovations, through the MTAC as well as through other PA-specific and statewide efforts. Many PAs have in-house staff of technical and engineering professionals with expertise in such areas as energy codes and standards, building energy simulation tools, lighting technology and controls, assessment of energy efficiency products, and product development, who are dedicated to new technology research and, in collaboration with their evaluation colleagues, savings verification. The PAs have driven the market in energy efficiency technologies, such as LEDs, and will seek increased penetration through award-winning marketing campaigns and national leadership. Additionally, the PA programs are tightly coordinated to ensure that innovations in technology and market dynamics are shared and leveraged.	III
19.	The EEAC recognizes that lighting baselines and certain building code provisions are changing in the coming years, and that these changes will affect the level of claimed savings. However, the EEAC remains confident that the PAs can deliver new and improved programs that continue to grow cost-effective and deeper savings by leveraging increasing customer awareness, reaching historically underserved sectors, and taking advantage of rapid changes in technologies such as lighting, controls, and heat pumps, aligned with decreasing capital and installation costs of these and other technologies.		The PAs engage in a collaborative and iterative planning process for setting savings goals, taking into account changes to baselines that affect the level of claimed savings, as well as innovations and new programming, evaluation studies, and performing a detailed review of market conditions. This Plan is designed as a strategic guiding document to provide the PAs with flexibility to make implementation changes to meet changing market conditions and other circumstances in order to deliver on their Plan goals and satisfy the GCA.	II.D; III; IV; V
	Cross-Cutting			
20.	a.	The PAs, in coordination with the	The residential and C&I customer profile studies were designed to provide geographic	VII.C

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		EEAC, should develop a methodology for reporting accurate program penetration and participation numbers that will be reported regularly to the EEAC. The EEAC appreciates the difficulty of reporting on upstream programs. As such, it is appropriate for the PAs to develop building-level tracking with zip-code level reporting for building level measures and to report on upstream programs at a measure level by PA territory.	information, program penetration and participation through the EM&V process. The draft *Residential Customer Profile Study* found that the PAs served 200,523 premises through their Residential and Low-Income offerings in 2013, which represents 7% of all premises in the state. This data does not include customers who may have participated in upstream programs or those who received a Home Energy Report through a behavioral initiative. Due to the difficulty of tracking unique customer program participation across PAs, and concerns with customer privacy, the EM&V process was the most appropriate means to gather this information. As discussed in more detail in the statewide database section, two separate databases have been developed to support the customer profile studies. The PAs plan to perform customer profile studies on an ongoing basis so that this type of information can be regularly tracked. Direct access by stakeholders to these databases is not possible because of the need for customer consent for access to sensitive customer account and usage information. The PAs will accept Council requests to query the data in these databases and will prioritize these requests based on the cost of providing answers, the purpose and benefit of the data query and the timing of the request relative to study cycles. For additional information, please see Section VII.C.4. The PAs are also planning to use the Mass Save Data (www.MassSaveData.com) platform to provide geographic information. The PAs are developing a geographic tab that will include electric and gas incentives, usage, and savings. The geographic tab will be populated from the EM&V databases used to support the customer profile studies. In order to protect customer privacy, the PAs must ensure that the data in the geographic tab is sufficiently aggregated to avoid reverse engineering. This tab is still under development and the PAs' aggregation standards are still under discussion. Nevertheless, the PAs expect that they will be able to display C&I data at the town level and are reviewing whether this data can be displayed at the zip code level for Boston. The PAs are waiting for the residential customer profile study to be finalized and will then explore if it is feasible to present data at the zip code level.	
21.	b.	The PAs should support products and practices that reduce winter and summer peak demand by taking the following actions:	The PAs will assess new technologies and demand reduction strategies as they become available and commercially viable. Additionally, the PAs will support products and practices that reduce winter and summer peak demand where appropriate and cost-effective.	III.H.3
22.	i.	Design, implement, and evaluate a demand reduction or demand response offering in each PA's service territory.	The PAs are committed to working together with the Council's consultants to develop alternative efforts focused on creating demand savings during the 2016-2018 Plan. The PAs are currently focused on strategy identification and quantification of demand savings values. To that the end, the PAs have engaged in an expanded AESC study to develop avoided costs during seasonal "super peaks". This is a first step towards identifying benefits and costs of alternative strategies, assessing customer response to alternative strategies, and leveraging smart grid investments.	III.H.3
23.	ii.	Detail the results of the PAs' ad hoc group that is exploring demand	See above.	

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		reduction strategies, including a description of subsequent actions to be taken, and a timeline for implementation of such strategies in the Revised Plan.		
24.	iii.	Collaborate with the EEAC consultants in investigating the potential impact on efficiency savings from a greater emphasis in program design on demand savings or peak demand savings, including reviewing whether changes to the cost-benefit screening tools are appropriate.	See above. This work is in progress but is unlikely to be completed prior to the statutory filing date for this Plan.	
25.	c.	The PAs should work with the Department of Energy Resources (DOER) to identify appropriate incentives in the Mass Save programs for renewable thermal technologies.	The PAs remain committed to working with the EEAC consultants to explore addressing renewable thermal savings in 2016-2018. PAs are seeking to better understand exactly what technologies are contemplated by Councilors and their applicability in a three-year energy efficiency plan under the GCA and whether implementation of some of these efforts is better handled in other contexts or proceedings, such as grid modernization. In reviewing these matters, PAs will work with the Council's consultants to discuss and determine if there are cost-effective measures/strategies that can be appropriately delivered as energy efficiency measures, as opposed to renewable supply side measures, what funding sources are available, what energy savings and other quantifiable benefits can be claimed for incentivizing these measures, and what, if any, are the most promising potential technologies and, if applicable, choosing a set of them to prioritize. The PAs also suggest that any additional efforts beyond ongoing energy efficiency efforts should be supported with an appropriate performance incentive to better align PA and public policy interests as has been done with traditional energy efficiency efforts.	
26.	i.	DOER and the PAs shall jointly develop a methodology to claim savings associated with the installation of renewable thermal equipment and fully account for savings where appropriate associated with the reduction in use of the prior fuel source.	See above	
27.	ii.	The PAs should provide rebates and incentives for renewable thermal	See above	

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		technologies, where deemed appropriate and cost-effective at the sector level pursuant to the above methodology, not later than Q3 2016.		
28.	iii.	The PAs should continue to coordinate with the Massachusetts Clean Energy Center and DOER to provide information to customers and promote coordinated rebates and incentives for renewable thermal technologies.	The PAs will continue working with the CEC and cross-promoting incentives where there is overlap with PA programs, as appropriate. PAs can work to direct customers to the CEC website for CEC offerings related to renewable thermal technologies.	
	C&I Recommendations			
	A. Segment Specific Approaches			
29.	The Draft Plan includes several examples of existing segment - specific approaches such as coordination with municipalities, and it is clear that these are an important part of the PAs' C&I strategies. a. The PAs should provide more specifics about segment - specific approaches in the Revised Plan, including:		The Plan provides an expanded discussion of segment-specific approaches, including a visual representation of the drivers, barriers and metrics the PAs take into consideration, along with information about purchasing behavior and procurement practices, supply chain dynamics and past efficiency investment patterns, when developing a customized strategic approach to a variety of high-priority C&I customer segments, as identified by the Council and/or the PAs. These factors underpin the PAs choices regarding a wide range of design and implementation elements such as product/technology offerings, incentive levels and structure, marketing and messaging mix, channel selection and engagement, staffing, etc.	
30.	i..	Which segments will be and are being served with segment - specific approaches, and the timeframes and strategies for introducing new approaches.	See table referenced above and accompanying narrative discussion, as well as a chart on the immediately following page entitled *"Current & Planned Segment-based Approaches"*, which illustrates the customer segmented approaches that are deployed by the PAs now, or are in active development for deployment in the 2016-2018 Plan period.	
31.	ii.	The PAs' forthcoming on - line application and energy conservation measure portal.	A full discussion of both can be found in a subsection entitled *"More Tools for Customer Engagement"* within the C&I Retrofit section of the Plan.	
32.	iii.	How the PAs are leveraging industry, professional and Councilor	A section in the Plan entitled *"Mechanisms for Program Collaboration, Continuous Improvement, Incorporating Emerging Technologies, and Sharing and Incorporating Best Practices Information"* contains an explanation, along with examples, of the PA's current and future efforts	

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		associations and networks.	to leverage relationships with a wide variety of important stakeholders including peer PAs around the country, professional and industry organizations and associations, etc. all of which are extremely important resources upon which the PAs rely for information, program performance feedback, ideas for program enhancements, improved delivery and marketing approaches, and other learnings.	
33.	iv.	More details and timeframes on staff and vendor training to better communicate with customers the value proposition of energy efficiency, address concerns, and stimulate interest in moving forward with recommendations.	The Plan contains a subsection entitled *"Education and Training for Customers, Trade Allies, and PA Staff and Contractors"* within the C&I Retrofit section. This section provides a full discussion of the variety of ways in which the PAs already offer regular specialized training sessions for all their trade allies, other energy professionals who support or participate in the programs, and for their own program and technical staff as well. Common formats include webinars and live presentations at multiple sites around the service territory, including on site at vendor facilities. In addition, every year the PAs sponsor and participate in hundreds of training or educational events around the Commonwealth to reach and influence all the parties who own, manage, or operate and staff buildings in Massachusetts. Some of these events provide customers with a broad exposure to a number of energy-savings technologies and service providers, such as the annual PA-sponsored Vendor Open Houses, while others are more focused and specialized, such as presentations to business associations, chambers of commerce, and meetings of local ASHRAE and IES chapters.	
34.	v.	How the PAs are addressing demand and peak load reduction through segment-specific approaches.	Each Plan initiative with potential to reduce demand while reducing consumption is now described in the Plan with language that notes the dual potential. In addition, the PAs will be exploring the potential to adapt elements of the C*alifornia Advanced Lighting Controls Training Program* (CALCTP) to Massachusetts. (See full discussion under the above-referenced training section.) CALCTP provides electrical contractors and electricians with training and a certification in Advanced Lighting Controls (ALC). The curriculum covers the proper programming, testing, installation, commissioning and maintenance of advanced lighting control systems, including dimmers, occupancy sensors, photo-sensors, relay modules and communication-based control devices. The PAs view this model has having the potential to capture significant KW as well as KWh savings. Additionally, the PAs plan to continue advancing new "smart" technologies and energy efficiency measures that directly or indirectly impact demand and peak load reduction in a cost effective manner.	
35.	vi.	How the PAs are addressing the topic of statewide consistency and best practice sharing for segment - specific approaches	The C&I Management Committee (C&IMC) serves as the ongoing venue for sharing individual PA innovations in program design, marketing, and delivery. The C&IMC regularly reviews its processes and operations in order to continuously optimize the balance between innovation and consistency and will continue these efforts throughout 2016-2018. For example, the PAs respond to the variations of local markets and market conditions through experimentation in program design, product promotion, or a unique focus on distinct customer segments of local importance. This localized testing allows concepts that might have statewide applicability to be tested and evaluated in a limited low-risk/low-cost environment, with the results then shared and scaled up statewide as appropriate and practicable. In addition, the PAs have a variety of other mechanisms to ensure that a robust process to identify and screen candidate technologies is maintained. Full discussions can be found in the	

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			sections entitled *"Mechanisms for Program Collaboration, Continuous Improvement, Incorporating Emerging Technologies, and Sharing and Incorporating Best Practices Information"* and *"The Massachusetts Technology Assessment Committee (MTAC)."*	
36.	vii.	More information about targeted communication materials for sectors as well as improvements to the Mass Save website to provide these materials.	The Plan includes an expanded discussion of PA plans to reorganize and refresh the Mass Save® website to better direct customers to information specific to their needs in their business segment. As referenced in the Plan, the new design will focus less on technologies and programs and more on customers and their end uses along with available services. It will also feature new materials directed to specific segments and their needs. In addition, the redesign will also provide improved organization, navigation, and more customer-oriented language.	
37.	b.	The EEAC requests that the PAs report regularly on progress and innovations with respect to how the PAs are implementing segment specific approaches. The PAs should propose a format and schedule in the Revised Plan for these less formal updates.	The PAs will continue to report on segment-specific approaches, either as part of annual EM&V studies (primarily the C&I Customer Profile Report), or on a one-off basis to the Council as a whole, or to individual members as has been the practice for a number of years. Also, the PAs have discussed various approaches to providing more frequent and transparent communication to the Council regarding a variety of C&I related efforts and initiatives, including segment-specific approaches, and will work with the DOER early in the plan period to develop a process for enabling that to happen.	
38.	c.	Healthcare - The PAs shall provide information about how recommendations from the joint PA/EEAC Consultant Healthcare Best Practices study, or other segment strategy, will be implemented, including commitments to specific timelines for adoption.	As referenced in the section entitled *"Segments of Special Interest/Large Customers*", the Plan describes how the PAs invest significant staff and third party resources, as well as financial incentives, to serving the highest use customers, which are heavily represented by hospitals. The Health Care Best Practices studies was directed by the EEAC Consultants, and despite its methodological shortcomings, largely confirmed that the PAs' approaches to serving these customers constituted best practices – support for comprehensive audits, use of MOUs, providing educational support for facility managers, collaboration with industry organizations and associations, etc. For quite some time these have been, and will continue to be, foundational elements in the PAs approach to serving this strategically critical segment of customers.	
39.	d.	Mid - Size Customers - The PAs shall provide a timeline and details for new mid - size customer strategies.	All of the PAs have developed streamlined approaches to encourage comprehensiveness in the new construction/major renovation market for smaller and mid-sized buildings, a segment that accounts for 95% of the US non-residential building stock. National Grid and Cape Light Compact use the Advanced Buildings ("AB") approach in this market and Eversource has developed its own approach using engineering assumptions, building modeling, and an analysis approach that are very similar to those used by NBI. Under both models, the customer receives a set of recommendations that guides them to a more comprehensive approach to their building project without the necessity of a complex and often expensive modeling process. For existing Mid-Size Customers, the often cited *Mid-size Customer Needs Assessment* which looked at a single program year has been followed by the *2013 Customer Profile Study* which looks at customer trends longitudinally and largely shows Mid-size Customers are equitably served. The PAs have identified sections in the Plan that will specifically impact Mid-size	

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			customers. See the sections entitled "*Highlights of 2016-2018 Enhancements*" and "*Further Market Segment Delivery*". To this end, the PAs plan to continue offering program services and initiatives, through various delivery mechanisms, which will provide mid-sized customers a diverse portfolio of cost effective energy efficiency strategies to further participation in these programs.	
40.	e.	Non - Profits - The PAs shall provide a timeline and details of strategic outreach, for serving non - profits beyond what is included in the Draft Plan.	In a section entitled *"Commercial Non-Profits",* the Plan describes how, drawing on delivery models from other programs and initiatives such as multi-family and the residential home energy services effort, as well as experiences of other PAs around the country, National Grid is developing a prototype approach for serving a particular subset of non-profit commercial customers – houses of worship. That prototype will be developed and tested within National Grid's service territory using a phased approach over a number of months. The results of that effort will be analyzed and shared, as are all such efforts, with the other PAs. This will provide the basis for a collective determination as to whether such an approach could successfully be extended and adopted statewide. The plan is to have this prototype launched before the start of the Three-Year Plan and learnings developed and reviewed with other PAs once sufficient data exist upon which to draw reasonable conclusions and inferences, likely within 6-9 months of launch. Also, the reexamination of the Small Business initiative will include a review of how effectively it currently provides services to non-profits, as many, if not most, non-profits access the programs through the Small Business Core Initiative pathway.	
41.	f.	Commercial Real Estate (CRE) - The CRE sections were not included in the Draft Plan. The EEAC requests that the PAs develop a CRE section of the Plan, informed by the findings of the CRE Working Group before August 1st, if not sooner. i. This section should include the following information:	A section entitled *"Further Engage the Commercial Real Estate Sector"* has been included in the Plan document. This section details the PA response to each of the recommendations contained in the report of the Commercial Real Estate Working Group. The discussion also incorporates similar findings from a study of the CRE market in the Pacific Northwest that was issued at about the same time as the CRE Working Group report. The PAs also note that during 2016-2018 NYSERDA will develop and conduct a set of studies of efficiency packages in key CRE building types and market segments. The objective of these pilots will be to acquire building data for analysis and to conduct M&V studies to provide insights into the actual performance of these packages. Results will be used to produce case studies that will be shared with the efficiency industry. Also in 2016-2018, NYSERDA will partner with large portfolio owners in key building segments (CRE, medical centers, colleges/universities, etc.) and providers of various Real Time Energy Management (RTEM) service providers to conduct a set of replicable pilots using a variety of these tools that monitor data and use analytics to identify where, when, and how energy is being used in a building. NYSERDA will acquire building data for analysis and will conduct M&V and persistence studies "to provide insights into the technical/operational underpinnings of RTEM and to develop credible models and case studies to support a clear value proposition for owners of similar buildings." The PAs will discuss with NYSERDA management the potential for collaboration in these test areas, and potentially others as well. These discussions will be led by National Grid, as the PA whose operations span both jurisdictions. At a minimum, the PAs own test designs can be informed by NYSERDA experience.	

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42.	1.	Plans for evaluating sub‐metering for the CRE sector, including whether it will be considered as part of PAs' offerings, and a date by which that determination will be made or implementation will occur.	A section of the Plan entitled "Further Engage the Commercial Real Estate Sector" provides great detail about PA plans for working with CRE customers. Additionally, the Plan notes that, as has long been the case, submetering is incorporated into MOU agreements when, in the judgment of the principals, it will help identify and prioritize opportunities at the outset of the relationship and it will lead to customer action; that is, lead to savings. Submetering is also integral to the EM&V process, particularly when attribution and verification of behavior-based savings must be established. To the extent that CRE customers engage in MOU related agreements, the above would apply. While it is important to recognize that submeters in and of themselves do not produce savings, the PAs have and will continue to use submetering as a tool to support their "Pay for Performance" offering in which customers are rewarded for actual gas and/or electric usage reductions relative to a pre-established baseline which is determined by the prior installation of submeters.	
43.	2.	An assessment of all recommendations for CRE from the EEAC's March resolution, and a specific response to each.	See above.	
	B. Continuous Technology Improvement			
44.	The PAs did not propose in the Draft Plan any pilot programs, as the EEAC recommended in March, but note that they will undertake a "consolidated research and development ('R&D') effort to (a) support the work of the Massachusetts Technology Assessment Committee (MTAC), and (b) pursue technologies of interest in order to remain at the top of the 'innovation curve.'" However, there is little detail on how this work will be undertaken. New for the Draft Plan is the PA inclusion of a budget line item for "C&I R&D and Demonstration". The Revised Plan should include:		The Plan contains a section entitled *"Mechanisms for Program Collaboration, Continuous Improvement, Incorporating Emerging Technologies, and Sharing and Incorporating Best Practices Information"* which discusses in detail how the PAs identify and vet new technologies and new delivery approaches. Among the areas discussed are: in-house R&D (particularly among the PAs with multi-state operations); outcomes from partnerships with MOU Customers; and cooperative relationships with other program administrators or other regional efforts. There is also a full discussion of how the Massachusetts Technology Assessment Committee (MTAC) operates to identify and qualify technologies.	
45.	a.	More details about the scope and operation of R&D projects, including work performed at the MTAC and PA innovations outside the MTAC.	See above.	
46.	b.	Commitment to implement	See above.	

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		demonstration projects that advance innovation, especially as it relates to products that reflect rapid innovations in the marketplace, are of high customer interest, and/or have dependence on the customer for persistent savings.		
47.	c.	Regular updates to the EEAC on R&D and demonstration projects. The PAs should propose a format and schedule for these less formal updates in the Revised Plan.	The PAs have committed to provide quarterly status updates to internal stakeholders such as the C&I and Residential Management Committees as well as the Energy Efficiency Advisory Council along with semiannual updates to other external stakeholders. Documentation of recently reviewed technologies is always posted on the Mass Save® website at: http://www.masssave.com/en/professionals/business-opportunities/assessment-of-new-efficiency-technologies.	
	C. C&I Reporting			
48.	The PA Draft Plan has included more initiatives in the C&I programs, largely in line with the Council recommendations. These initiatives will have their own goals and budgets associated with them and will be part of the regular PA tracking data. In the Revised Plan, the PAs should:		The PAs share the Council's desire for increased transparency and the Plan has separated out elements of the programs for budget/planning/reporting purposes. Within the New Construction Program, the PAs created a Core Initiative for "New Buildings & Major Renovations" and another for "Initial Purchase & End of Useful Life" thereby increasing the granularity with which the Program, and its component elements, will be tracked during the course of the 2016-2018 Plan period.	
49.	a.	Establish a three‐year Combined Heat and Power (CHP) goal (not necessarily as a separate initiative in C&I Retrofit) and track/report on this CHP‐specific goal as part of the PAs' annual reports to the EEAC/Department.	After careful consideration, the PAs have decided not to separately plan, establish goals and budgets, and report on CHP. CHP results are, by nature of the complexity, relative risk, and long lead times of projects, highly variable and exhibit large fluctuations year to year, usually due to both the size and unpredictability of individual projects. It should be noted, however, that CHP measure level information is available in the electric PAs' BCR screening models, which are made available with the annual reports to the EEAC/Department and with the Plan.	
50.	b.	Consider adding an Upstream Products break‐out for New Construction that includes products beyond lighting, such as water heaters.	Given the relative infancy of the upstream delivery model as it relates to products other than lighting, the PAs do not believe it is a significant driver of overall C&I savings and or expenditures which would make it worthy of a separate Program and/or Core Initiative. However, during these early stages in their lifecycle, just as has previously been done very successfully with lighting, the PAs will be tracking the progress of any new upstream offerings on a nearly continuous basis, working collaboratively across PAs as well as with the PAs' contracted third party program implementation vendors. As with lighting, during these relatively early stages, evaluation studies are often undertaken and can provide valuable and comprehensive insights about progress to date and associated learnings. Should the Council so	

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			desire, they could review the findings of these studies, which are found on the Council's website, or could ask for, and the PAs would provide, a high level summary, of such progress.	
51.	c.	Commit to continuing to report annually on C&I segment - specific approaches (e.g. CRE, healthcare, mid - size, industrial, etc.).	The PAs will continue to report on segment-specific approaches, either as part of annual EM&V studies (primarily the C&I Customer Profile Report), or on a one-off basis to the Council as a whole or individual member as has been the practice for a number of years.	
52.	d.	Increase goals for LED lighting, and C&I Retrofit in accordance with the results of the key drivers analysis.	The PAs have included in their goals significant increases in lighting in general and LED lighting specifically. In order to achieve these higher savings, the PA recognize that LED lighting technology offerings require careful positioning through the various program delivery mechanisms to maximize program impact, achieve savings goals and meet both short and long term customer energy savings requirements.	
53.	e.	Commit to semi - annual reporting to the EEAC on LED streetlight conversions.	As municipal budgeting and decision making is relatively slow paced, the conversion of streetlights to LED is likely to take place over quite a number of years – it has at times taken multiple years for a single community to move from consideration to installation. The PAs will collaborate with the DOER early in the Plan period to develop an appropriate structure and timeline for providing updates regarding progress in conversion of streetlights to LED.	
	D. C&I Updates			
54.	The PAs deliver significant energy savings and benefits through the programs through hard work and innovation. Updates from the PAs help inform the EEAC of these efforts and innovations. In the March 31, 2015 resolution, the EEAC asked for regular PA updates on a number of topics. For some topics, like the CHP potential analysis, these requests will require formal reports. Other areas, like the updates on sector - specific approaches or small business program innovations, will not necessarily require regular formal written reports. For topics not needing a formal written report, the EEAC would like the PAs to commit to a less formal reporting method to keep the Council informed of these and other efforts through means such as presentations to the EEAC or periodic (quarterly) PA C&I webinars. The PAs should propose a format and schedule for these updates in the Revised Plan. The Council thinks these less formal program		The PAs have discussed various approaches to providing more frequent and transparent communication to the Council regarding a variety of C&I related efforts and initiatives. The PAs agree that focused reporting on mutually-agreed topics can be very beneficial to increase Council understanding of program specifics, and will work with the DOER early in the plan period to develop a process for enabling that to happen. Alternative communication vehicles, such as webinars or workshops, might be useful approaches that would respect the time and logistical constraints of all parties.	

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	updates will also provide checkpoints for the PAs to share program success.			
	E. Retro-Commissioning, Building Controls, and Sub-metering			
55.	The Draft Plan notes that the PAs will align the PAs' retro‐commissioning (RCx) programs with the recommendations from the "Retro‐commissioning Best Practices Study" completed by the PAs and the EEAC Consultants. Existing building operator training programs are discussed, but no new training programs are proposed. The Draft Plan does not address benchmarking in the context of commissioning or legacy controls. In the Revised Plan, the PAs should:		See below.	
56.	a.	Address issues of persistence of savings from RCx projects. Monitoring‐based commissioning can increase and ensure persistence of savings and should be further explored and demonstrated.	The PAs will continue to support and facilitate the implementation of RCx strategies, building systems optimization, and advanced controls operations wherever appropriate and consistent with energy efficiency program guidelines. To this end, the PAs will proactively implement the recommendations of the recently completed Retro-Commissioning Best Practice Study to streamline the RCx offerings and to achieve greater implementation of these strategies. For example, the PAs have already tested some of the RCx Best Practices recommendations by developing and implementing customized approaches to providing targeted RCx services to hospitals with a similar approach for labs currently in development. In addition, the PAs are committed to developing a common tool for RCx measures and expanding training for RCx for providers.	
57.	b.	Address how legacy controls will be included in the PAs' retrofit and RCx programs.	The PAs will continue to implement cost-effective energy efficiency measures and strategies consistent with program guidelines. As energy efficiency savings opportunities to existing advance building systems controls are identified through the retrofit program, or a component of that program such as RCx, the PAs plan to support measures in accordance with program guidelines and practices.	
58.	c.	Address how the use of benchmarking, sub‐metering and pre/post metering will be integrated into programs.	The PAs will continue to implement Energy Star® Benchmarking and will fully consider implementing additional cost effective benchmarking strategies on a case by case basis. Pre- and Post-metering has been integrated in the programs for the past several years, typically utilized during the consideration of complex projects and for the verification of energy savings. Sub-metering and pre and post metering devices alone do not result in energy savings. Whenever practical and cost effective, the PAs will continue to consider the use of appropriate pre/post metering, and sub-metering devices included in energy efficiency projects or strategies that lead to cost effective and quantifiable energy savings that are consistent with program guidelines and practices.	

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59.	d.	Commit to a strategy that expands building operator training programs, beyond the Draft Plan and traditional Building Operator Certification (BOC) offerings, including soliciting input from customers.	The Plan includes a greatly expanded discussion of the training opportunities currently provided by the PAs, as well options that will be considered and assessed during the coming plan period. Included are examples of local organizations and customer trade groups with which the PAs have regularly partnered and collaborated in the past, and expect to continue to do so in the future, to deliver educational and training content that fits the unique energy concerns of their members and constituencies. The Plan also discusses significant updates to the BOC training modules made by the BOC sponsors in recent years. Almost 40% of the content has been updated or replaced since 2013. The new curriculum focuses on low-cost opportunities to improve energy performance, building scoping and tune up, retro-commissioning, high performance HVAC systems, energy diagnostics using data loggers and BAS, selling efficiency projects, occupant engagement, and water conservation. Additional new BOC products include a continuing education webinar series to help BOC graduates maintain their certification; one day MOC events provided in partnership with sponsoring PAs for BOC graduates in their service areas; and a blended, online Level I course offering a mix of classroom and online training. The Plan also discusses several other new educational offerings that the PAs are considering.	
60.	e.	Commit to specific program enhancements and timelines for adoption of best practices identified in the RCx Best Practices Study.	The RCx subsection specifically addresses each of the five recommendations from the Best Practices Study report.	
61.	f.	Commit to increasing the availability of qualified RCx providers.	In discussions with program managers at identified “best practices” RCx programs, the PAs learned that no special effort was required to develop the supply of qualified RCx providers to meet program demands. Given consistent and clear direction as to program requirements and outcome expectations, and a commitment to funding availability, the local markets responded in a timely manner to take advantage of the business opportunity. As a result, there is no need to commit to increasing the availability of qualified RCx providers.	
	F. Behavioral and Engagement			
62.	The PAs note that they engage in Strategic Energy Management (SEM) in the context of existing programs and will consider expanding SEM offerings by engaging with early SEM adopters from the Pacific Northwest. The Draft Plan contains little information about behavioral programs and does not commit to deliver reports on either SEM or behavioral programs as requested by the Council. The PAs should include		The concept of Strategic Energy Management is fluid and evolving, and can encompass a number of interconnected and mutually reinforcing activities. A common definition of SEM is that it is “a comprehensive set of business practices that establish energy management as a standard operating procedure”. While there are different variations in SEM programs, they all focus on business practice change - shifting how organizations get things done, improving their capacity to reduce energy waste, and reducing energy intensity throughout the entire organization. The PAs plan to support behavior type initiatives that lead to cost effective, quantifiable, and persistent energy savings. To this end, the PA offerings may vary by service territory to support	

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	the following information in the Revised Plan:		customer energy efficiency efforts within that service territory.	
63.	a.	Commitment to assess cost effectiveness of SEM projects in line with the EEAC March 31, 2015 Resolution and, if deemed cost - effective at the sector level, a commitment to develop and evaluate an SEM demonstration project.	When considering expanding SEM efforts, much as with retro-commissioning, it will be critical for the success of recruitment efforts to understand what individual customer characteristics or categories of customers can be identified that will identify them as those who are most likely to see a value proposition in SEM. As the PAs consider SEM expansion opportunities (both in number and in kind) they will integrate the growing body of knowledge from their own local MOU/SEMP experiences and engage with SEM early adopter jurisdictions and their allies (such as the Pacific Northwest and the Northwest Industrial Strategic Energy Management Collaborative), and incorporate the results of their research activities and field experience.	
64.	b.	More detail on behavior approaches outside of memoranda of understanding (MOUs) and on whether and how savings are claimed from customer behavior changes.	See above.	
65.	c.	More detail on direct load control and methods for how the PAs could engage customers in demand response.	Efforts such as direct load control, and demand response more generally, are being, and will continue to be, considered by a collaborative working group comprised of the PAs and the Council consultants.	
66.	d.	Commitment to using the Consortium for Energy Efficiency (CEE) Minimum Elements document as a reference when discussing SEM programs, in order to ensure a common understanding of what is included.	See above.	
67.	e.	Commitment to implement and evaluate behavioral demonstration projects for small and medium C&I customers.	See above.	
	G. Small Business			

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68.	The Council appreciates the PAs' commitment to the Small Business program. The Draft Plan addresses a number of Council recommendations including realizing deeper savings, expanding gas measures, and expanded sector‐specific approaches. The PAs intend to make program enhancements though a series of incremental improvements. Using building analytics is under consideration by the PAs and web‐based customer engagement portals will be implemented by the PAs. The PAs should include the following information in the Revised Plan:		The PAs are very committed to serving Small Business customers through diverse offerings and delivery mechanisms available in the energy efficiency programs, particularly through the Small Business Core Initiative, and have included a detailed description of their on-going efforts and future plans for advancing that program to meet the customer's ever changing energy efficiency requirements, thereby improving upon their long-standing success with this important and large subset of C&I customers. As the Plan describes, he PAs have already embarked on an aggressive effort to test a wide range of potential improvements the results of which, once collected and synthesized, could form the basis of future improvements. Until such time as this process is complete, it is unclear and inappropriate to speculate whether improvements will be implemented incrementally, in phases, comprehensively, or at all.	
69.	a.	Specific commitments to program enhancements for the Small Business program, and a timeline for these enhancements. Some of the enhancements the EEAC thinks are important include: expanding offerings for gas measures, more comprehensive marketing/outreach/awareness programs, and more customized approaches for Small Business customers (by size and segment).	The *Small Business Core Initiative* subsection discusses the variety of tests which will be undertaken to explore concepts or approaches which show potential to expand the variety of gas measures available, reach more customers and/or hard to reach customers, as well more customized approaches for Small Business customers.	
70.	b.	A timeline for evaluating potential and cost effectiveness of building analytics and portals for small business customers (EEAC Councilors discussed a Q3 2016 deadline).	See above.	
71.	c.	An action plan, including timelines, for using the data collected by online portals to analyze and benchmark energy use to effectively target small businesses.	By its very nature, the Three Year Plan is not an operational or implementation- focused document and thus is not an appropriate vehicle in which to include an action plan. Instead, the PAs have described in great detail their on-going efforts and future plans to improve upon their already industry-leading efforts to effectively serve the energy efficiency needs of small business customers in the Commonwealth.	
	H. Combined Heat and Power			

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72.	The PA Commitment to CHP is clear and the PAs largely incorporated the Council's recommendations. The PAs should include the following information in the Revised Plan:		See below.	
73.	a.	A firm commitment to complete the CHP potential report and implement findings including:	The PAs have included a lengthy description of CHP in their Plan and plan to aggressively target CHP opportunities during the 2016-2018 period, including a commitment to increase education and outreach as well as a commitment to commission a best practices review of CHP programs nationally and a reassessment of CHP opportunities in Massachusetts. While sharing the Council's commitment to excellence with regard to CHP delivery and the undertaking of research to enhance performance, the PAs do not feel it appropriate to adopt a specific time line for reporting on CHP activities or the results of any related research.	
74.	i..	Deliverable dates for a best practices review and potential study (EEAC suggested end of 2016)	The PAs are not planning to impose artificial deadlines or require additional reporting that would risk diverting the focus from providing customers with the highest quality information and greatest access to efficiency opportunities, a strategic commitment shared by both the PAs and the Council.	
75.	ii.	Specific mention of pre‐packaged and third party CHP options	The PA's CHP Guidebook, referenced in the Plan, identifies the many alternatives available to customers considering CHP and discusses key considerations for customers or third parties to achieve the appropriate, cost-effective CHP plants.	
76.	b.	A clear CHP goal and a schedule for annual reporting on the progress toward the three‐year goal, even if this is not a separate initiative outside of C&I Retrofit.	See C(a) above.	
77.	c.	Higher goals for CHP, in accordance with the results of the key drivers analysis.	Since the April 30th draft, the PAs have increased the savings contribution to goal expected to come from CHP. It is important to recognize that increased goals adds plan risk and uncertainty, as CHP savings are dependent on a relatively small number of large projects with relatively lost cost of savings which are difficult to replace at a comparable cost. Substitute savings will almost always be higher cost.	
	I. LED Streetlights			
78.	LED Streetlights represent a significant source of savings in the Commonwealth. The Draft Plan notes success with streetlight retrofits by Cape Light Compact and other PAs. However the Draft Plan does not commit to any innovations around streetlights, or to the EEAC‐requested goal of retrofitting the majority of utility owned streetlights		See below.	

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	and all municipal owned streetlights by 2018. The PAs should include the following information in the Revised Plan:			
79.	a.	An action plan for stimulating rapid conversion for municipally - owned street lights; for example:	The PAs remain committed to providing their municipal customers with the most up-to-date street lighting technology, including both lighting and controls. Local conditions and priorities of the local governing body in each unique city or town will control the rate at which the conversion can be accomplished.	
80.	i.	Cape Light Compact managed a joint conversion process for all of its municipalities, providing technical assistance and project management through the entire process.	See above.	
81.	ii.	Upstream or bulk purchase pricing for municipalities.	See above.	
82.	b.	A strategy and timeline to retrofit the majority of utility - owned street lights to LEDs within this Plan's timeframe (including a timeframe and commitment for filing of an appropriate tariff for utility-owned LED streetlights at the Department). The EEAC intends to support such a tariff at the Department, to aid in removing this barrier for the PAs.	The PAs are also committed to supporting the conversion of utility-owned streetlights to LED technology once the electric utilities in the state have developed, filed, and had approved the necessary tariffs. The PAs have identified a viable pathway to address an energy efficiency incentive structure that addresses utility owned streetlights conversion to LED technology and the manner by which it may be applied in the energy efficiency project implementation process.	
83.	c.	Higher savings goals attributable to LED streetlights in accordance with the results of the key drivers analysis.	The PAs savings goals do assume higher than previously planned savings to be derived from LED lighting in general, including street lighting, in part as a result of the key drivers analysis. LED streetlighting savings that are achievable is limited to the number of customer owned systems that have not yet converted to LED technology, which varies by PA.	
	J. Zero Net Energy (ZNE) Ready Buildings			
84.	In the Draft Plan, the PAs propose to establish a basis of technical knowledge and expertise, and a framework for program support for ZNE ready buildings. However there is no timeline or commitment to implement a Zero Net Energy		The PAs will continue to provide, as they have historically, technical and modeling assistance and incentives for all the efficiency measures towards Net Zero Ready that are cost-effective through the Whole Building Path of the New Construction Program. This path is explicitly designed for the purpose of promoting high performance buildings with lower energy use intensities (EUIs) and ongoing operational costs than code compliant buildings and is specifically	

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	Buildings (ZNEB) program. The PAs should commit to assessing a ZNE ready building tier and include a timeline for a new construction offering in the Revised Plan.		motivated through the programs using a performance based incentive basis (i.e., greater savings beyond code compliance the greater the incentive). Indeed, the PAs view a Net Zero Ready (NZR) Building as the ultimate expression of this path – driving the energy use intensity of the building to the lowest practical and cost-effective level before considering renewables. The PAs will also help customers with the necessary coordination with the Clean Energy Center in order to qualify for renewables incentives and inform them of the interconnection process to move the final step to Net Zero. However, the PAs underscore the importance of weighing NZE efforts in the context of overall savings potential and efforts to reduce greenhouse gas emissions in the Commonwealth. If the recent uptake of this concept serves as a guide, the actual number of market-based and cost-effective non-residential Net Zero buildings constructed in the Commonwealth over the coming three years is likely to be very, very small, and those that are undertaken are likely to be very modest in size. However, a somewhat larger cohort may be interested in pursuing Near Net Zero, or highly efficient, status. Energy Efficiency program support is but one area necessary to implement a NZE vision in the Commonwealth. It will take policy support, code support, grid integration, and more for Massachusetts to realize a NZE future and the PAs will continue to contribute where practical.	
	K. Delivered Fuels and Thermal Efficiency			
85.		There is no mention of the PAs' marketing comprehensive assessments to non - gas C&I customers. The PAs should include the following information in the Revised Plan:	While detailed, a Three-Year Plan is meant to serve as a statewide strategic plan and not an implementation or operational plan. A statewide strategic plan provides the PAs with the flexibility necessary to make implementation changes to meet changing circumstances based on evolving market dynamics in order to deliver on their Plan goals and satisfy the requirements and objectives of the Green Communities Act. The PAs have been and remain actively engaged in the RCS regulatory process. PAs have planned for treatment of oil heated multi-family properties, but await further development of the current RCS regulations. The PAs will continue to follow the regulatory process and when C&I tariff customers are eligible we will promote delivered fuel opportunities. The PAs will continue to consider cost effective C&I custom measures which save at least one utility-delivered fuel whether through a delivered fuel or renewable thermal equipment.	
86.	a.	A strategic plan for marketing, in-print, online, and in-person, a non-gas customer's ability to self-fund the thermal portion of a comprehensive energy assessment using a PA auditor.	See above.	
87.	b.	A timeline for assessing any barriers	See above.	

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		or limitations to implementing the strategic plan, and a commitment to work with the EEAC to seek ways to address any barriers/limitations.		
	Residential Recommendations			
	A. New Initiatives			
88.	*Moderate Income Initiative* - The EEAC supports the Draft Plan proposals to develop a new moderate income offering within the Home Energy Services (HES) core initiative and the PAs' proposal to initially focus on households earning 61-80% of state median income (SMI). This initial offering should be developed further into an initiative to attract new participants to the HES and multi-family retrofit programs, as well as support follow-through of existing customers with deeper savings opportunities. Therefore, the Revised Plan should include:		The PAs are including a moderate income offer in the 2016-2018 Plan, with deployment in Q1 2016. Additional details of the program's design have been included in the Whole House residential program description under the Home Energy Services Initiative. As the moderate income offer is implemented, PAs will closely monitor, test, and refine. PAs have worked with the LEAN network to develop a triage system to examine cases of buildings which may not achieve a majority of units under 60% SMI, but do achieve a majority of units under 80% SMI, to determine if these can be enrolled through the LI Multi-family Initiative.	III.E.4.c (Detail within New Enhancements and Core Initiative Design sections)
89.	a.	Detail on the proposed scope of measures and program marketing plan, including plans to leverage partnerships with community groups, possible points of entry, and qualification for eligible customers.	The moderate income offer is an opportunity to be "qualified" for an increased incentive(s) when income is a barrier. The initial enhanced incentive is planned for insulation, covering 90% of costs up to $3000. PAs continue to evaluate enhancements to measures, including enhancements that may target moderate income customers. The moderate income offer is specifically designed to be offered when opportunities for deeper savings have been identified and recommendations have been made. This ensures that the additional administrative costs, including income verification, are tied tightly to actionable savings opportunities. This approach maximizes cost-effective savings and ensures equal access for all moderate income customers. It also allows HES to use cost-effective marketing techniques to drive customers to the initiative, preserve the Mass Save® brand awareness, and leverage the current penetration success of the Home Energy Assessment (HEA) channel. HES vendors will be given program collateral and support to enable them to have conversations with HEA participants who have identified savings opportunities. Vendors will provide these customers with further direction on how to submit for income verification. Customers who have completed income verification prior to assessment through the low-income program, will be triaged into HES for an HEA, and the income verification completed by the low-income agency will go with the customer into the HES program.	Detail in HES Initiative, Residential Whole House program section.

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			PAs remain enthusiastic about the ideas discussed in workshops regarding existing municipal efforts and local community organizations that currently serve this target market of moderate income customers. PAs have noted in the Plan their commitment to learn more and to leverage opportunities to use such connections to increase access for moderate income customers to Mass Save® incentives, with an emphasis on increasing installations. These opportunities and relationships are inherently service-area based and are evolving, with different implementation opportunities available for each PA.	
90.	b.	Detail about the customers in this income range, including number and proportion of residential customers in the 61-80% SMI in each PA territory and the number of those customers that the PAs expect to serve.	Based upon data from previous evaluation work for Efficient Neighborhoods+® (EN+), the population of residential customers that own and live in 1-4 family homes is estimated to be less than 10% statewide with some variation by PA service territory. Please note that renters have been identified as a separate target market. During implementation, PAs will monitor participation, the impact on budgets, and cost of savings, and will seek to understand the extent to which the offer successfully secures additional savings from a population who may not be currently participating due to financial barriers.	
91.	c.	Commitment to provide and incorporate, as appropriate, lessons learned from the Efficient Neighborhoods +® (EN+) evaluation and other pilots, demonstrations, or applicable programs by Q1 2016.	The PAs are committed to incorporating lessons learned from the EN+ evaluation and other pilots, demonstrations, and applicable programs and program evaluations by Q1 2016. Preliminary lessons learned from EN+ and other applicable programs were taken into account when designing the moderate income offer. The EN+ evaluation demonstrated that a proxy method of geographic targeting, paired with targeted outreach, has a very high cost per opportunity secured. The PAs designed the moderate income process with a more targeted enrollment process. The moderate income offer appears as a result of the HEA, with income verification. This puts more program dollars directly to work benefiting customers and securing identified opportunities.	
92.	d.	Commitment to assess by Q2 2017 the potential for serving customers at 81-100% and 101- 120% of state median income as part of an expanded moderate income offering.	The PAs will be closely monitoring the rollout of the moderate income offer and will assess impacts, both positive and negative, providing regular updates at EEAC meetings, as information is available (and to the extent updates are requested and placed on the meeting agenda).	
93.	*Renter Specific Initiative* - The EEAC supports the PAs' inclusion of a renter-specific initiative in the Draft Plan that recognizes a large and relatively underserved customer base. In order for the EEAC to fully comment on and understand this initiative, the PAs should include the following clarifying details in the Revised Plan:		The PAs are including a renter-specific visit as an enhancement of the HES core initiative.	III.E.4.c (Detail within New Enhancements and Core Initiative Design sections)
94.	a.	The implementation strategy and	By Q1 2016 the HES renter visit will be available to all HES customers. The renter visit is an	

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		schedule for the renter-specific offering, providing dates, milestones, and a date in 2016 by which the offering will be available to qualified HES and multi-family customers. The PAs should provide details on program marketing, including plans to leverage partnerships with community groups.	enhancement of the HES core initiative available to 1-4 unit buildings on a single property. The PAs will maintain a single call to action through the statewide phone line. PAs are planning to update the on-line audit tool to include a renter scenario to support both renters and landlords enrolling in the HES program. PAs, as appropriate, will work with existing community resources, such as Renew Boston, to ensure that trusted community allies that serve high populations of renters are aware of the program and offer specialized materials for landlords. Customers will continue to be screened at the time of intake. If it is determined that a customer would be best served with a renter visit they will be scheduled for this, rather than a full HEA. PAs plan to offer a Whole Building incentive for 2-4 unit buildings, modeled on the Renew Boston Whole Building incentive, as extra support to engage landlords.	
95.	b.	The PAs' proposed engagement strategy to ensure immediate benefits to renters, with a plan for securing landlord buy-in and follow-through with whole-house/building measures.	At the time of intake, PAs plan to request contact information for landlords for additional follow-up. The potential adjustments to the on-line audit tool would ideally allow renters to share information about their landlord and other interested tenants in the same building. The renter visit will include the installation of no-cost instant-savings measures as listed below. The renter visit will also include a refrigerator screening, high-level visual inspection of possible weatherization opportunities, and review the heating system for potential rebates. The customer will also receive materials noting deeper measures that could be installed with landlord approval. PAs plan to develop marketing materials specifically tailored to renters. The Energy Specialist will attempt to collect the landlord information for follow-up (if not already received during intake). The Energy Specialist will leave door hangers on other renter units, noting the benefits of the visit and encouraging the other tenants to call. The Lead Vendor will then send follow-up information to landlords, including information on the Whole Building incentive.	
96.	c.	The savings measures that will be offered to renters and how such measures compare to the measures currently provided under the HES and multi-family retrofit initiatives.	No-cost instant savings measures for renters will parallel the HES gas and electric instant savings measures, including: • High efficiency lighting (LEDs & CFLs) • Low-flow showerheads • Faucet aerators • Smart strips • Programmable or wireless-enabled thermostats, if applicable and allowed by the landlord As mentioned, PAs plan to develop marketing materials tailored to renters. As the effort evolves	

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			PAs will continue to explore other potential renter-specific rebates.	
	B. Whole House Program			
97.	a.	A commitment to household-level tracking of all non-upstream measures, where technically feasible.	The term "household-level tracking" has not been defined. To the extent this term is synonymous with customer or account level tracking, disclosure of this information would require written customer consent. For a discussion of customer privacy issues, please see the statewide database section (VII.C); the PAs' April 2, 2014 Comments in Appendix [x]; An Act Establishing the Massachusetts Residential Conservation Service, Chapter 465, Acts of 1980 ("No person shall disclose the name of a customer or the contents of an energy audit report prepared for such customer to any person other than the customer, a subsequent purchaser of the audited building, the utility serving such customer, the secretary of energy resources, or their designees, unless the customer or subsequent purchaser waives his right to confidentiality with respect to such information"). Furthermore, customer privacy and data access issues are the subject of a pending docket with the Department: D.P.U. 14-141. Notwithstanding customer privacy concerns, tracking data at the customer level across programs and PAs at the zip code level is not technically feasible. Due to integrated gas and electric audits, which PAs believe customers greatly prefer, measures recommended by one PA may be installed by another, and the installation cannot be tracked in a cost-efficient manner from audit directly to customer. The residential and C&I customer profile studies were designed to provide geographic information on customers through the EM&V process. Finally, careful consideration of the purpose, costs and benefits of collecting and reporting this additional data, which may not increase savings or assist the PAs in meeting their goals, is necessary before spending customer funds. While providing details at the individual customer or account level is not technically or economically feasible, the HES Activity tab on Mass Save Data provides information about how customers are utilizing the programs. The HES tab shows a breakdown of measure-specific information, including the total number of Home Energy Assessments performed, quantity of bulbs installed, and the number of unique customers who received weatherization measures. In addition, the PAs are working on providing measure level information on Mass Save Data for 2016-2018 and expect to display quantity, total incentives, savings, and total benefits by measure.	
98.	i.	Include a proposal, with dates and milestones, for linking rebates and incentives provided to the same household across programs and PAs, together with a plan for reporting this whole house coordinated information at a zip-code level.	See above response.	

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99.	b.	Dates for: completion of the extensive review of the HES program, development of a plan for implementation of identified opportunities, and a report back to Council.	The plan references a "review of customer experience to identify opportunities for increased streamlining, simplifying and better targeting time and content of customer information to maximize the opportunity to influence customers taking action." Considerable work is currently in process with outside expert consultants to adjust the collateral materials provided to HES participants. The PAs are not planning to impose artificial deadlines or require additional reporting that would risk diverting the focus from providing customers with the highest quality information and greatest access to efficiency opportunities, a strategic commitment shared by both the PAs and the Council.	
100.	c.	Details, dates, and milestones regarding improvement of the integrated "one-stop shop" customer experience, including providing customers with both Mass Save and non-Mass Save incentive/rebate information, regardless of heating fuel source, consistent with the proposed Residential Conservation Services (RCS) regulations.	As discussed above, PAs are committed to continuous improvement of the customer experience. The current design and implementation of the initiative features a one-stop-shop approach and provides comprehensive information to customers on Mass Save® opportunities. The HES and LI single family initiatives serve all customers regardless of fuel type. The Multi-family and LI Multi-family initiatives are preparing to transition to a parallel approach when RCS regulations are final. The Mass Save® website has become a critical focal point in the comprehensive marketing program, providing a consolidated one-stop shop for residents and businesses to learn about energy efficiency offerings and opportunities. The Mass Save® website and strategies that drive customers to it will continue to be refined to ensure the highest quality customer experience. A majority of residential customers are aware of the website, and 30 percent of those surveyed report using it more than once in the past year. The Mass Save® assessment materials link customers to a federal website with updated information on tax credits and additional incentives. If the Commonwealth would like to provide a link to a URL that is updated on a regular basis and encompasses all available state incentives, the PAs would be pleased to link to that as well. The HEAT Loan initiative enabled over 11,000 loans in 2014, including financing for several fuel blind measures and provides another avenue for customers to access cross-initiative incentive opportunities.	
101.	d.	Details of the expected oil and propane savings by PA, based on an analysis of their service territory.	The current versions of the BCR models include measures for serving oil and propane customers. The April versions of the electric models are available on the EEAC website, and the PAs expect that the September versions will be added shortly after September 18th.	
102.	e.	Commitment to collaborating with DOER and the EEAC consultants to identify the actions and implementation steps needed to provide customers with an asset-based "home energy scorecard", including cost estimates for each	The deployment of the online assessment tool speaks to the ongoing commitment of PAs to reach out broadly and provide an effective and creative entry point for customers. PAs thoroughly researched tools to provide customers with clear insight on their energy use, including conducting an RFQ process to identify the best in class technology. The online assessment provides customers with a no–cost home energy scorecard tied directly to customer-specific, actionable Mass Save® energy efficiency opportunities, based on the resident's unique circumstances, all from the comfort of the customer's keyboard and at their	

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		step.	leisure. Each user can be tracked and followed up with, regardless of whether they move on to an HEA or are better suited for another Mass Save® opportunity. The existing online assessment tool and resulting scorecard, provides a cost-effective, customer-centric approach, and already addresses the Council's interest in ensuring that customers have access to actionable home energy scorecards. PAs will continue to monitor DOE's ongoing research in neighboring states on alternative scorecards. Several PAs serve territories beyond Massachusetts where ongoing DOE research and program testing of scorecards is being conducted. These PAs will bring what they learn elsewhere to their Massachusetts customers and partner PAs as applicable. Currently the alternative models under review increase administrative overhead without connecting to energy savings.	
103.	f.	Strategies (including continuation of existing strategies) tailored to specific customer groups or segments, such as targeted approaches, technical assistance, or offerings (e.g., homes undergoing remodeling work, high energy users, and customers using electric resistance heat).	Each program and initiative description includes a description of the target market and a section detailing marketing strategies and targeted approaches for the targeted market. PAs have and will continue to segment and target market to customers with high energy use and electric resistance heat to support their adoption of energy savings offers. As discussed under behavior, high energy users are a primary target for the Home Energy Report. The Home Energy Report frequently promotes Residential core initiatives and is a valuable tool to spark participation from customers who have been identified through behavioral program efforts as high energy users. The deployment of the on-line assessment tool also allows PAs to learn more about customers, prior to a home visit, and connects customers to offerings targeted to their needs. The success of the Mass Save Facebook and other social media platforms has further supported PAs ability to target message to key consumer groups as well as leverage seasonal and other factors influencing customer interest and readiness to engage on specific energy efficiency opportunities.	
104.	g.	A description of efforts to ensure equitable treatment of Home Performance Contractors (HPCs) compared to lead vendors, including 3rd party quality control inspections and regular opportunities to engage and present to the Residential Management Committee (RMC).	Over 7,000 companies/contractors interact with MA energy efficiency initiatives through a multitude of participation paths (direct contract, open market rebate submittals, contracted to lead vendors, etc.). The approximately 20 Home Performance Contractors (HPCs) play an important role in the HES initiative and are therefore engaged through several channels including direct interaction with PAs through the BPWG, quarterly meetings, and an elected EEAC member. In fact, the Best Practices Working Group (BPWG) was established as an official conduit for formal feedback to the PAs for HPCs and IICs participating in the HES Initiative. A minimum of one RMC representative always attends the BPWG meetings. Through the BPWG meetings the RMC has effectively been made aware of HPC concerns. Based on the April Council recommendation, PAs reviewed the current composition of the BPWG and determined that it currently provides a higher representation of HPCs as a proportion of participating contractors statewide. HPCs hold 30% of the contractor seats while representing	III.E.4.c (Detail within Delivery Mechanism section)

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			approximately 18% of the contractors in the HES core initiative. The BPWG remains a critical and equal forum for interaction. The PAs have agreed to also participate in a new Contractor Performance and Engagement Forum to be convened by the DOER (not in replacement of or in lieu of the ongoing BPWG), which will review topics of relevance to the residential energy efficiency contractor community and the PAs. Topics may include how residential program contractors can be most effectively engaged in the programs, optimization of contractor performance, and suggestions from the contractor community for enhancements and improvements. This Contractor Performance and Engagement Forum will be convened by the DOER and will be an advisory forum and not an adjudicatory, regulatory, or dispute resolution body. Both lead vendors and HPCs are subject to 3rd party quality control (QC) inspections by a vendor competitively procured by the PAs. The QC vendor and program evaluations also provide valuable, external information and feedback to the PAs on HES successes, its vendors and subcontractors, and identifies areas of possible improvement.	
	C. HEAT Loans and Financing			
105.	a.	Strategy, dates, and milestones to assess how moderate income customers are currently served and could be better served by the HEAT Loan program, including assessment of the cost and effectiveness of a loan loss reserve, taking due account for the economic vulnerability of some customers.	Data presented at the Residential Workshops demonstrated that 87% of loans are approved. At this time, a loan loss reserve is not being considered. The Mass Save® HEAT Loan initiative is the most successful initiative of its kind in the nation, growing from 532 loans in 2006 to over 11,000 loans in 2014 (annual). Since inception, the Mass Save® HEAT Loan has made over $250 million available to thousands of homeowners implementing home energy efficiency improvements. With over $250 million financed (residential) - more than other leading states, <u>combined</u>- the Mass Save® HEAT Loan initiative has the largest volume of loans. It also has the broadest lender participation, with over 60 local banks and credit unions across the Commonwealth offering this product. Since 2011, the initiative has incorporated a broad FICO score acceptance, well into the sub-prime category. Approximately 45% of households taking the HEAT Loan in 2014 had incomes between $40,000 and $80,000, and banks indicate that income is not a major barrier for HEAT loan approval (detail found on page 229 of the DRAFT 2016-2018 Plan). The current HEAT Loan developed, deployed, and offered to customers by the PAs, in conjunction with the Massachusetts Bankers Association and Credit Unions, has low costs to the Programs, a very attractive interest rate, no credit enhancements, and no loan administrative costs passed back to PAs. Lenders bear the principal risks. PAs will continue this successful program working closely with our partners in the lending community who are best positioned to offer advice on loan application and approval processes. All customers of electric PAs receive HEAT Loan collateral with an indication of applicable measure opportunities identified in their home. Gas PAs that have municipal electric companies within their territories will offer the HEAT Loan to natural gas and municipal electric customers as	

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			well. In this way, all customers that pay into the funds are able to access the HEAT Loan. This universal access and common 0% interest rate has tremendous marketing and brand value for energy efficiency and the PAs' energy efficiency programs. The Mass Save® HEAT Loan is a major success story. The PAs have given the Council's recommendation serious attention. At this time the current structure, including the single 0% interest rate, is working well, both in terms of costs to administer and results in broadly serving the Massachusetts market place by leveraging the expertise and capital of the existing lending community. Similarly it does not appear at this time that there is reasonable justification for a loan loss reserve given the programs current success in serving moderate income customers and current broad FICO score acceptance. The PAs will continue their efforts to identify the nature of barriers for different customer segments, which may be related to accessing capital, and will explore financing products/solutions to address them. The PAs will also continue to review the cost to administer the HEAT Loan offer and seek out efficiencies and cost savings.	
106.	b.	A date by which the PAs will finalize additional measures to be financed through the HEAT loan, including those currently funded through DOER's Expanded HEAT Loan Program.	Two of the "additional measures" offered under the DOER expanded program are grant offers, not financing, and are therefore not appropriate to add to the HEAT Loan. PAs would consider allowing the highly successful HEAT Loan process to be leveraged by DOER and other partners for additional energy measures where the partner entity provides the supporting funding. However, PAs cannot commit to add measures that are not clearly consistent with current efficiency program savings goals and aligned with efficiency program incentives.	
	D. Multifamily Retrofit			
107.	a.	Provide detail on the PAs' proposed single point of contact and commit to assessing what changes are necessary to integrate commercial and residential rate codes into a whole building approach.	Under the enhanced program design, customers will have a designated project point of contact ("PPC"). The PPC will be the designated agent or lead vendor identified by the PA responsible for the efficiency measures for the primary heating fuel. For example, if the primary heating fuel for the building is natural gas, the gas PA will designate the PPC who is responsible for providing the customer with a seamless project-level experience. Conversely, if the primary heating fuel is electric, (and as the proposed RCS regulations would allow oil and other fuels), the electric PA will designate the PPC who is responsible for providing the customer with a seamless project-level experience. The PPC is envisioned to be responsible for managing the full program delivery path once assigned to a project, coordinating efficient delivery of applicable measures. The plan is for the PPC to be responsible for clearly tracking all measures and incentives by meter type, i.e. residential and commercial meters, electric, and gas, at each stage from initial assessment through final reporting and billing. PAs have already identified and broken out for tracking measures both by meter type (Commercial/Residential) and fuel type (Gas/Electric) in the planning documents.	III.E.4.b (Detail within New Enhancements and Core Initiative Design sections)

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108.	b.	Commit to developing and providing targeted offerings to different segments of the multifamily building market.	PAs will continue to deploy segmentation strategies in all programs. The Whole Building approach utilized in the Multi-Family Initiative already allows tailoring based on the unique characteristics of the building, such as mixed use, construction type, and variations in ownership and occupancy.	
109.	c.	Provide plans for improving the integration of efficiency into refinancing events, such as through a proposed partnership with the state's housing finance agencies or commercial lending institutions.	The PAs are engaged in ongoing discussions with the State's housing finance agencies. The PAs will not be providing plans or other details as part of the three-year plan. This is not a program, or even an implementation detail, but a conversation between PAs and their customers about optimal ways and potential partnerships to provide energy efficiency services.	
110.	d.	Commit to providing multi-family customers with user-friendly benchmarking tools to track unit-level energy usage and comparisons against peers.	The PAs currently offer, and will continue to offer, support for Multi-Family properties to benchmark their properties through the EPA Benchmarking tool (Portfolio Manager). The link to this nationally recognized tool is included on the website page(s) associated with the Multi-Family Retrofit core initiative. EPA Portfolio Manager is a free tool available to all property owners that represents a gold standard for benchmarking. The PAs have supported data upload through the Green Button Initiative and have extensively coordinated with disclosure efforts such as the Boston Energy Reporting and Disclosure Ordinance to support customers' ease of access to benchmarking and compliance with reporting requirements. It should be noted there are no savings associated with benchmarking itself. Unit-level energy usage is not a common element of multi-family benchmarking. The PAs behavioral program does serve multi-family units and provides those units with unit-level energy information and comparison against peers (i.e. other multi-family units).	
111.	e.	Implement a pay-for-performance demonstration program.	The Multi-Family Initiative already includes a comprehensive Energy Action Plan with incentive levels based on the extent of energy savings (i.e. performance). Customers choosing higher performance options or more/all measures will achieve high performance and the highest available incentive. In addition, PAs offer building-operator training to support customers in maintaining their efficiency gains through proper operations and maintenance.	
	E. Behavior			
112.	a.	Commit to expand behavior program participation and include dates and milestones to implement this expansion. PAs not implementing behavior programs should document why these measures are not cost-effective and why the PA is not partnering with other PAs that are	The request to expand participation in behavioral programs fails to acknowledge critical elements of behavioral program design and evaluation. The current behavioral program design and evaluation are based upon the highest industry standard, specifically, the SEE Action Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations (https://www4.eere.energy.gov/seeaction/system/files/documents/emv_behaviorbased_eeprograms.pdf.) Based on this standard, PAs are maintaining the planning assumptions for projected participation and initiative savings.	

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		implementing behavior programs.	Behavioral program savings per household are very small. Program design must therefore include a very large control group to clearly pick up the signal of savings. Program design must also include a buffer for participant attrition, i.e. you must leave some customers available to fill in for customers who opt-out of the program. This is necessary just to maintain current levels of savings but further limits the number of customers who can be assigned to the treatment group. If the program "steals" participants from the control group to add to treatment group (i.e. expand treatment participants), we risk losing statistical precision on savings estimates and possibly not conforming to industry best practices. In addition, there is not a direct relationship between increasing the size of the program and increasing the amount of savings (i.e. you cannot increase the program size by 10% and expect a 10% increase in savings). The treatment group, by design, includes the highest kWh/therm users first, as they are most likely to save more per household. As customers with lower usage per household are added to the treatment group we will begin to see lower absolute savings per household. Because the cost to treat each customer remains constant but we would secure less savings per customer, program cost effectiveness would decline.	
	F. New Construction			
113.	a.	By Q4 2016, commit to working with the EEAC consultants to explore how to claim savings for renewable energy systems in the cost/benefit analysis.	The PAs remain committed to working with the EEAC consultants to explore addressing renewable thermal savings in 2016-2018. PAs are seeking to better understand exactly what technologies are contemplated by Councilors and their applicability in a three-year energy efficiency plan under the GCA and whether implementation of some of these efforts is better handled in other contexts or proceedings, such as grid modernization. In reviewing these matters, PAs will work with the consultants to discuss and determine if there are cost-effective measures/strategies that are appropriately delivered as energy efficiency measures, as opposed to renewable supply side measures, what funding sources are available, what energy savings and other quantifiable benefits can be claimed for incentivizing these measures, and what, if any, are the most promising potential technologies and, if applicable, choosing a set of them to prioritize.	
114.	b.	Add a performance path for multi-family housing.	A performance path for the multi-family high rise program will be implemented in 2016. PAs are currently reviewing several modeling products to achieve this goal.	
115.	c.	Implement a renewable-ready requirement in the highest two performance tiers and the top prescriptive tier.	For 2016-2018 the PAs are exploring a "Path to Zero" option for the top tiers of the performance path. The enhancement would recognize new construction home builders for achieving both a high energy efficiency standard as well as the incorporation of renewable energy building features. Key components of the "Path to Zero" option would likely include renewable-ready requirements and key energy efficiency measures. Proposed PA Zero Net Energy education and marketing will communicate how builders can use the RNC initiative and the "Path to Zero" enhancement to reach net zero or net zero ready.	
116.	d.	By Q4 2016, commit to working with the EEAC consultants to assess the	In late 2017, PAs will assess how the Zero Net Energy Builder trainings and "Path to Zero" options are affecting Zero Net Energy residential building practices in Massachusetts. PAs will	

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		impact of creating a ZNE incentive top performance tier and report findings to the Council. Use findings to inform implementation of a ZNE top performance tier.	make adjustments to the new construction initiative, if necessary, to continue driving the market toward Zero Net Energy residential new construction.	
	G. Renewable Thermal			
117.	a.	The PAs should actively collaborate with DOER on the development and implementation of RCS guidelines, and by Q4 2016, update and maintain the cost-benefit screening tools for renewable thermal technologies.	The PAs have been and remain actively engaged in the RCS regulatory process. PAs have planned for treatment of oil heated multi-family properties, but await movement on the current RCS regulations. PAs continue to work with EEAC consultants and request pertinent updates, to date no updates have been provided. The PAs will continue to update and maintain screening tools for all qualifying measures.	
	H. Products Program			
118.	*Lighting* - The EEAC supports the commitment in the Draft Plan to phase out incentives for specialty CFLs by 2016. However, the Draft Plan does not fully address the Council's recommendations on LEDs and appears to use inconsistent and overly conservative volume and cost projections for 2016-2018.		Since the April Draft, the PAs have revised volumes and incentives per bulb, as referenced in conversation with the Consultants.	
119.	a.	Increase savings projections to reflect a growing market share of LEDs and increasing sales volumes for retail lighting.	The PAs have revised LED/CFL volumes. The PAs are committed to using the best data available for projection.	
120.	b.	Commit to quarterly reporting to the EEAC on progress of LEDs during Plan implementation.	The PAs will share updates at regular EEAC meetings when new information is available and requested.	
121.	*Heating and Hot Water* - The PAs did not propose residential upstream incentives for hot water heaters in the Draft Plan, although this is being implemented for C&I customers. The Council recognizes that the PAs need to understand the market potential for this incentive and the effects			

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	of implementing an upstream program on savings.			
122.	a.	Include an assessment of implementing upstream incentives for residential tankless water heaters and other potential HVAC measures and report back to the Council by Q3 2016.	With pending evaluations in the 2016-2018 Plan, the PAs are still awaiting the best information to adjust their initiatives. As mentioned in a past EEAC meeting by the EEAC EM&V Consultants, there could be some impacts that will need to be addressed. The residential group will assess potential savings impacts of DHW measures moving upstream. The PAs will watch the implementation of upstream incentives in C&I and evaluation results as part of this assessment.	
	Low-Income Recommendations			
123.	The EEAC acknowledges the establishment of the income guideline for Low Income programs at 60% of state median income (SMI) in the Green Communities Act, and the PAs' inclusion of a moderate income offering within the residential Whole House programs in the Draft Plan. The Council recognizes the need for flexibility in programs that serve buildings with high tenant turnover or families living on the margin of eligibility in the Low Income programs. In addition, the Council recognizes the variety of organizations that hold nonprofit status and that some of those organizations own buildings that serve low income populations and may have opportunities for energy savings. The Revised Plan should commit to:			
124.	a.	Explore ways to flexibly serve low‐income multi‐family buildings with at least 50% of residents earning up to 80% SMI.	The PAs have established a process to work with LEAN to identify and flexibly serve buildings with a majority of residents at or under 80% (SMI) residents. The PAs and LEAN will be addressing these situations on a case-by-case basis.	
125.	b.	Explore alternative incentives or service approaches for non‐profit organizations that primarily serve low income customers.	PAs and LEAN will work together to explore providing alternate funding or enhanced incentives to certain non-profit organizations that primarily service low-income customers where appropriate. PAs and LEAN have discussed this group of customers, noting that it is not likely a large group, and have determine that they will review these situations on a case-by-case basis. Each PA will provide LEAN with a point of contact; when a customer is identified, the PA and LEAN will review the situation and determine an appropriate solution for that customer.	

I. **<u>Council's Resolution of October 26, 2015</u>**

Massachusetts Energy Efficiency Advisory Council Resolution Regarding the 2016-2018 Massachusetts Joint Statewide Three-Year Electric and Gas Energy Efficiency Investment Plan

October 26, 2015

BE IT RESOLVED THAT

The Members of the Energy Efficiency Advisory Council ("Council") present the following comments on the draft 2016-2018 Massachusetts Joint Statewide Three-Year Electric and Gas Energy Efficiency Investment Plan ("Statewide Plan") submitted to the Council on October 23rd, 2015, and the individual plans ("Individual Plans") prepared by each of Program Administrators ("PAs") for submission to the Department of Public Utilities ("DPU") as required by the Green Communities Act of 2008 ("GCA"). Under the GCA, the Council is charged with reviewing the PAs Statewide Plan and submitting its approval and comments to the DPU and the PAs. The Council recognizes and commends the PAs on the significant achievements made during the first two Statewide Plans, in particular the economic and energy benefits that nation-leading comprehensive energy efficiency programs have delivered to the ratepayers of Massachusetts. The 2016-2018 Statewide Plan recognizes energy efficiency as a resource, setting nation-leading savings levels for both electric (2.93% of retail sales) and gas (1.24% of retail sales). The proposed plan also ensures continued growth of energy efficiency in the Commonwealth with year over year increases in annual and lifetime savings goals for both electric and gas. These goal levels represent a significant increase from the 2013-2015 Three Year Plan, including a 15% increase in electric (2.55% of retail sales) and a 10% increase in gas (1.13% of retail sales).[1]

In developing its input on this Statewide Plan, the Council undertook a comprehensive engagement process to solicit and discuss input for the development of the 2016-2018 plans, starting with creating an engagement plan in Q3 2014. The Council held a special meeting for public comments in January 2015. Following that, the Council held seven topical workshops in February and March, led by the Department of Energy Resources ("DOER") that featured extensive and in-depth discussion between Councilors, PAs and the EEAC Consultants. The workshops and public comments informed the Council's March 31st, 2015 resolution regarding the Statewide Plan and culminated in specific programmatic recommendations from the Councilors[2].

The PAs submitted a draft of the Statewide Plan on April 30, 2015. Some of the recommendations from the Council were included in the plan but the consensus of the Council was that the savings goal levels proposed were too low, there were program details missing, and the projected cost per unit of savings was too high. The Council held another special meeting for public comments in May as well as two facilitated workshops in June to develop comments on the draft Statewide Plan. These efforts informed the July 21st, 2015 EEAC resolution to the DPU[3].

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[1] These goal levels also represent a significant increase from the PA's April draft Statewide Plan, while reducing the cost to achieve; annual electric goals increased 17% while the cost per unit of savings decreased 13%, and annual gas goals increased 15% while the cost per unit of savings decreased 6%.
[2] Briefing Documents, presentations, and meeting summaries from the workshops are available at ma-eeac.org
[3] http://ma-eeac.org/wordpress/wp-content/uploads/Final-EEAC-July-Resolution-7-21-15.pdf

In July through September of 2015, the DOER, the Executive Office of Energy and Environmental Affairs ("EEA"), and the Attorney General's Office ("AGO") met to discuss and explore common agreement of the 2016-2018 goals and budgets with the PAs. These goals were incorporated into the September 23rd draft plan which was presented to the Council. Through September and October the Council provided additional input on the draft Plan, culminating in this resolution.

Overall Plan Comments

The Council appreciates the significant efforts the PAs have invested in the development of the Statewide Plan to address the priorities of the Council and stakeholders. We recognize and appreciate the significant contributions of PA staff, Council consultants, Councilors, the Low-Income Energy Affordability Network ("LEAN"), and stakeholders in preparing these energy efficiency plans. The development of the 2016-2018 Statewide Plan reflects significant collaboration across PAs and among members of the Council, DOER, EEA and the AGO.

These comments present the judgment and determination of the Council based on its review of the draft of the Statewide Plan, which was submitted by the PAs on October 23rd, 2015:

- The Council has reviewed the Statewide Plan that the PAs submitted to the EEAC on October 23rd, 2015. We approve and support the 2016 – 2018 Statewide Plan, as these savings levels represent record levels of energy efficiency savings in the United States and continue Massachusetts on a path to achieving all cost effective energy efficiency.[4]
- We confirm that the Statewide Plan[5] includes ambitious energy savings goals, sensible program budgets, and substantial benefits to Massachusetts consumers as required by the GCA, and highlights a continued commitment to innovation and technology, demand/peak reduction efforts, and contractor engagement. The programs and strategies in the Statewide Plan represent a significant opportunity to maximize the benefits of energy efficiency for the Commonwealth over the next three years, and represent an increasing commitment to gas and electric savings through energy efficiency.
- We expect the Individual PA Plans will remain fully consistent with the Statewide Plan. Specifically, the energy savings levels and budgets in the Statewide Plan, and reflected in the electric and gas Terms Sheet should be reflected fully in the Individual Plans.
- While the current savings, budgets, and benefits proposed in the Statewide Plan are appropriate, there exists significant variation in the plan details among individual PAs. The Council urges the PAs to continue their joint planning and best practices efforts, with the goal of achieving programmatic consistency and equivalency while fostering creativity and providing equitable service for customers across the Commonwealth.
- We recognize the opportunity for energy efficiency to reduce energy usage at times of peak demand and mitigate energy and capacity prices. We support the establishment of a Demand Savings Group with participation from interested and qualified Councilors and

[4] This approval is provided there are not unexpected or contrary data or details that appear in later PA submissions. In approving this resolution, the Council also acknowledges the right of the DOER, the Attorney General, and any other member of the Council to participate in the proceedings before the DPU.
[5] http://ma-eeac.org/plans-updates/

other stakeholders, to address opportunities to reduce peak demand in an expeditious way.

- We recognize that performance incentives are an integral part of the planning and implementation of the energy efficiency programs. We accept, consistent with DPU Guideline 3.6, the performance incentives set forth in the Statewide Plan, including the performance incentive pool (emphasizing the maximum performance incentive pool at the design level shall be $118 million, comprised of $100 million for electric programs and $18 million for gas programs).
- We believe that the costs to implement and operate energy efficiency programs should be kept as low as possible, while achieving the objectives and requirements of the GCA. We appreciate the willingness of the PAs to project reduced costs to achieve savings and plan for sensible program budgets consistent with the Council's priorities as defined in the Council's July 21st Resolution. Achieving ambitious energy savings at sensible program costs will provide significant and lasting benefits to ratepayers, businesses, and the Commonwealth.
- We expect that the PAs will use competitive procurement whenever possible to obtain the highest quality, lowest cost service providers in the implementation of the Statewide Plan.
- We recognize that minimizing bill impacts on customers is an essential consideration. The approach in the Statewide Plan to be filed on October 30th, 2015 pursues ambitious savings goals at sensible program costs, and indicate that most PAs' customer bill impacts are expected to result in moderately low incremental cost compared to prior years. The Council and PAs will continue working together to ensure that savings are being delivered cost-efficiently, including maintaining a keen eye on program costs.
- The Council and PAs will continue to work collaboratively throughout the three-year roll-out of the Individual Plans, as directed by the GCA, through continued quarterly reports and specific updates in regular meetings that focus on topics to be determined by the Council. We expect the PAs to analyze new lessons learned, develop adjustments, and put them into practice.

On a statewide basis, the October 23rd, 2015 Statewide Plan reflects the highest levels of efficiency savings goals, as well as close PA attention to Council recommendations from the July 21st resolution, and inclusion of many specific recommendations. We appreciate that these elements are reflected in the plan including:

- A renter-specific initiative to be rolled out in Q1 2016, including semi-annual PA reports to the EEAC that will include timely rental visit metrics including participation levels and conversion rates by renters and their landlords by PA, and qualitative information on any barriers encountered and plans to address them.
- A moderate income initiative beginning in Q1 2016, including semi-annual PA reports to the EEAC on participation rates by PA.
- PAs will continue to work with the Commonwealth's housing financing agencies and LEAN (with mutual expectations and deliverables) to develop and implement enhanced approaches to leverage multi-family refinancing events to maximize retrofit potential.

The parties will specifically consider performance-based retrofit products. The PAs will present the results of these efforts and specific proposals derived from them by the close of Q1 2016.

- More detail about the PA's Massachusetts Technology Assessment Committee (MTAC), and semi-annual updates to the Council on progress reviewing and implementing new technologies into programs.
- A clear commitment to Combined Heat and Power (CHP) installations, and tracking CHP project savings and expenditures (subject to customer confidentiality requirements) against PA's CHP Plan projections in semi-annual presentations to the EEAC and in data sets provided on Mass Save Data.
- Regular and specific updates to the Council on C&I program progress and penetration (including segment specific approaches - especially for challenging subsectors such as small and mid-size commercial, small hospitals, non-profits, and multifamily - measures such as street lighting and LED costs and conversion, and innovations such as strategic energy management) through semi-annual presentations to the EEAC. The PAs will collaborate with DOER by the end of 2015 to consider how best to present this information (e.g., potential use of roundtables, webinars, etc.) and to develop a schedule for updates on specific topics.

However, data tracking and reporting issues have yet to be satisfactorily resolved by the Mass Save Data website. We recommend that the DPU continue to investigate the need for greater state-wide data transparency and reporting by the PAs through its open proceeding D.P.U. 14-141 *Response of the Department of Public Utilities to Data Privacy and Data Security Issues Related to the Statewide Energy Efficiency Database*.

The PAs have recently provided the Technical Reference Manual (TRM), 2016-2018 Plan Version, which provides the important supporting details for the savings included in the Statewide Plan. The Statewide Plan commits that an online Technical Reference Library (TRL) will be available in 2016. Since the Council has not had an opportunity to review the TRM and subsequent TRL, the Council reserves its rights to complete a review of these documents and provide comments to the DPU as appropriate.

Accordingly, the Members of the Energy Efficiency Advisory Council in recognition of the aforementioned reasons, respectfully request the Commissioners of the Department of Public Utilities to approve the 2016-2018 Massachusetts Joint Statewide Three-Year Electric and Gas Energy Efficiency Investment Plan and the Individual Plans of the electric and natural gas companies and municipal aggregators, to the degree that the Individual Plans are fully consistent with the Statewide Plan. We further request that said approval consider, embrace and reflect the comments that we articulate above.

J. **Avoided Energy Supply Costs in New England: 2015 Report**

Avoided Energy Supply Costs in New England: 2015 Report

Prepared for the Avoided-Energy-Supply-Component (AESC) Study Group

March 27, 2015

Revised April 3, 2015

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List of Acronyms

AEO	Annual Energy Outlook
AGT	Algonquin Gas Transmission
AIM	Algonquin Incremental Market
BACT	Best Available Control Technology
BART	Best Available Retrofit Technology
Bcf	Billion Cubic Feet
BDAT	Best Demonstrated Available Technology
CAGR	Compound Annual Growth Rate
CCR	Coal Combustion Residuals
CCS	Carbon Capture and Sequestration
CECP	Clean Energy Climate Plan (Massachusetts)
CSAPR	Cross State Air Pollution Rule
DOER	Massachusetts Department of Energy Resources
DRIPE	Demand Reduction Induced Price Effects
EIA	Energy Information Administration
EMF	Energy Modeling Forum
EUR	Estimated Ultimate Recovery
FCAs	Forward Capacity Auctions
FCM	Forward Capacity Market
GWSA	Massachusetts Global Warming Solutions Act
IEA	International Energy Agency
IGCC	Integrated Gasification Combined-Cycle
IGTS	Iroquois Gas Transmission System
IPCC	Intergovernmental Panel on Climate Change
IRP	Interstate Reliability Project
LAER	Lowest Achievable Emissions Reductions
LDCs	Local Distribution Companies
LNG	Liquefied Natural Gas
LSEs	Load-Serving Entities
M&NP	Maritimes & Northeast Pipeline
MACT	Maximum Achievable Control Technology

MMcf	Million Cubic Feet
NAAQS	National Ambient Air Quality Standards
PDR	Passive Demand Resources
PNGTS	Portland Natural Gas Transmission System
RACT	Reasonably Available Control Technology
REC	Renewable Energy Certificate
RGGI	Regional Greenhouse Gas Initiative
RPS	Renewable Portfolio Standard
SEDS	State Energy Data System
TCPL	TransCanada Pipelines
TETCO	Texas Eastern Transmission
TGP	Tennessee Gas Pipeline
VOM	Variable Operating and Maintenance Costs
WTI	West Texas Intermediate

Chapter 1: Executive Summary

This 2015 Avoided-Energy-Supply-Component Study ("AESC 2015," or "the Study") provides projections of marginal energy supply costs that will be avoided due to reductions in the use of electricity, natural gas, and other fuels resulting from energy efficiency programs offered to customers throughout New England. All reductions in use referred to in the Study are measured at the customer meter, unless noted otherwise.

AESC 2015 provides estimates of avoided costs for program administrators throughout New England to support their internal decision-making and regulatory filings for energy efficiency program cost-effectiveness analyses. The AESC 2015 project team understands that, ultimately, the relevant regulatory agencies in each state specify the categories of avoided costs that program administrators in their states are expected to use in their regulatory filings, and approve the values used for each category of avoided cost.

In order to determine the value of efficiency programs, AESC 2015 provides projections of avoided costs of electricity in each New England state for a hypothetical future, the "Base Case," in which no new energy efficiency programs are implemented in New England from 2016 onward. The Base Case avoided costs should not be interpreted as projections of, or proxies for, the market prices of natural gas, electricity, or other fuels in New England at any future point in time, for the following two reasons. First, the projections are for a hypothetical future without new energy efficiency measures and thus do not reflect the actual market conditions and prices likely to prevail in New England in an actual future with significant amounts of new efficiency measures. Second, the Study is providing projections of the avoided costs of energy in the long term. The actual market prices of energy at any future point in time will vary above and below their long-run avoided costs due to the various factors that affect short-term market prices.

AESC 2015 provides a fresh assessment of avoided electricity and natural gas costs from a new team using a model that simulates the operation of the New England wholesale energy and capacity markets in an iterative, integrated manner. On a 15 year levelized basis AESC 2015 estimates direct avoided retail electric costs on the order of 11 cents/kWh and direct avoided gas costs at utility city-gates in the order of $6.00 to $8.00/MMBtu depending on location and gas end-use.

The AESC 2015 estimates of direct avoided electricity and gas costs are similar to the corresponding AESC 2013 estimates. Certain AESC 2015 projections differ from those in AESC 2013 due to differences in market conditions that have occurred since AESC 2013 was completed, differences in certain assumptions regarding future market conditions and differences in analytical approaches. Key changes are:

- Increases in the quantity of shale gas production available at low marginal production costs, resulting in somewhat lower projections of avoided gas supply costs and lower avoided costs for electric energy;
- Assumed addition of a total of 1 Bcf/day of new pipeline capacity through November 2018;
- Earlier retirement of Brayton Point (2017 versus 2020) and higher costs for new fossil fueled generating capacity additions, leading to higher estimates of avoided costs for electric capacity;
- Higher Renewable Energy Credit (REC) prices due to the lower projection of wholesale energy market prices;
- Lower estimates of electricity demand reduction induced price effects ("DRIPE") from reductions in electricity use due to lower estimates of the size of those DRIPE effects and to shorter projections of the duration of those effects; and
- Lower estimates of natural gas and cross-fuel DRIPE from reductions in natural gas consumption due to lower estimates of gas supply elasticity and differences in analytical approach

The Study provides detailed projections of avoided costs by year for an initial 15-year period, 2016 through 2030, and extrapolates values for another 15 years, from 2031 through 2045.[1] All values are reported in 2015 dollars ("2015$") unless noted otherwise. For ease of reporting and comparison with AESC 2013, many results are expressed as levelized values over 15 years.[2] The AESC 2013 levelized results are calculated using the real discount rate of 2.43 percent, solely for illustrative purposes.[3]

1.1 Background to Study

AESC 2015 was sponsored by a group of electric utilities, gas utilities, and other efficiency program administrators (collectively, "program administrators" or "PAs"). The sponsors, along with non-utility parties and their consultants, formed an AESC 2015 Study Group to oversee the design and execution of the report.

The Study sponsors include: Cape Light Compact, Liberty Utilities, National Grid USA, New Hampshire Electric Co-op, Columbia Gas of Massachusetts, Eversource Energy (Connecticut Light and Power, NSTAR Electric & Gas Company, Western Massachusetts Electric Company, Public Service Company of New Hampshire, and Yankee Gas), Unitil (Fitchburg Gas and Electric Light Company, Unitil Energy Systems,

[1] Escalation rates for extrapolation are based on compound annual growth rates specific to the value stream and are noted throughout the report.

[2] 15-year levelization periods of 2014-2028 for AESC 2013 and 2016 to 2030 for AESC 2015. AESC 2013 used a real discount rate of 1.36 percent.

[3] The AESC 2015 real discount rate is a projection of the rate for a ten-year U.S. Treasury Bond developed from *An Update to the Budget and Economic Outlook: 2014 to 2024*, Congressional Budget Office, August 2014 and the Energy Information Administration (EIA) Annual Energy Outlook 2014 (AEO 2014), as detailed in Appendix E.

Inc., and Northern Utilities), United Illuminating Holding (United Illuminating, Berkshire Gas Company, Southern Connecticut Gas and Connecticut Natural Gas), Efficiency Maine, and the State of Vermont. The non-sponsoring parties represented in the Study Group include: Connecticut Department of Energy and Environmental Protection, Connecticut Energy Efficiency Board, Massachusetts Energy Efficiency Advisory Council, , Massachusetts Department of Public Utilities, Massachusetts Department of Energy Resources, Massachusetts Attorney General, Massachusetts Low-Income Energy Affordability Network (LEAN), Acadia Center, New Hampshire Public Utilities Commission, Rhode Island Division of Public Utilities and Carriers and Rhode Island Energy Efficiency and Resource Management Council.

The AESC 2015 Study Group specified the scope of services, selected the Tabors Caramanis Rudkevich ("TCR") project team, and monitored progress of the study. As instructed by the Study Group, the TCR team developed seven distinct forecast components which, are reported in Chapters 2 through 7 of this report (See Exhibit 1-1).

For each component, the TCR project team presented its methodologies, assumptions, and analytical results in draft deliverables for each of the subtasks specified by the Study Group. The TCR team reviewed each draft deliverable with the Study Group in conference calls. The relationships between the sections of this report, the forecast components, and the subtask deliverables are presented in Exhibit 1-1.

Exhibit 1-1. Relationship of Chapters to Forecast Components and Subtasks

Chapter/Appendix	Forecast Component	Subtasks
Chapter 2 – Avoided Natural Gas Costs	1	2A, 3A
Chapter 3 – Avoided Costs of Fuel Oil and Other Fuels	2, 5	2B, 3B, 2E, 3E
Chapter 4 – Embedded and Non-Embedded Environmental Costs	6	2F, 3F
Chapter 5 – Avoided Electricity Costs	3, 4	2C, 3C , 2D, 3D
Chapter 6 – Sensitivity Analyses	N/A	4B
Chapter 7 – Demand Reduction Induced Price Effects	7	2G, 3G
Appendix A – Usage Instructions	N/A	4C
Appendix G – Survey of Transmission and Distribution Capacity Values	N/A	4A
Appendix E – Common Financial Parameters	N/A	1

This report was prepared by a project team assembled and led by TCR. Rick Hornby managed the project. Dr. Benjamin Schlesinger and Dr. John Neri of Benjamin Schlesinger and Associates ("BSA") led the development of forecasts of natural gas and fuel oil supply costs as well as of gas demand reduction induced price suppression (gas DRIPE). Dr. Alex Rudkevich developed the forecasts of wholesale electric energy and capacity costs as well as of electricity DRIPE effects. Scott Englander of Longwood Energy Group led the analysis of Renewable Portfolio Standard ("RPS") requirements and compliance costs as well as of environmental costs avoided by reductions in energy use. Dr. Richard Tabors served as senior advisor.

1.2 Avoided Costs of Electricity

Initiatives that enable retail customers to reduce their peak electricity use ("demand") and/or their annual electricity use ("energy") have a number of key monetary and environmental benefits. Major categories of benefits include:

- Avoided costs due to reductions in quantities of resources required to meet electric demand and annual energy. Electric capacity costs are avoided due to a reduction in the annual quantity of electric capacity that load serving entities ("LSEs") will have to acquire from the Forward Capacity Market ("FCM") to ensure an adequate quantity of generation during hours of peak demand. Electric energy costs are avoided due to a reduction in the annual quantity of electric energy that LSEs will have to acquire. These avoided costs include a reduction in the cost of renewable energy incurred to comply with the applicable RPS.[4] Non-embedded environmental costs are avoided due to a reduction in the quantity of electric energy generated. (A non-embedded environmental cost is the cost of an environmental impact associated with the use of a product or service, such as electricity, that is not reflected in the price of that product.) AESC 2015 uses the long-term abatement cost of carbon dioxide emissions as a proxy for this value.
- Local transmission and distribution ("T&D") infrastructure costs are avoided due to delays in the timing and/or reductions in the size of new projects that have to be built, resulting from the reduction in electric energy that has to be delivered. AESC 2015 surveyed participating sponsors for recent values.
- Reductions in the quantities of capacity and energy that have to be acquired from wholesale energy and capacity markets may cause prices in those markets to decline relative to Base Case levels for a period of time. AESC 2015 refers to the reduction or mitigation of market prices due to reductions in demand for electric capacity and electric energy as "capacity DRIPE" and "energy DRIPE," respectively. In addition, reductions in annual retail electricity use will cause a reduction in gas consumption for electric generation, which is expected to have a price suppression effect on gas production and basis prices, which we refer to as electric own-fuel and cross-fuel DRIPE. (Reductions in annual retail gas use also have a price suppression effect on gas production and basis prices, which we refer to as gas fuel and cross-fuel DRIPE).

AESC 2015 developed estimates of the following major components of avoided electricity costs:

- **Avoided retail capacity.** Avoided retail capacity costs for the AESC 2015 Base Case consist of revenue from demand reductions bid into the FCM and the value of generating capacity avoided by demand reductions that are not bid into the FCM. Projected annual FCM prices are higher than in AESC 2013, for example 15 year levelized costs are approximately 77% higher. This

[4] Electric energy is measured in kilowatt hours (kWh) or megawatt hours (MWh); electricity capacity is measured in kilowatts (kW) or megawatts (MW).

increase is primarily due to earlier retirements of existing capacity (e.g. Brayton Point) and higher costs of new capacity.

- **Avoided retail energy.** This is the largest component of avoided electricity costs. It consists of the wholesale electric energy price increased by an assumed risk premium of 9%. Levelized annual avoided energy costs under the AESC 2015 Base Case are approximately 13% lower than those in AESC 2013, depending on the pricing zone. The levelized annual wholesale electric energy costs are lower primarily due to projections of lower natural gas prices and somewhat lower projected costs for compliance with anticipated federal regulations of carbon emissions.
- **Avoided RPS compliance costs.** Energy efficiency reduces the load subject to RPS obligations, avoiding the associated cost of compliance. The cost of RPS compliance is driven by the prices of renewable energy certificates (RECs), which are the principle means of compliance. AESC 2015 REC prices are approximately 40% higher than AESC 2013 because of the lower 2015 projections of wholesale energy prices.
- **Avoided non-embedded CO_2 costs.** This is the cost of controlling CO_2 emissions, to the extent that cost is not reflected in electricity market prices. The AESC 2015 projections are approximately the same as AESC 2013.
- **Electricity DRIPE.** This is the value of the reduction in capacity and energy market prices expected from reductions in electric energy use. AESC 2015 is projecting no electric capacity DRIPE and a smaller amount of electric energy DRIPE. The lower estimates are due to differences in projections of market conditions and differences in analytical approach. These are summarized in Section 1.4 and discussed in detail in Sections 6.10 and 7.2.

The relative magnitude of each component for the Summer On-Peak costing period is illustrated in Exhibit 1-2 for an efficiency measure with a 55-percent load factor implemented in the West Central Massachusetts zone ("WCMA").

Exhibit 1-2. Illustration of Avoided Electricity Cost Components, AESC 2015 vs. AESC 2013 (WCMA Zone, Summer On-Peak, 15-Year Levelized Results, 2015$)

Illustration of Avoided Electricity Cost Components, AESC 2015 BASE vs. AESC 2013 (WCMA Zone, Summer On-Peak, 15 Year Levelized Results, 2015$)

	AESC 2013 in 2013$	AESC 2013 in 2015$ [1]	AESC 2015 BASE	AESC 2015 BASE Relative to AESC 2013	
	cents/kWh	cents/kWh	cents/kWh	cents/kWh	% Difference
Avoided Retail Capacity Costs [2,3,4]	2.01	2.08	2.91	0.83	40%
Avoided Retail Energy Cost [5, 6, 7]	6.98	7.22	6.29	-0.93	-13%
Avoided Renewable Energy Credit [5, 6, 8]	0.66	0.69	0.96	0.27	39%
Capacity and Energy Subtotal	**9.65**	**9.99**	**10.15**	**0.17**	**2%**
CO_2 Non-Embedded	4.33	4.48	4.48	0.00	0%
Capacity DRIPE	0.69	0.71	0.00	-0.71	-100%
Intrastate Energy, Own Fuel and Cross-Fuel DRIPE	2.84	2.94	1.08	-1.86	-63%
DRIPE Subtotal	**3.53**	**3.65**	**1.08**	-2.57	-70%
Total	**17.51**	**18.12**	**15.71**	-2.41	-13%

Notes

1. AESC 2013 values levelized (2014-2028); escalated to 2015$ at		**1.035**
2. Assumes load factor of		**55%**
3. Avoided Cost of Capacity purchases ($/kW-year)	AESC 2013 (2013)	**$ 96.55**
	AESC 2015 (2015)	**$ 140.10**
4. Adjusted for 8% distribution losses and 17% reserve margin		
5. Retail Adjustment = Avoided Wholesale Cost * (1 + risk premium)		
6. Risk premium		**9%**
7. Avoided Energy Cost 2015$/MWh		**$ 57.68**
8. AESC 2015 REC (cents/kWh) pre-adjustment		**$ 0.88**

For this costing location and period, AESC 2015 is projecting total avoided costs from direct reductions in energy and capacity of 10 cents per kWh. This amount is approximately 2 percent higher than the corresponding AESC 2013 total.

The total of all components—i.e., the avoided cost of energy and capacity reductions (10 cents per kWh), plus energy and capacity DRIPE, plus non-embedded CO_2 costs—is 16 cents per kWh. This total is 13 percent lower than the corresponding AESC 2013 total.

1.2.1 Avoided Electric Capacity Costs

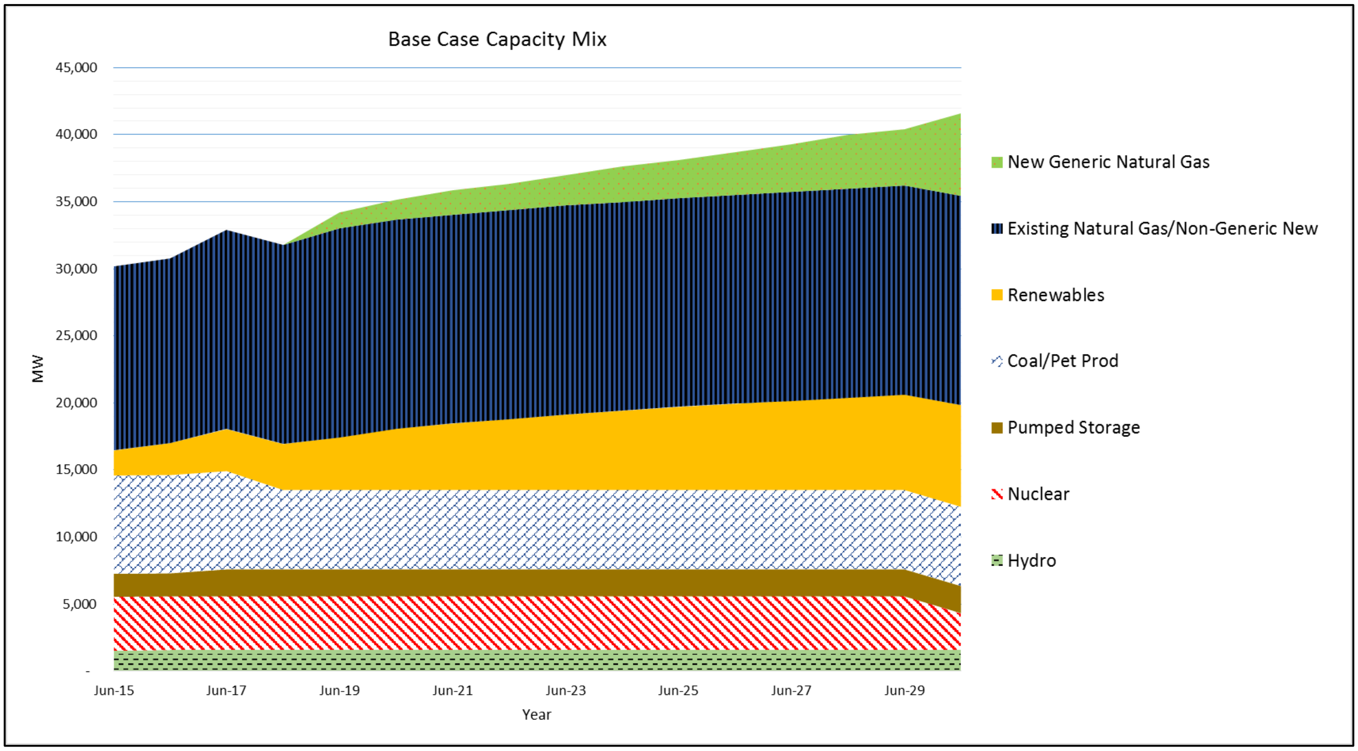
Avoided electric capacity costs are an estimate of the value of a load reduction by retail customers during hours of system peak demand.[5] The major input to this calculation is the wholesale forward capacity price to load (in dollars per kilowatt-month), which is set for a capacity year (June–May) roughly three years before the start of the capacity year. To develop an avoided cost at the meter, the wholesale electric capacity price is first increased by the reserve margin requirements forecasted for the year, then increased by eight percent to reflect ISO-New England's (ISO-NE's) estimate of distribution losses.

The major drivers of the avoided wholesale capacity price are system peak demand, capacity resources, and the detailed ISO-NE rules governing the auction. ISO-NE rules specify which resources are allowed to bid in the auction, how the resources' capacity values are computed, and what range of prices each resource category is allowed to bid. The load-resource balance is determined by load growth, retirements of existing capacity, addition of new capacity from resources to comply with RPS requirements, imports, exports, and new, non-RPS capacity additions.

As indicated in Exhibit 1-3, AESC 2013 projects that new capacity, other than RPS-related renewable resources, will have to be added starting in the 2018/2019 power year (The ISO-NE power year is June through May). This change is driven primarily by earlier projected retirements of certain existing fossil units.

[5] The benefit arises from two sources: the reduction of load at the system annual peak hour and the capacity credit attributed to energy-efficiency programs (called "passive demand response" in the ISO-NE forward capacity mechanism), measured as the average load reduction of the on-peak hours in high-load months or the hours with loads over 95 percent of forecast peak.

Exhibit 1-3. AESC 2015 Capacity Requirements vs. Resources (Base Case), MW



The AESC 2015 Base Case estimate of levelized capacity prices is approximately 40 percent higher than the estimate from AESC 2013 on a 15-year levelized basis... The higher values are primarily due to earlier retirements of existing generating units and more expensive capacity additions.

The actual amount of wholesale avoided electric capacity costs that a reduction in demand will avoid depends on the approach that the program administrator (PA) responsible for that reduction takes towards bidding it into the FCM. PAs will achieve the maximum avoided cost by bidding the entire anticipated kW reduction from measures in a given year into the FCA for that power year. PAs have to submit those bids when the FCA is held, However, the FCA for a given power year is held approximately three years in advance of the applicable power year. Some expected load reductions may not be bid into the first FCA for which the reduction would be effective, due to uncertainty about future program funding and energy savings.[6]

[6] PAs also avoid capacity costs from kW reductions that are not bid into FCAs, since those kW reductions lower actual demand, and ISO-NE eventually reflects those lower demands when setting the maximum demand to be met in future FCAs and the allocation of capacity requirements to load. However, the total amount of avoided capacity costs is lower because of the time lag—up to four years—between the year in which the kW reduction first causes a lower actual peak demand and the year in which ISO-NE translates that kW reduction into a reduction in the total demand for which capacity has to be acquired in an FCA. Since the load reduction in one year will affect the allocation of capacity responsibility in the next year, the PA's customers experience a one-year delay in realized savings that are not bid into the auctions at all.

1.2.2 Avoided Electric Energy Costs

Avoided electric energy costs at the customer meter consist of the wholesale electric energy price plus the REC cost plus a wholesale risk premium. Exhibit 1-4 presents the projected mix of generation underlying our projection of electric energy prices.

The AESC 2015 Base Case is projecting generation from natural gas to be the dominant source of electric energy over the study period. Renewable generation is projected to increase over time in compliance with RPS requirements. Generation from nuclear is projected to remain flat until year 2029 and then decline based on the assumption of Seabrook retiring in March 2030. Coal generation is projected to decline substantially by 2020 as unit retire.

Exhibit 1-4. AESC 2015 Base case Generation Mix (GWh)

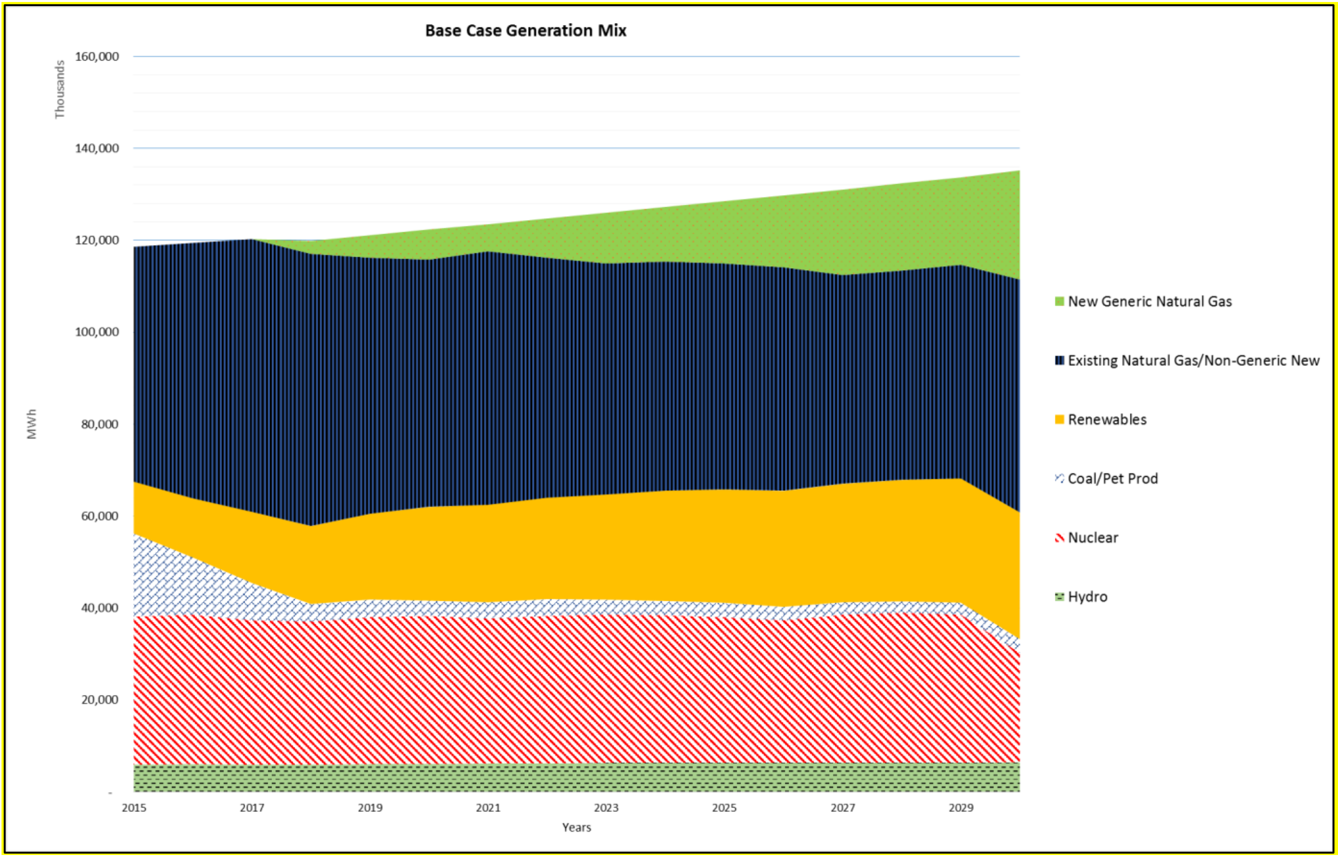


Exhibit 1-5 presents the AESC 2015 electric energy prices for the West Central Massachusetts zone for all hours compared to energy prices from AESC 2013. This WCMA price also represents the ISO-NE Control Area price, which is within this zone. On a 15 year levelized basis (2016-2030), the AESC 2015 annual all-hours price is $56.58/MWH (2015$), compared to the equivalent value of $61.95/MWh from AESC 2013, representing a reduction of 8.7 percent. The lower estimate for AESC 2015 is primarily due to a lower estimate of wholesale natural gas prices in New England and of CO_2 emission compliance costs.

Exhibit 1-5. AESC 2015 vs. AESC 2013 – All-Hours Prices for West-Central Massachusetts (2015$/kWh)

	Winter Peak Energy	Winter Off-Peak Energy	Summer Peak Energy	Summer Off-Peak Energy	Annual All-Hours Energy
AESC 2015 (2016-2030)	$62.10	$56.82	$57.68	$45.04	$56.58
AESC 2013 (2014 - 2028)	$66.64	$58.78	$66.03	$53.33	$61.95
% Difference	-6.8%	-3.3%	-12.6%	-15.6%	-8.7%

Notes:
All prices expressed in 2015$ per MWh.
Discount Rate 1.36% for AESC 2013, 2.43% for AESC 2015

Exhibit 1-6 presents the resulting 15-year levelized avoided electric energy costs for AESC 2015 by zone, after adding in the relevant REC costs and wholesale risk premiums. This exhibit also provides the corresponding estimates from AESC 2013 by zone.

Exhibit 1-6. Avoided Electric Energy Costs, AESC 2015 vs. AESC 2013 (15-year levelized, 2015$)

Avoided Electric Energy Costs, AESC 2015 versus AESC 2013 (15 year levelized 2015$)
Avoided Electric Energy Costs AESC 2015 and AESC 2013

		Winter On Peak Energy	Winter Off-Peak Energy	Summer On Peak Energy	Summer Off-Peak Energy
	AESC 2015	**$/kWh**	**$/kWh**	**$/kWh**	**$/kWh**
1	Connecticut (statewide)	0.078	0.072	0.073	0.059
2	Massachusetts (statewide)	0.077	0.072	0.073	0.059
3	Maine (ME)	0.067	0.061	0.062	0.049
4	New Hampshire (NH)	0.076	0.071	0.071	0.058
5	Rhode Island (RI)	0.073	0.068	0.068	0.054
6	Vermont (VT)	0.067	0.062	0.063	0.049
	AESC 2013	**$/kWh**	**$/kWh**	**$/kWh**	**$/kWh**
1	Connecticut (statewide)	0.079	0.070	0.078	0.064
2	Massachusetts (statewide)	0.079	0.070	0.078	0.064
3	Maine (ME)	0.066	0.060	0.064	0.054
4	New Hampshire (NH)	0.075	0.068	0.074	0.062
5	Rhode Island (RI)	0.066	0.060	0.064	0.053
6	Vermont (VT)	0.074	0.065	0.073	0.059

Exhibit 1-7 shows the change between AESC 2015 and AESC 2013 values, expressed as a percentage and in terms of 2015$ per kWh.

Exhibit 1-7. Avoided Electric Energy Costs for 2015: Change from AESC 2013 (expressed in 2015$/kWh and percentage values)

Avoided Electric Energy Costs, AESC 2015 versus AESC 2013 (15 year levelized 2015$) Avoided Electric Energy Costs : AESC 2015 Change from AESC 2013					
		Winter On Peak Energy	Winter Off-Peak Energy	Summer On Peak Energy	Summer Off-Peak Energy
	Change from AESC 2013 ($/kWh)	$/kWh	$/kWh	$/kWh	$/kWh
1	Connecticut (statewide)	(0.001)	0.002	(0.005)	(0.005)
2	Massachusetts (statewide)	(0.001)	0.001	(0.005)	(0.005)
3	Maine (ME)	0.001	0.002	(0.002)	(0.005)
4	New Hampshire (NH)	0.001	0.002	(0.003)	(0.004)
5	Rhode Island (RI)	0.007	0.008	0.004	0.002
6	Vermont (VT)	(0.007)	(0.003)	(0.011)	(0.010)
	Change from AESC 2013 (%)	%	%	%	%
1	Connecticut (statewide)	-1.4%	3.0%	-7.0%	-7.1%
2	Massachusetts (statewide)	-1.5%	1.6%	-6.8%	-8.4%
3	Maine (ME)	1.6%	3.0%	-3.2%	-9.6%
4	New Hampshire (NH)	1.1%	3.6%	-3.8%	-7.2%
5	Rhode Island (RI)	10.5%	12.5%	6.3%	3.2%
6	Vermont (VT)	-9.0%	-5.3%	-14.6%	-16.9%

1.2.3 Embedded and Non-Embedded Environmental Costs

Some environmental costs associated with electricity use are "embedded" in our estimates of avoided energy costs, and others are not. The costs that are embedded are incorporated in the pCA model used to generate wholesale energy prices for AESC 2015.

For AESC 2015, we anticipate that the "non-embedded carbon costs" will continue to be the dominant non-embedded environmental cost associated with marginal electricity generation in New England.

Based on our review of the most current research on marginal abatement and carbon capture and sequestration ("CCS") costs, and our experience and judgment on the topic, we believe that it continues to be reasonable to use the AESC 2013 CO_2 marginal abatement cost of $100 per short ton.

1.3 Avoided Natural Gas Costs

Initiatives that enable retail customers to reduce their natural gas use also have a number of benefits. The benefits from those reductions include some or all of the following avoided costs:

- Avoided gas supply costs due to a reduction in the annual quantity of gas that has to be produced;
- Avoided pipeline costs due to a reduction in the quantity of gas that has to be delivered; and
- Avoided local distribution infrastructure costs due to delays in the timing and/or reductions in the size of new projects that have to be built resulting from the reduction in gas that has to be delivered.

Detailed results of our analysis are presented in Appendix C, Avoided Natural Gas Cost Results. A summary of results is presented below.

1.3.1 Wholesale Natural Gas Supply Costs

AESC 2015 assumes that the Marcellus/Utica shale will be the primary source of gas supply to New England. However, because a dominant liquid hub has yet to develop for that production area the forecast of wholesale natural gas commodity prices in New England is derived from projected gas prices at the Henry Hub. There are far more forecast and trading data available for Henry Hub than for the Marcellus/Utica area, a situation we expect will change over time.

The AESC 2015 Base Case estimate of Henry Hub prices is $ 5.18/MMBtu (2015$) on a 15-year levelized basis for the period 2016 to 2030. This is approximately 7 percent lower than the 15-year levelized price from the AESC 2013 Base Case for a similar time period.[7]

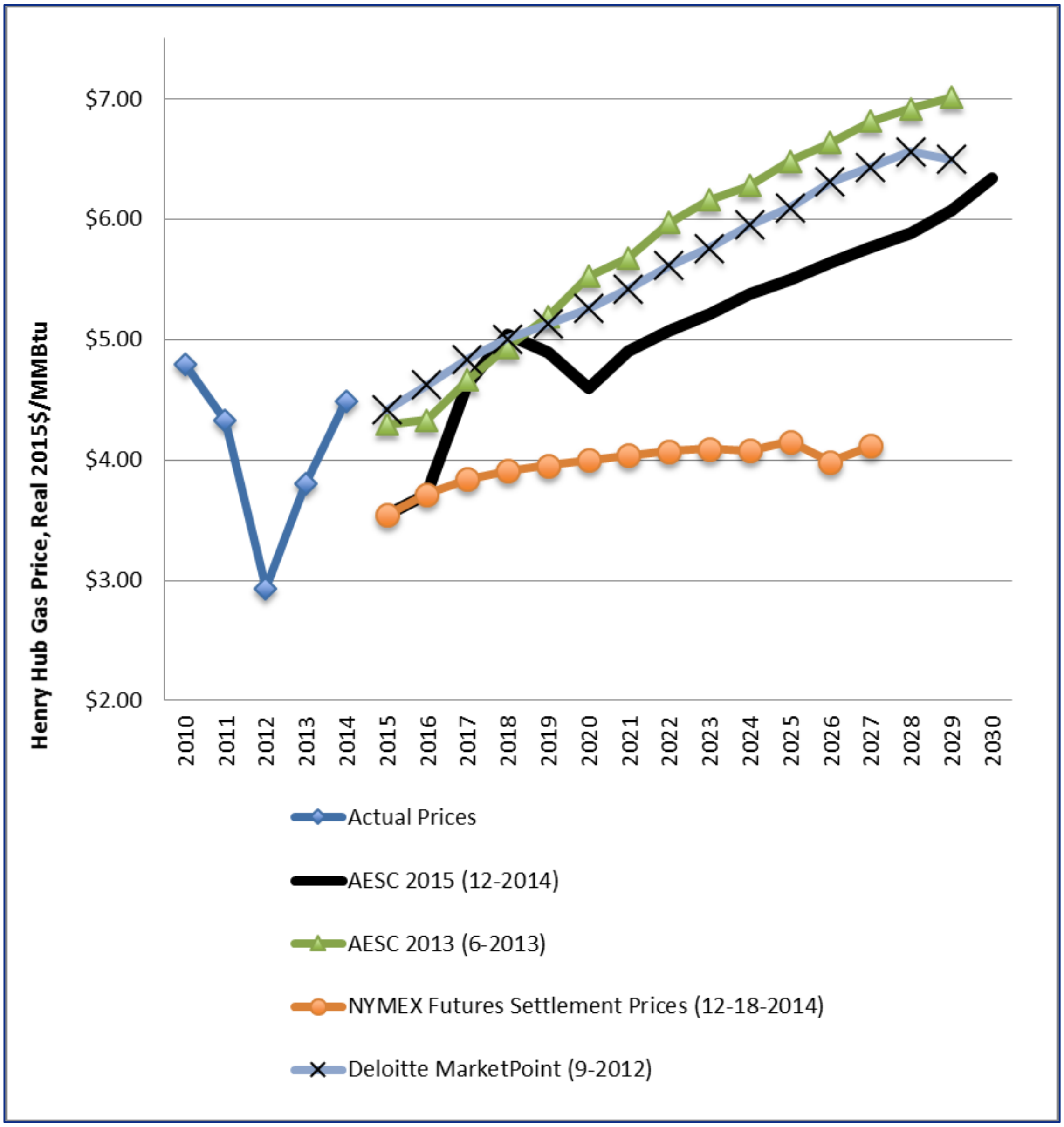
The AESC 2015 Base Case Henry Hub estimate is composed of NYMEX futures prices (as of December 18, 2014) through December 2016, and on a forecast derived from the Reference Case forecast from the Energy Information Administration's ("EIA's") Annual Energy Outlook ("AEO") 2014 for 2017 through 2030. The near-term forecast is based on NYMEX futures because they are an indication of the market's estimate of prices for the future months for which trading volumes are significant.[8] For the remaining period, the forecast is based on an AEO long-term forecast because it captures the market fundamentals that will drive those prices (i.e., demand, supply, competition among fuels) and because its underlying inputs and model algorithms are public.

Exhibit 1-8. Actual and Projected Henry Hub Prices (2015$/MMBtu) illustrates the difference between the AESC 2015 and AESC 2013 Henry Hub prices.

[7] The 15-year levelized (2014-2028) AESC 2013 Base Case in 2015$ is $5.56/ MMBtu, i.e.., 5.37/MMBtu (2013$) * 1.035).

[8] The NYMEX futures used to prepare prior AESC studies have proven to be higher than actual Henry Hub prices, indicating that price expectations of the gas industry are not always accurate.

Exhibit 1-8. Actual and Projected Henry Hub Prices (2015$/MMBtu)



This Exhibit indicates the downward trend in long-term forecasts of Henry Hub gas price forecasts since AESC 2013 was completed. Long-term gas price forecasts have been declining for several reasons. Actual gas prices have remained low. Expectations that gas supply will decline due to severe shale gas production decline rates have not materialized, nor have fears of significant production cost increases associated with the need to comply with tighter environmental regulations. Finally, and perhaps most importantly, drilling productivity has increased beyond expectations and drilling programs have become far more efficient, and time- and cost-effective.

1.3.2 Avoided Wholesale Gas Costs in New England

AESC 2015 developed a forecast of the avoided wholesale cost of gas in New England based on an analysis of the market fundamentals expected to drive that cost over the study period, using much the same general approach as the AESC 2013 Study. Specifically, the forecast of the avoided cost of gas supply begins with primary sources serving New England, and then forecasts avoided cost of gas delivery from primary sources to gas users in New England. The difference between the wholesale market price of gas at one delivery point and another delivery point is referred to as a gas price basis differential, or simply “basis.” AESC 2015 developed the avoided wholesale cost of gas in New England as the avoided cost at the Henry Hub plus the basis between the Henry Hub and New England.

In addition to developing a projection of the cost of gas from the Henry Hub and the Marcellus/Utica shale, the TCR team examined other key market fundamentals that will affect the avoided cost of gas in New England including projected demand for gas for electric generation and for retail end-uses, the projected quantity of imports of gas from Atlantic Canada and of LNG, and the projected level of pipeline capacity to deliver gas from the Marcellus/Utica shales into New England. (The projected demand for gas in New England for electric generation will be driven by numerous factors, including the long run projected price of fuel oil relative to the price of natural gas, and the level of financial penalties ISO-NE may impose on generating units which fail to meet their capacity performance obligations).

1.3.3 Avoided Natural Gas Costs by End Use

The avoided cost of gas at a retail customer’s meter has two components: (1) the avoided cost of gas delivered to the local distribution company (“LDC”), and (2) the avoided cost of delivering gas on the LDC system (the “retail margin”). AESC 2015 presents these avoided gas costs without an avoided retail margin and with an avoided retail margin, as the ability to avoid the retail margin varies by LDC.

The AESC 2015 avoided cost estimates are summarized in Exhibit 1-9 and Exhibit 1-10. These exhibits also compare the AESC 2013 results to the corresponding values from AESC 2013. Vermont requested AESC 2015 to provide avoided costs for a different set of costing periods.

Exhibit 1-9. Comparison of Avoided Gas Costs by End-Use Assuming No Avoidable Retail Margin, AESC 2015 vs. AESC 2013 (15-year levelized, 2015$/MMBtu except where indicated as 2013$/MMBtu)

	RESIDENTIAL				COMMERCIAL & INDUSTRIAL			ALL RETAIL END USES
	Non Heating	Hot Water	Heating	All	Non Heating	Heating	All	
Southern New England (CT, MA, RI)								
AESC 2013 (2013$)	6.08	6.57	6.73	6.60	6.26	6.58	6.44	6.53
AESC 2013 (b)	6.29	6.80	6.97	6.83	6.48	6.81	6.66	6.76
AESC 2015	6.00	6.53	6.70	6.56	6.20	6.54	6.39	6.48
2013 to 2015 change	-5%	-4%	-4%	-4%	-4%	-4%	-4%	-4%
Northern New England (ME, NH)								
AESC 2013 (2013$)	6.03	7.53	8.02	7.62	6.58	7.54	7.12	7.39
AESC 2013 (b)	6.24	7.80	8.30	7.89	6.82	7.81	7.37	7.65
AESC 2015	6.00	7.69	8.25	7.80	6.63	7.71	7.24	7.54
2013 to 2015 change	-4%	-1%	-1%	-1%	-3%	-1%	-2%	-1%

	Design day	**Peak Days**	**Remaining winter**	**Shoulder / summer**
Vermont				
AESC 2013 (2013$)	$ 389.03	$ 20.68	$ 8.68	$ 6.32
AESC 2013 (b)	$ 402.76	$ 21.41	$ 8.98	$ 6.54
AESC 2015	$ 523.08	$ 21.83	$ 7.51	$ 6.19
2013 to 2015 change	30%	2%	-16%	-5%

Factor to convert 2013$ to 2015$ 1.0353

Note: AESC 2013 levelized costs for 15 years 2014 - 2028 at a discount rate of 1.36%.
AESC 2015 levelized costs for 15 years 2016 - 2030 at a discount rate of 2.43%.

This set of AESC 2015 avoided natural gas cost estimates for Southern and Northern New England are generally lower than the AESC 2013 estimates, primarily due to the difference between the AESC 2015 projection of gas prices at Henry Hub and the AESC 2013 projection. The estimates for VT are also generally lower, except for the design day costs, which are higher due to a higher projection of Vermont Gas System (VGS) marginal transmission costs.

Exhibit 1-10. Comparison of Avoided Gas Costs by End-Use Assuming Some Avoidable Retail Margin, AESC 2015 vs. AESC 2013 (15-year levelized, 2015$/MMBtu except where indicated as 2013$/MMBtu)

	RESIDENTIAL				COMMERCIAL & INDUSTRIAL			ALL
	Non Heating	Hot Water	Heating	All	Non Heating	Heating	All	RETAIL END USES
Southern New England (CT, MA, RI)								
AESC 2013 (2013$)	6.67	7.17	8.30	8.12	6.88	7.74	7.44	7.80
AESC 2013 (b)	6.91	7.42	8.59	8.41	7.13	8.01	7.70	8.07
AESC 2015	6.62	7.89	8.32	8.13	6.81	7.68	7.37	7.35
2013 to 2015 change	-4%	6%	-3%	-3%	-4%	-4%	-4%	-9%
Northern New England (ME, NH)								
AESC 2013 (2013$)	6.53	8.04	9.35	8.91	7.04	8.40	7.86	8.17
AESC 2013 (b)	6.76	8.32	9.68	9.23	7.29	8.70	8.14	8.46
AESC 2015	6.52	8.86	9.64	9.15	7.11	8.61	8.01	6.88
2013 to 2015 change	-4%	6%	0%	-1%	-3%	-1%	-2%	-19%

Factor to convert 2013$ to 2015$ 1.0353

Note: AESC 2013 levelized costs for 15 years 2014 - 2028 at a discount rate of 1.36%.
AESC 2015 levelized costs for 15 years 2016 - 2030 at a discount rate of 2.43%.

This set of avoided natural gas cost estimates are also generally lower than the AESC 2013 estimates, again principally due to the lower projected gas price at Henry Hub. The exception is residential water heating, whose avoided margin was underestimated in AESC 2013.

1.4 Demand Reduction Induced Price Effects (DRIPE)

DRIPE refers to the reduction in wholesale market prices for energy and/or capacity expected from reductions in the quantities of energy and/or capacity required from those markets during a given period due to the impact of efficiency and/or demand response programs. Thus, DRIPE is a measure of the value of efficiency received by all retail customers during a given period in the form of expected reductions in wholesale prices.

DRIPE effects are typically very small when expressed in terms of their impact on wholesale market prices, i.e., reductions of a fraction of a percent. However, DRIPE effects may be material when expressed in absolute dollar terms, e.g., a small reduction in wholesale electric energy price multiplied by the quantity of electric energy purchased for all consumers at the wholesale market price, or at prices / rates tied to the wholesale price.

The value of DRIPE is a function of (i) the projected size of the impact on market prices, (ii) the projected duration of that price effect, and (iii) the quantity of energy purchased at prices tied to the wholesale market price during the duration of the price effect.

AESC 2015 estimated three broad categories of DRIPE:

- **Electric efficiency direct DRIPE:** The value of reductions in retail electricity use resulting from reductions in wholesale electric energy and capacity prices from the operation of those wholesale markets.

- **Natural gas efficiency direct and cross-fuel DRIPE:** The value of reductions in retail gas use from reductions in wholesale gas supply prices and reductions in basis to New England. Gas efficiency cross-fuel DRIPE is the value of the reductions in those prices in terms of reducing the fuel cost of gas-fired electric generating units, and through them wholesale electric energy prices.

- **Electric efficiency fuel-related and cross-fuel DRIPE:** The value of reductions in retail electricity use from reductions in wholesale gas supply prices and reductions in basis to New England. The reductions in those prices reduces the fuel cost of gas-fired electric generating units, and through them wholesale electric energy prices. Electric efficiency cross-fuel DRIPE is the value of the reductions in the wholesale gas supply price to retail gas users.

Exhibit 1-11 provides a high level overview of the AESC 2015 estimates of electricity and natural gas DRIPE.

Exhibit 1-11. DRIPE Overview

Reduction in Retail Load	Cost Component Affected	DRIPE Category
Electricity	Electric Energy Prices	Own-price (energy DRIPE)
Natural Gas	Gas Production Cost	Own-price (gas Supply DRIPE)
	Gas Production Cost	Cross-fuel (gas to electric)
	Basis to New England	Cross-fuel (gas to electric)
Electricity	Gas Production Cost	Own-price (gas Supply DRIPE)
	Basis to New England	Own- price (basis DRIPE)
	Gas Production Cost	Cross - fuel (electric to gas)

The AESC 2015 electric efficiency direct DRIPE results are lower than the corresponding AESC 2013 DRIPE results because AESC 2015 is projecting electricity DRIPE to be smaller in size and shorter in duration. The differences between the two studies are due to differences in analytical approach and in projected market conditions.

The AESC 2015 natural gas efficiency direct and cross-fuel DRIPE results, and electric efficiency fuel-related and cross-fuel DRIPE results are lower than the corresponding AESC 2013 DRIPE results primarily because of a lower estimate of basis due to a different analytical approach.

1.4.1 Analytical Approach to Estimate Electricity DRIPE

AESC 2015 estimated the size and duration of electricity DRIPE in New England, both capacity and energy, using a differential approach based on direct simulations of projected market conditions and resulting projected market prices under several different cases. AESC 2015 used a BAU Case, described in Chapter 6, as the reference point against which it measured the size and duration of DRIPE effects under each of the other cases. The other cases are the BASE Case, described in Chapter 5, and state-specific DRIPE Cases for each New England state, described in Chapter 7. The different approach is the analytical approach most commonly used to estimate DRIPE. AESC 2013 estimated the size of DRIPE using regression analyses and estimated the duration of DRIPE based on qualitative estimates.

1.4.2 Size of Electricity DRIPE.

AESC 2015 is projecting a capacity price DRIPE effect of zero. In the short term ISO New England (ISO-NE) has already set capacity prices through the 2018 power year. In the long term, as discussed in Section 6.10, AESC 2015 models future ISO-NE auctions to avoid acquiring surplus capacity and presumes that the cost characteristics of the new gas CT and CC units that will be setting the capacity market price are essentially the same.

AESC 2015 is projecting smaller energy DRIPE effects than AESC 2013 over the period January 2015 through May 2018. AESC 2015 projects the energy market prices under the BAU case and each state-specific DRIPE case by simulating the formation of energy prices based on the energy supply curve and the ISO-NE unit commitment process. The formation of energy prices under those cases, and hence the size of the resulting energy DRIPE is largely driven by the AESC 2015 assumptions' regarding the supply curve and unit commitment process.

The supply curve dampens energy DRIPE because the section of the curve that sets energy prices on most days is essentially flat, as described in Section 6.10. The unit commitment process dampens energy DRIPE because ISO-NE makes its decisions regarding which units to commit to serving load based on its projection of load for 24 hours, not for just one hour, as described in Chapter 5. Because of those two factors, AESC 2015 did not find a simple linear relationship between the energy load in a given hour and the load in that hour. Instead, AESC 2015 has demonstrated that the relationship between energy prices and loads in a given hour, is affected by load throughout the day, fuel prices on the day and unit availability on the day.

There will be days on which actual conditions will differ from the ISO NE forecast conditions due to unanticipated market conditions, e.g., an unexpected outage, oversupply or unexpectedly high or low demand. It is not clear that energy DRIPE effects would occur under those types of unexpected market conditions, i.e., when the market did not operate exactly as planned ("perfect markets" or according to perfect foresight). Many factors can cause unexpected market conditions, and one would have to identify and analyze those factors in order to determine if load reductions from energy efficiency would have any effect on prices under those conditions. In other words, to estimate the energy DRIPE effect of efficiency reductions on a day when actual conditions are materially different from forecast conditions, one must know the specific cause of the difference. It is also important to note that energy efficiency is a long-term, passive demand resource. As such, its load reduction profile is very different from that of Active Demand Resources, which provide reductions only at the time of and only in response to unexpected market conditions.

1.4.3 Duration of Electricity DRIPE

AESC 2015 is projecting electricity DRIPE effects to be shorter in duration than AESC 2013, ending after two and a half years (June 2018) rather than eight years. The differences in estimates of duration are due to differences in projection of market conditions and in analytical approach. AESC 2015 projects that ISO-NE will begin adding gas-fired capacity in all zones starting in the 2018/19 power year, approximately three years earlier than ASESC 2013. Also, AESC 2015 developed its projections of capacity and energy DRIPE from 2018 onward directly using simulation modeling of the energy market.

1.5 Avoided Cost of Fuel Oil and Other Fuels

Some electric and gas efficiency programs enable retail customers to reduce their use of energy sources other than electricity or natural gas. The benefits associated with reducing the use of "other fuels"—such as fuel oil, propane, kerosene, biofuel, and wood—include avoided fuel supply costs. For petroleum-related fuels, the major driver of these avoided costs are forecast crude oil prices.

The avoided costs of fuel oil and other fuels are used primarily by administrators of electric energy efficiency programs. Detailed results are presented in Appendix D, Avoided Costs of Other Fuels.

Exhibit 1-12 summarizes the prices projected by AESC 2015 and AESC 2013 for fuel oil and other fuels.

Exhibit 1-12. Comparison of AESC 2015 and AESC 2013 Fuel Oil and Other Fuel Prices (15-year levelized, 2015$)

Sector	Residential						Commercial	
Fuel	No. 2 Distillate	Propane	Kerosene	BioFuel	Cord Wood	Wood Pellets	No. 2 Distillate	No. 6 Residual (low sulfur)
AESC 2015 Levelized Values (2015$/MMBtu); 2016-2030	$ 19.20	$ 18.35	$ 20.94	$ 18.68	$ 6.80	$ 7.74	$18.70	$16.47
AESC 2013 Levelized Values (2015$/MMBtu); 2014-2028	$ 28.89	$ 29.16	$ 31.73	$ 30.35	$ 10.47	$ 17.45	$ 27.78	$ 16.80
AESC 2015 vs AESC 2013, % higher (lower)	-33.5%	-37.1%	-34.0%	-38.5%	-35.0%	-55.6%	-32.7%	-1.9%

The projected AESC 2013 prices for these fuels are generally lower than those from AESC 2013, primarily due to a fundamentally lower forecast of underlying crude oil prices. On a 15-year levelized basis, the AESC 2015 values range from 32 percent to 55 percent lower than the AESC 2013 projections, except for residual.

Chapter 2: Avoided Natural Gas Costs

This Chapter presents the AESC 2015 projections of avoided natural gas costs to power plants and to retail gas customers in New England. It describes the major economic and technical assumptions underpinning the major component of those projections, i.e., the avoided costs of gas production, the avoided cost of delivering gas from production areas to wholesale buyers in New England, and the avoided costs of distributing gas to retail end-users.

2.1 Overview of New England Gas Market

In order to place our forecast of wholesale natural gas prices for New England in context we begin with an overview of demand for natural gas in New England by major consuming sector as well as the physical supply of gas to the region.

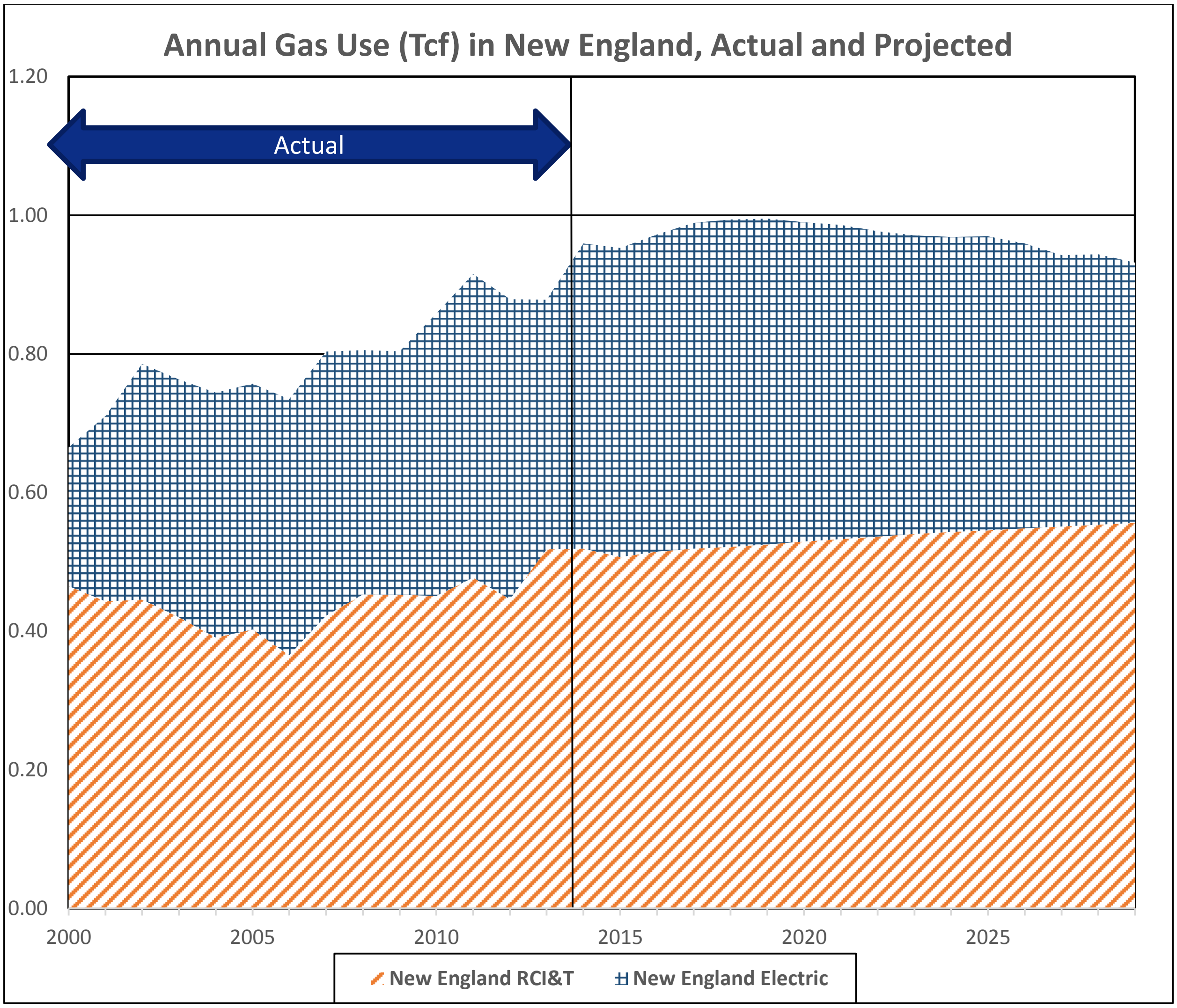
2.1.1 Demand for Gas in New England

Total gas use in New England is currently about 1 trillion cubic feet per year (EIA 2014). The market for that gas can be grouped into two distinct categories. The first category is natural gas purchased for direct use by, or on behalf of, very large end-users in the electric-generation, industrial, commercial, and institutional sectors. The second category is gas purchased by local distribution companies (LDCs) for re-sale to retail customers in the residential, commercial, and industrial (RC&I) sectors. The annual quantity of gas use in each category, actual and projected is presented in Exhibit 2-1.

The annual quantity of natural gas purchased for direct use by very large end-users, primarily for electric generation, has increased dramatically since the 1990s. That demand today accounts for roughly half of the annual gas consumption in New England. In its 2014 Annual Energy Outlook (AEO 2014), the Energy Information Administration (EIA) forecast annual gas use for electric generation in New England to remain relatively constant between 2014 and 2028 in most cases.[9]

[9] AEO 2014, Table: Energy Consumption by Sector and Source, New England, Reference case and High Oil & Gas Resource Case.

Exhibit 2-1. Actual and Projected Annual Gas Use in New England (Tcf)



The annual quantity of gas purchased by LDCs for resale to residential, commercial and industrial customers has been relatively stable since the 1990s. The AEO 2014 Reference Case projects gas use in those sectors to grow at about 0.39% per year between 2014 and 2028.[10] There is a strong interest in expanding retail use of gas in New England by extending existing distribution systems to provide consumers in under-served areas greater access to natural gas service. However, experience from other jurisdictions indicates that increasing retail gas use in this manner typically takes a number of years. For example, growth of retail natural gas use in Nova Scotia and New Brunswick has been gradual following

[10] The AEO 2014 High Resource Case projects gas use in those sectors to grow at 0.57% per year over that period.

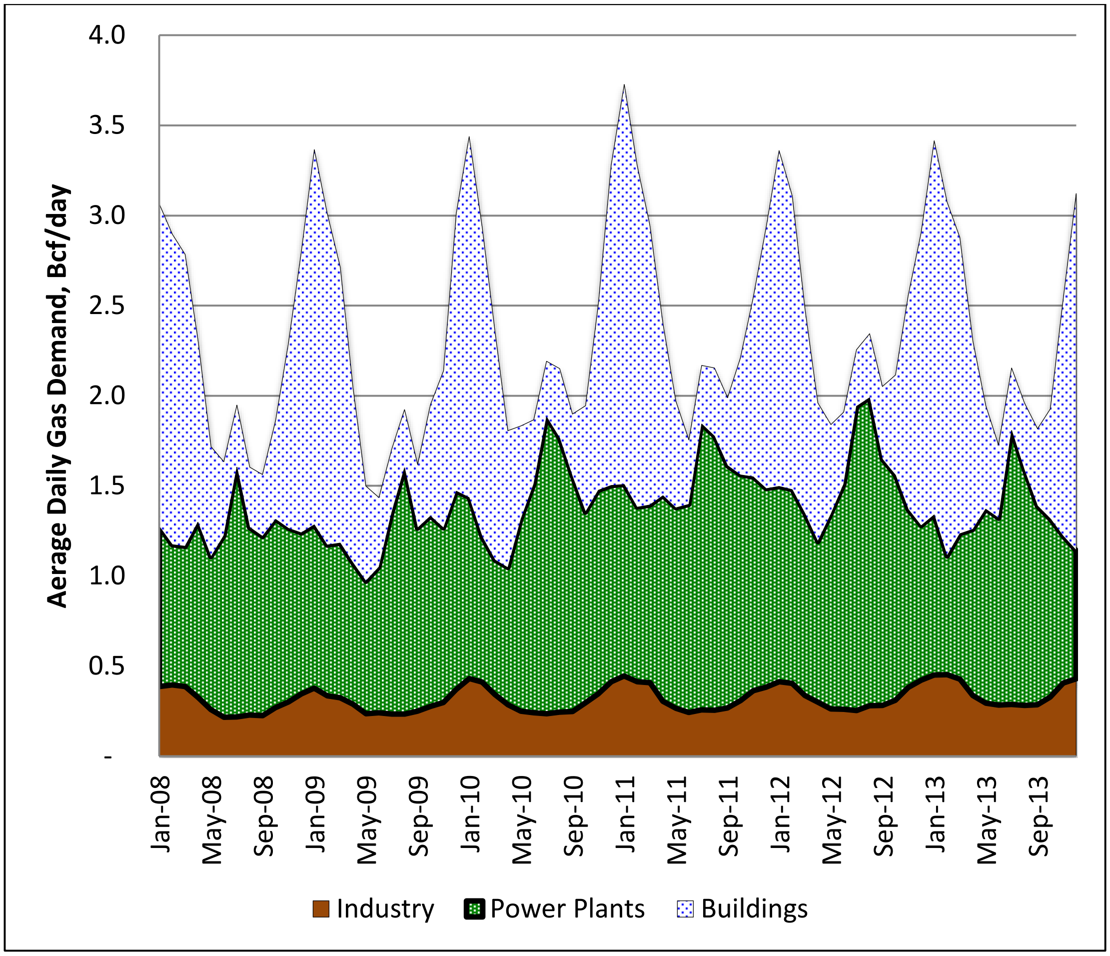
completion more than a decade ago of the large-scale M&NP; the same was the case in California following major expansions of gas pipeline capacity from Western Canada.[11]

The demand for wholesale gas in New England in all sectors varies substantially by season, and in some cases, from month by month within each season. The quantity of gas for direct use varies by month, with the greatest use occurring in summer months. In contrast, the greatest gas use by retail customers occurs in winter months since the dominant end-use is heating. As a result, LDCs have a much greater seasonal swing in gas load during the course of a year. For example, an LDC's gas load in January or February can be five times its load in July or August. Because of these large swings in gas load, LDCs acquire a portion of their winter requirements during the summer, store it in underground facilities outside of New England, and withdraw it during the winter when needed. In addition, LDCs use liquefied natural gas (LNG) and propane stored in New England to meet a portion of their peak requirements on the coldest days of the winter.

The variation in gas use by month in New England in 2008-2013 is illustrated in Exhibit 2-2.

[11] Source: Statistics Canada, California Energy Commission; pipelines refer to 0.55 Bcf/day M&NP (Canadian portion) completed in 1999 and 0.2 Bcf/day PG&E Line 401 expansion in 2002.

Exhibit 2-2. Monthly Gas Use in New England (January 2008 through December 2013)



Source: EIA.

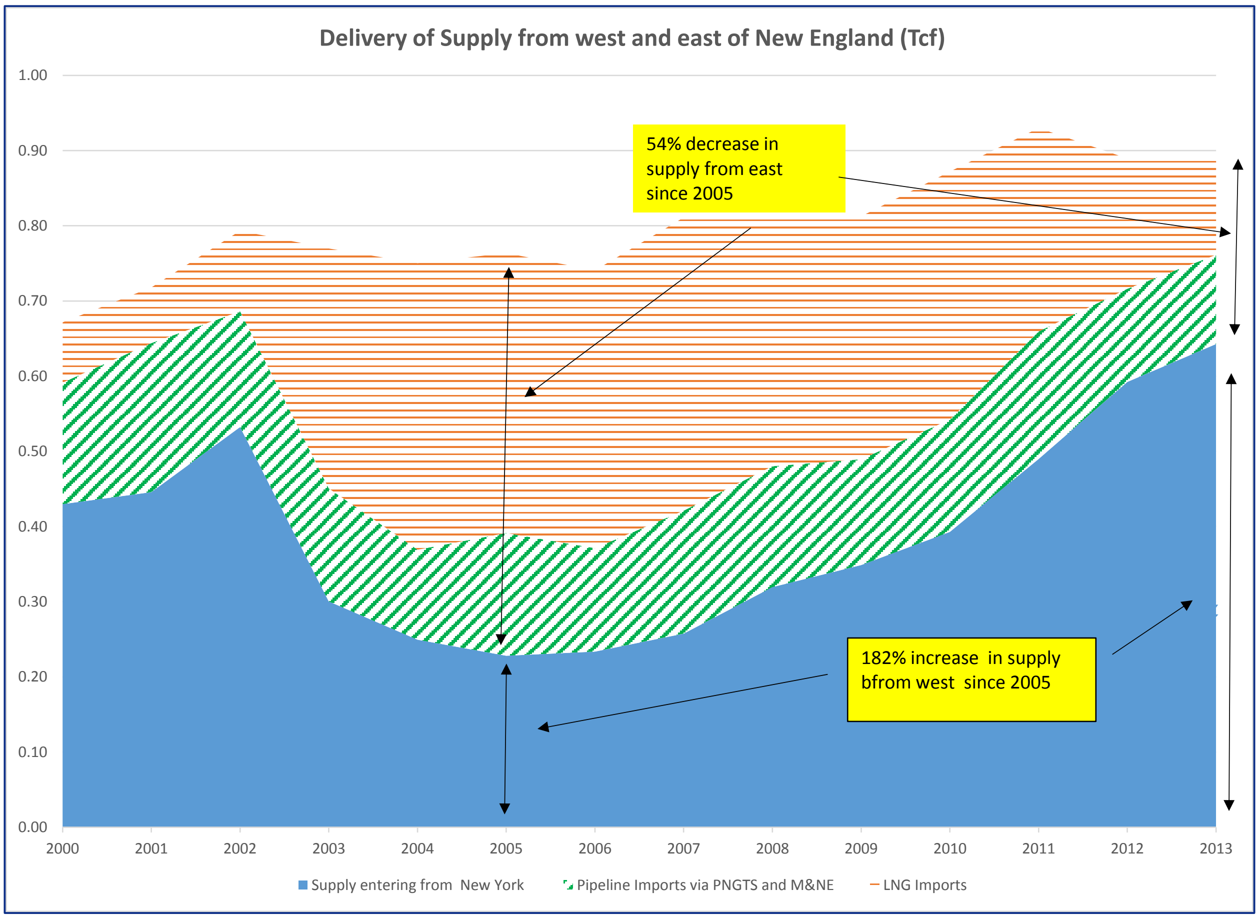
2.2 Supply of Wholesale Gas in New England

The natural gas used in New England is acquired from gas producing areas located outside New England and delivered to the region. Most of the gas consumed in New England is delivered by pipeline from producing areas in Appalachia, with smaller amounts from the U.S. Southwest, Western Canada, and Eastern Canada. Liquefied natural gas (LNG) is delivered by ship from LNG-exporting countries, principally Trinidad and Tobago in recent years.

Adequate delivery capacity from producing areas to New England, and within New England, is essential to ensure a firm supply of natural gas to, and within, the region. During the past two winters wholesale market prices spiked dramatically, to approximately $17/MMBtu in February 2012 and $25/MMBtu in February of 2013, and some gas-fired generating units were unable to operate due to inadequate gas supply. That experience highlights the need for additional delivery capacity within New England and, equally important, the need for additional delivery capacity to bring gas from producing areas west of New England, principally from the Marcellus/Utica fields, into New England in winter months.

That need for additional pipeline capacity to deliver gas from Marcellus/Utica to New England has been driven in part by the sharp decline in gas deliveries into eastern New England. Those gas deliveries are imports from Atlantic Canada and Quebec delivered into Maine, and LNG delivered into Massachusetts. Those imports have declined sharply, especially since 2011. As, indicated in Exhibit 2-3, the combined annual supply from those sources has declined over 50% since their peak in 2005. As we will discuss in 2.10, we do not expect supplies from those two sources to increase materially over the study period. In contrast, supply delivered from other producing areas into western points of the regional grid has increased over 180% since 2005.

Exhibit 2-3. Annual Gas Supply to New England



Source: TCR, from EIA data.

The following key features of the natural gas industry market structure, particularly the pipeline sector, help explain the lack of adequate delivery capacity to bring gas from producing areas west of New England in winter months.

- First, interstate pipelines, such as Algonquin Gas Transmission (AGT) and TGP which serve New England, are not allowed to sell gas; instead, they provide transportation and storage services to their customers ("shippers") under prescribed terms and conditions ("tariffs") under rate schedules approved by the FERC. Shippers acquire this capacity under long-term contracts of 10-20 years with the pipelines. Most pipelines serving the U.S. northeast, including New England, are fully subscribed, i.e., all of their capacity is spoken for (contracted) by shippers under firm transportation contracts guaranteeing shipment of gas up to the maximum amount in the contract, except for events of force majeure.

- Second, existing firm contract holders ("firm shippers") may release their capacity rights – much like sub-letting realty - in secondary markets in which firm capacity rights are acquired by other shippers. In this way, pipeline capacity rights are available in a flexible array of durations, some as short as a day or less (e.g., for power generation needs), and along various paths. But during times when gas demand is high, the firm shippers, many of whom are gas distribution utilities that must serve their retail customers, typically do not release their capacity.
- Third, FERC generally will not allow interstate pipelines to build new capacity unless they have lined up shippers who are prepared to enter long-term contracts for that new capacity. The major reason why there has been and continues to be, a shortage of pipeline capacity to deliver gas to power plants in New England, particularly in winter months, is the reluctance of those power plants to enter long-term contracts for firm capacity on those pipelines.

2.2.1 Pipelines delivering gas to, and within, New England

The physical pipeline system through which gas is delivered to New England is illustrated in Exhibit 2-4. Pipelines deliver gas directly to a number of electric generating units and very large customers, and indirectly through deliveries to LDCs which, in turn, distribute that gas to retail customers. A more extensive discussion of the New England gas industry and gas supply is published by the Northeast Gas Association (NGA 2013).

Exhibit 2-4. Natural Gas Pipelines Serving New England

Source: State of Connecticut, Joint Natural Gas Infrastructure Expansion Plan, 2014.

Deliveries into western New England

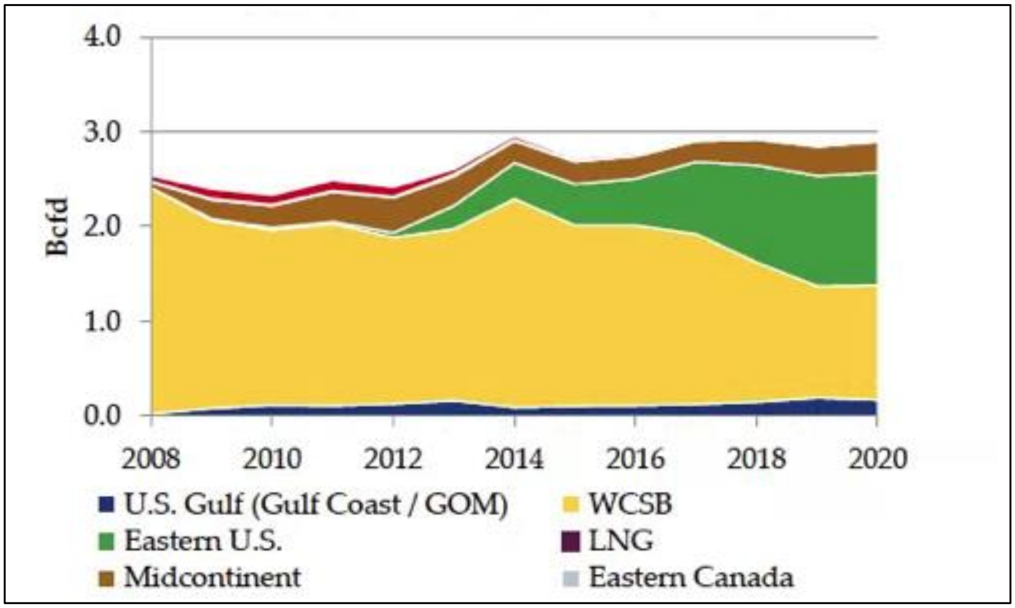
Two pipelines directly from the Marcellus/Utica shale region – Tennessee Gas Pipeline (TGP) and Algonquin Gas Transmission (AGT, an effective extension of Spectra's Texas Eastern Transmission system, or "Tetco") – deliver the majority of gas consumed in New England. TGP delivers primarily into Massachusetts, New Hampshire and Maine while AGT delivers primarily into Connecticut, Rhode Island, and Massachusetts.

The Iroquois Gas Pipeline delivers gas into Connecticut, which it receives from TGP in New York State and from the TransCanada pipeline in Quebec, Canada.

Deliveries from TCPL. The Portland Natural Gas Transmission System (PNGTS) receives gas from the TransQuebec and Maritimes Pipeline (TQM), which is an extension within Quebec of the TransCanada Pipeline (TCPL). The point of receipt is at the international border at Pittsburg, New Hampshire. PNGTS also receives gas from New Brunswick, Canada, via the Maritimes and Northeast Pipeline (M&NP), which moves gas from the international border at Eastport, Maine to an interconnection in, Maine. PNGTS, M&NP and Granite State Pipeline all then connect Westbrook, Maine with Tennessee Gas Pipeline (TGP) at an interconnection in Haverhill, Mass. The segment of between Westbrook, ME and Haverhill, MA consists of shared facilities jointly owned and operated by PNGTS, M&P and Granite State Pipeline. Gas deliveries to Vermont continue to be entirely from Canada, via TCPL, at an interconnection with Vermont Gas at the international border in Highgate Springs, VT.

An increasingly substantial portion of gas flowing from TCPL into Northern New England via PNGTS, into Connecticut from the Iroquois Gas Pipeline, and into Vermont Gas emanates from the Marcellus/Utica shale region. As shown in Exhibit 2-5, gas supplies into Ontario from the Eastern U.S. gas are increasingly replacing supplies from the WCSB – 'Eastern U.S.' in the exhibit refers to the Marcellus/Utica shale region, which has become the marginal source of gas supply on TCPL's eastern section because of its low price and ample volumes.

Exhibit 2-5. Gas Supply Mix in Ontario



Source: Navigant 2014 Mid-Year Outlook, from Ontario Energy Board, 2014 Natural Gas Market Review, Navigant Consulting, Inc., December 2014, page 37.

EIA data on pipeline gas imports and exports substantiate the Ontario analysis. They show that Niagara has turned into an export point carrying increasing volumes of pipeline gas from the Marcellus/Utica region into Ontario, while diminishing volumes are entering Canada from the St. Clair, Michigan, interconnection that formerly carried WCSB gas back into Canada via the Great Lakes Transmission Pipeline, a part of TCPL.

Deliveries into Eastern New England

The Maritimes & Northeast Pipeline (M&NP) and Portland Natural Gas Transmission System (PNGTS) systems deliver gas into Maine, Massachusetts, and New Hampshire. Those pipelines ultimately deliver into the TGP system at the interconnection in Dracut, Massachusetts and into Algonquin via the Hubline project from Beverly to Weymouth, Massachusetts (see the potion of Algonquin located offshore northeastern Massachusetts in Exhibit 2-4). M&NP delivers gas from the Canaport LNG receiving/regasification import terminal in New Brunswick, Canada, and from offshore Nova Scotia. PNGTS receives gas from the TransQuebec & Maritimes Pipeline (TQM) in Quebec, Canada. As noted earlier, an increasingly substantial portion of gas flowing on PNGTS emanates from the Marcellus/Utica shale region as TQM receives all of its gas supplies from TCPL in Ontario.

LNG imports are delivered into the regional grid from three LNG facilities in New England - Distrigas in Everett, Massachusetts, the Northeast Gateway facility completed in 2008 offshore Cape Ann, Massachusetts and the Neptune LNG facility completed in 2010 off the coast of Gloucester. The Distrigas facility, which has operated continuously since 1971, delivers gas into the Tennessee Gas Pipeline, the Algonquin Gas Pipeline, the Boston Gas component of National Grid (formerly KeySpan) system, the Mystic Electric Generating Station Units 8 & 9, and sends LNG by truck to LDC storage tanks throughout the region. The Northeast Gateway and Neptune facilities deliver gas into the Algonquin Gas Pipeline via the Hubline. Since 2010, both the Northeast Gateway and the Neptune facilities have been generally inactive.

2.3 Natural Gas Production Cost Assumptions

This section presents the assumptions underlying our projections of gas prices at the Henry Hub and in the Marcellus and Utica shale gas producing regions, as well as Henry Hub price forecasts.

AESC 2015 recognizes that the Marcellus/Utica shale will be the primary source of gas supply to New England throughout most of the planning horizon, but there is as yet an insufficiently reliable history of pricing data in the Marcellus/Utica region. In addition, no clearly dominant price reference point has yet emerged in that region as of year-end-2014, most likely because its production growth has been so quick. As a result, AESC 2015 relies, as part of its forecast model of the avoided cost of gas in New England, upon a projection of gas prices at Henry Hub, where economic and gas pricing data remain unparalleled.

The major demand and supply factors expected to drive the price of gas over the study period include:

- Gas resources, reserves, production and the technologies that underlie each of these,
- The general availability, upstream of and apart from New England, of ample gas pipeline transportation capacity, and the consequently widespread impacts of low-priced shale gas throughout North American markets, but for New England,
- Regional, national and, increasingly, international economic activity,
- Advances in technologies for gas production, transportation and use, e.g., notably in the past decade, respectively, horizontal drilling, advanced LNG systems, and high-efficiency gas-fired electricity generation using combined-cycle combustion turbines (CCGTs),
- Price elasticity of natural gas in each use and cross-elasticity with oil, electricity and other competing fuels, and
- Infrastructure expansion, including pipeline and storage capacity.

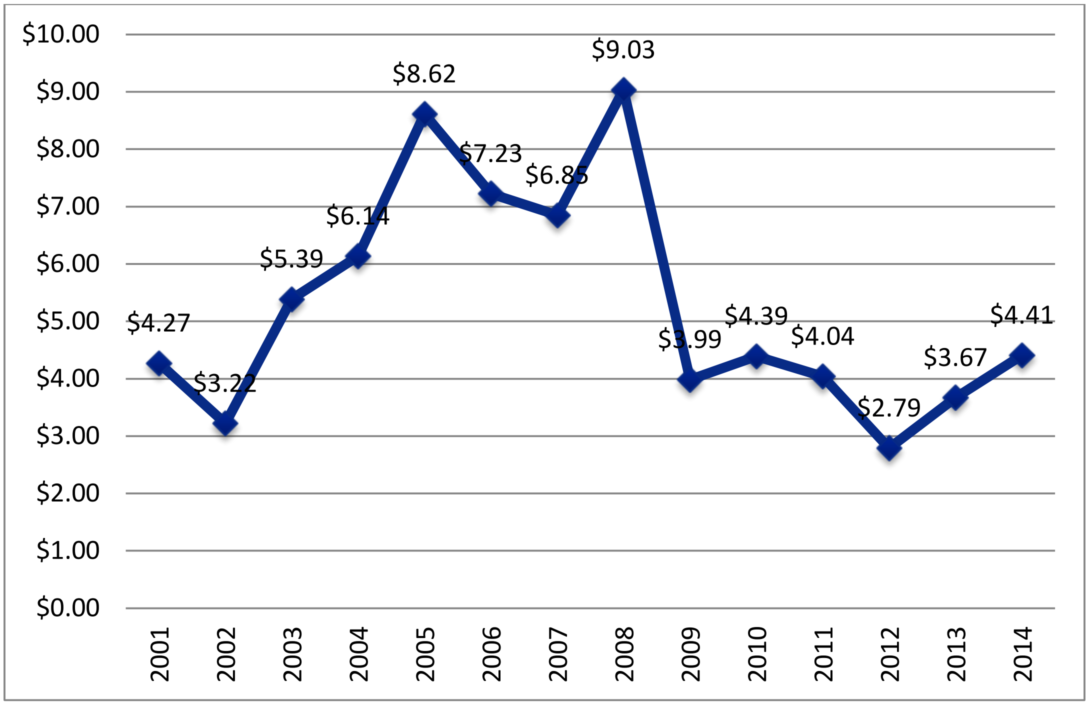
2.3.1 Major drivers of Natural Gas Production Costs over the past 30 years

For the past three decades, market forces of supply and demand have set prices for natural gas delivered into pipelines from producing areas throughout the U.S. and Canada.[12]

1980s-1990s (low conventional gas price era). Pressure from low-priced spot gas transformed U.S., then Canadian markets. The old-era pipeline-producer sales and purchase agreements (SPAs) were bought out, restructured, and otherwise disappeared, while spot and other negotiated gas markets surged to dominate the industry. By 1993, pipeline gas had disappeared from the market, and gas prices remained low in North America for nearly a decade. During this period, NYMEX launched its gas futures contract, which became their second most traded contract, after crude oil. A large number of gas-fired power plants began construction as well, including numerous cogeneration and combined-cycle plants in New England, buoyed by low gas prices and growing confidence in the now unregulated gas commodity markets. Most of the gas trading mechanisms described above evolved in the 1980s-to-2000 period as well, all within an environment of low gas prices.

[12] Decontrol of U.S. natural gas prices at the wellhead took effect initially under the Natural Gas Policy Act of 1978 (PL 95-621) in mid-1983, and was later codified under the Natural Gas Wellhead Decontrol Act of 1989 (PL 101-60).

Exhibit 2-6. Average Annual Henry Hub Gas Prices since 2000 ($/MMBtu)



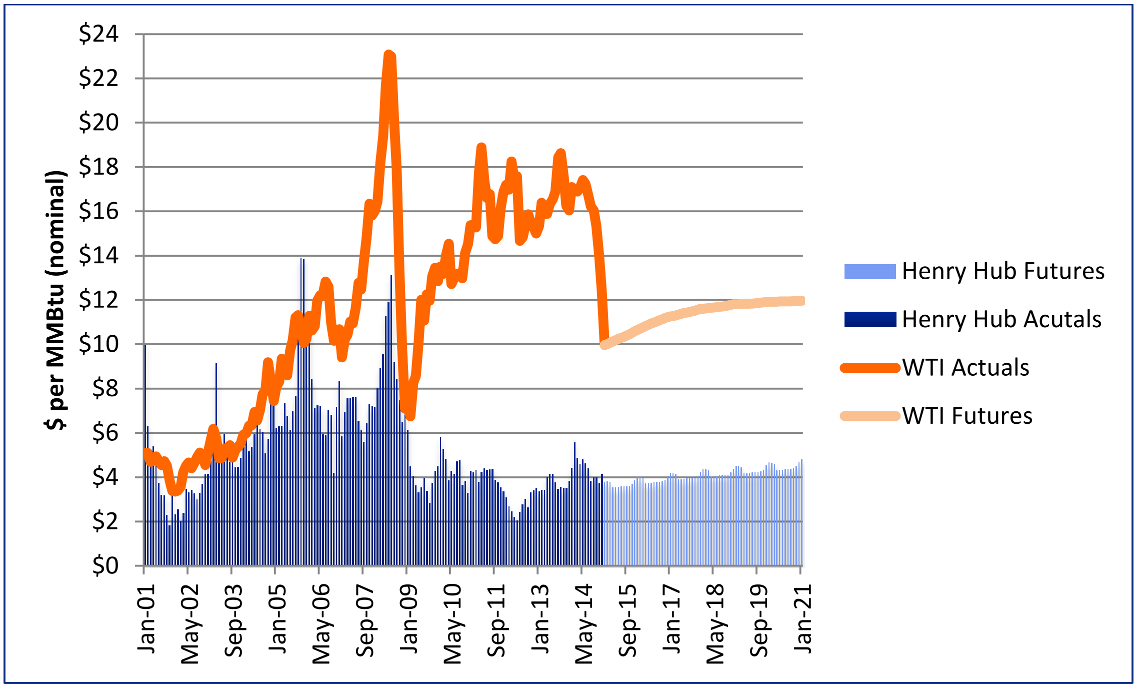
2000-2008 (second era of gas shortages). Rising gas demand for electricity generation throughout the U.S. forced higher gas prices and contributed to a series of price spikes that restored a general expectation of gas shortages. During this period, annual average Henry Hub prices rose from $4.00 per MMBtu up to range of $7.00 to $9.00 per MMBtu as indicated in Exhibit 2-6. During this period, delivered gas prices at times exceeded delivered fuel oil prices in New England, and seemed in national markets to track crude oil closely, as indicated in the actual monthly spot prices plotted in Exhibit 2-7. North America undertook a second wave of LNG import terminal construction, completing nine of them, including the Canaport terminal in New Brunswick that feeds LNG directly into New England via the Brunswick Pipeline and Maritime & Northeast Pipeline (M&NP). Also, Brent crude and WTI were closely correlated in this era.

2009-2020s and possibly beyond (the "shale revolution"). Widespread and quickly rising gas production from shale has obliterated the shortages mentality, and gas markets became quickly saturated, and then overwhelmed.[13] As illustrated in Exhibit 2-7 any price relationship that had existed between Henry Hub gas and crude oil completely disappeared, whether WTI or Brent. Henry Hub prices sunk to the $3.00-$4.00 per MMBtu range, where they remain at year end 2014. Familiar basis relationships around the North American continent have been upended, especially with increased – and still increasing – gas production from the Marcellus/Utica shales. Henry Hub, which since 1990 has spoken for the North

[13] The U.S. oil-versus-gas drilling rig count remains at about 4:1, according to data issued by Baker Hughes.

American continental gas market, is weakening as a price reference point, especially for pricing of gas in the regions between it and the Atlantic Ocean, including New England.

Exhibit 2-7. Monthly Prices of Natural Gas and Crude Oil – Actuals and Futures, 2001-2020



Source: CME-NYMEX, settlement prices at December 12, 2014; note figure plots past monthly spot prices for Henry Hub gas and WTI crude oil, as well as recent closing futures prices on CME-NYMEX for each of these same two commodities.

2.3.2 The "Shale Revolution"

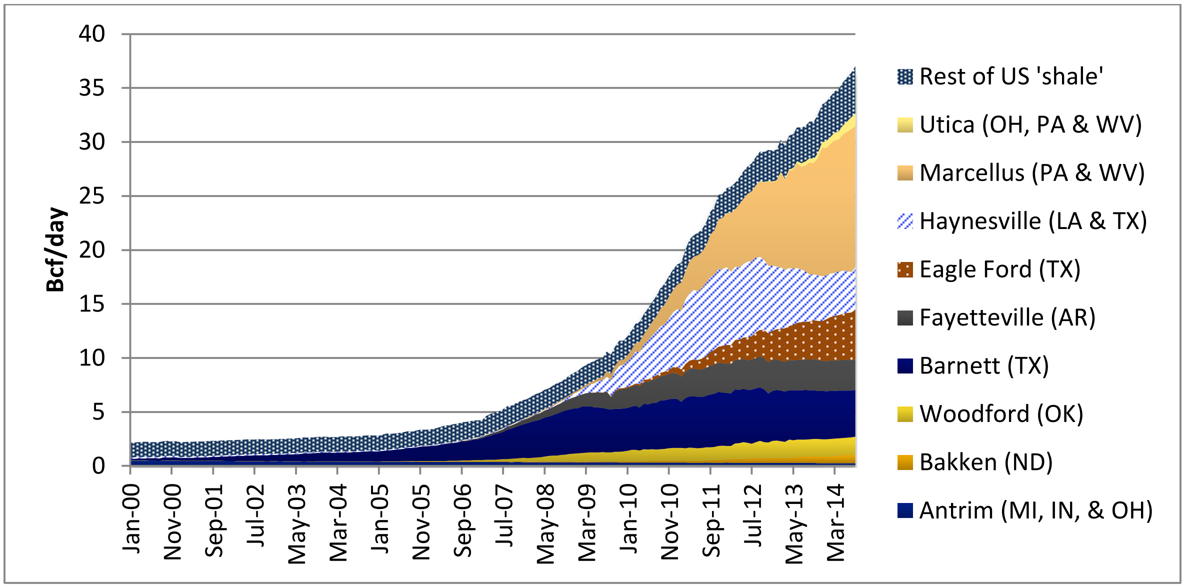
The so-called "Shale Revolution" that has been underway since the latter part of the previous decade refers to an unprecedented rise in gas production, and more recently, oil production as well, extracted from shale and other source rock beneath the earth's surface.

It is an overarching assumption of this forecast that the "Shale Revolution" can no longer be viewed as a temporary, fleeting phenomenon but is here to stay, at least over most of the life of this forecast (herein, the "planning horizon"). Recent increases in US gas production from shale are shown in Exhibit 2-8. As the exhibit makes clear, production increases have taken place over a short period of time, accelerating in the past half-decade from a relatively low base of activity. As recently as seven years ago, in January 2008, for example, natural gas produced from shale in the US had only just surpassed 6 Bcf/day, or about 10% of US gas production in 2008. In contrast, by year-end 2013, shale gas production was meeting 40.6% of US natural gas requirements (see Exhibit 2-9), a proportion that had risen to 43.2% by August 2014, and seemed likely to surpass 50% in 2015 or 2016.[14] All the while, total US gas

[14] Based on EIA data and forecasts, op.cite.

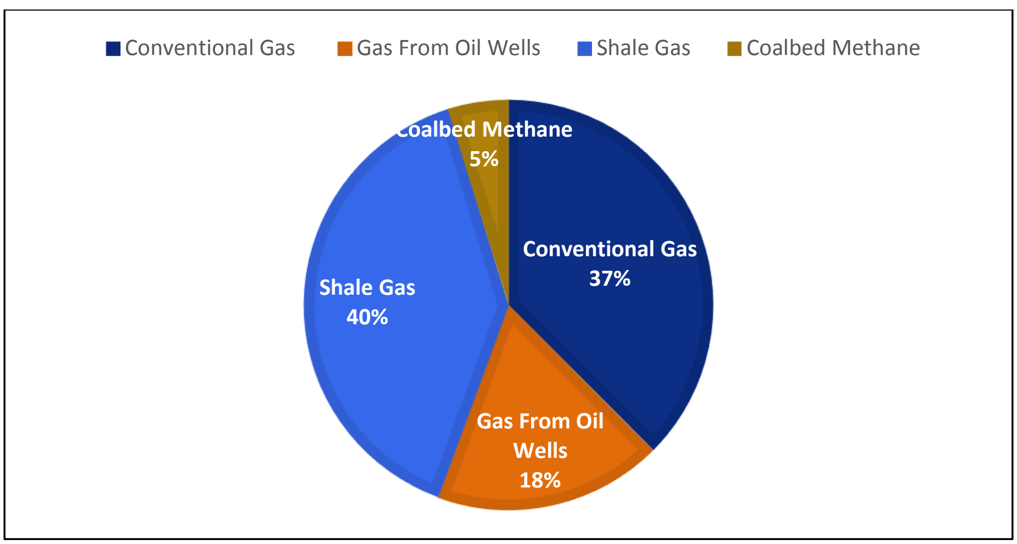
production has been rising, although not as quickly as production from shale, indicating that conventional resources are being crowded out to an extent by low-cost shale gas.

Exhibit 2-8. Increase in U.S. Natural Gas Production from Shale Fields, Monthly through August 2014



Source: EIA Administrator Adam Sieminski, in presentation before the US-Canada Energy Summit, Chicago, IL, October 17, 2014; compiled from state administrative data collected by Drilling Info Inc. Data are through August 2014 and represent EIA's official tight oil & shale gas estimates, but are not survey data. State abbreviations indicate primary state(s).

Exhibit 2-9. Derivation of U.S. Natural Gas Supplies, 2013



Source: EIA 2014, Natural Gas Gross Withdrawals and Production Volumes in 2013 (http://www.eia.gov/dnav/ng/ng_prod_sum_dcu_NUS_a.htm).

As shown in Exhibit 2-10, the Marcellus and Utica shales have proved to be especially productive. Together, these fields supplied about 20% of the entire US gas market at year-end 2014 – and a far higher percentage of the New England market – this from de minimus production levels only a half-decade earlier.[15] Averaging approximately 18.4 Bcf/day by February 2014 and rising by more than 0.3 Bcf/day per month,[16] the Marcellus/Utica shales have increased to the point where they are physically supplying nearly all of the gas requirements in the U.S. Northeast and New England, apart from imported LNG into New England.

A number of reasons are cited by Kuuskraa (2014) to explain why shale gas and oil production has evolved so quickly – these largely relate to improving drilling technologies and rig efficiencies, and also the presence of traded gas markets with open access on interstate pipelines:

- Improving well performance – longer well laterals, increasing number of fracturing stages, widespread availability of accurate well log data enabling reduction in the percentage of "dry holes" down to nearly zero
- Major efforts to reduce costs – increasing rig efficiencies, reduced well stimulation costs, reduced set-up and production timing
- Production of associated gas from "tight oil" plays – break-even costs of associated natural gas from "tight oil" are low to negative
- Steady introduction of new gas plays to counter resource depletion.[17]

The foregoing improvements in gas production have taken place within an environment of extensive field knowledge and experience gained from decades of drilling activity in conventional gas and oil plays located within the same regions as the major shale plays.

[15] EIA Drilling Productivity Report for Key Tight Oil and Shale Gas Regions ("EIA Drilling Productivity Report"), February 2015: 16,550 MMcf/day and 1,854 MMcf/day, respectively for Marcellus and Utica shales (see http://www.eia.gov/petroleum/drilling/#tabs-summary-2); and EIA Natural Gas Gross Withdrawals and Production, 2,674,827 MMcf in September 2014 (http://www.eia.gov/dnav/ng/ng_prod_sum_dcu_NUS_m.htm).

Note these volumes update even some very contemporary publications and articles relying on earlier or inaccurate data, e.g., article in Nature Magazine, "Natural gas: The fracking fallacy," by Mason Inman, 03 December 2014, where Marcellus Shale is depicted as peaking in 2020 at about 12-13 Bcf/day (120-130 Bcf/year) in 2020, despite current production cited earlier in this note, as reported by EIA, of 18.4 Bcf/day, including the adjacent Utica shales. See, further, December 2014 responses to the Nature Magazine article by EIA and the University of Texas, Bureau of Economic Geology (http://www.eia.gov).

[16] EIA Drilling Productivity Report, January 2015, as above.

[17] Vello Kuuskraa, President, Advanced Resources International, Inc. (ARI), in presentation before the Electric Power Research Institute (EPRI) 33rd Annual Fuel & Planning Seminar, Washington, DC, November 12, 2014.

Exhibit 2-10. U.S. Shale Gas Production and Rate of Increase at Year-End 2014

Region	February 2015 Gas Production, Bcf/d	Monthly Change at January 2015 MMcf/d	Monthly Change at January 2015, %
Marcellus/Utica	18.4	+305	1.7%
Eagle Ford	7.5	+97	1.3%
Haynesville	7.0	+69	1.0%
Permian	6.3	+74	1.2%
Niobrara	4.7	+41	0.9%
Bakken	1.5	+27	1.8%
Total	45.4	+613	1.4%

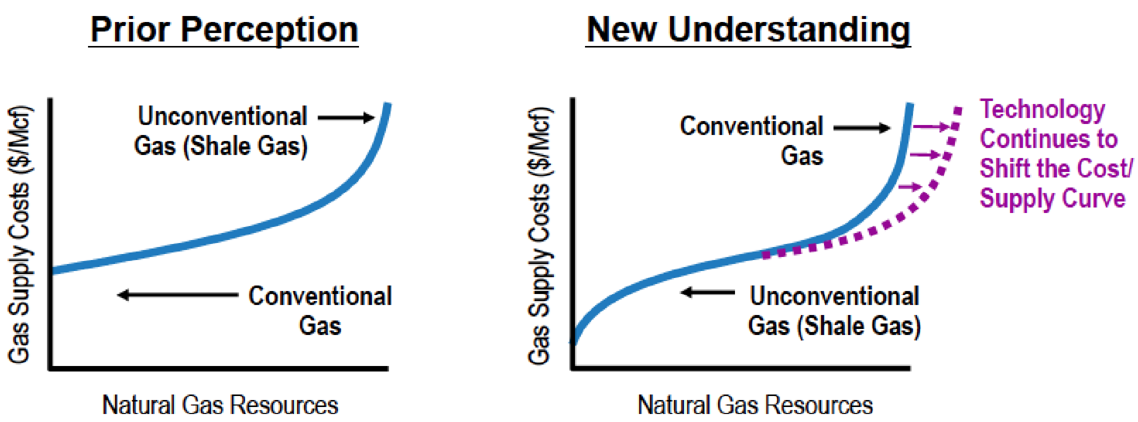
Source: EIA, Drilling Productivity Report, January 2015.

Natural gas production from the Marcellus/Utica shales has benefited greatly from its ability to access an extensive existing pipeline grid. This gas has generally been able to travel to where it is consumed on a "non-firm" basis, and gas sales take place within flexible, liquid, efficient spot gas markets. The one major exception has been pipeline capacity to the Northeast and New England during winter months. The lack of adequate firm pipeline capacity to deliver gas from the Marcellus/Utica shales to those regions has caused the wholesale market price of gas in New England to skyrocket during the past two winters, and in the Northeast last winter.

Kuuskraa (2014) goes on to explain that, under past perceptions, conventional gas and oil was cheaper to produce than unconventional resources such as shale, tight sands, tight oil, and the like, which require well stimulation techniques of one kind or another. In Exhibit 2-11, he makes the point that conventional gas used to occupy the lower left-hand portion of the overall US price-quantity gas supply curve, while unconventional resources occupied the upper right-hand portion. In other words, gas from ordinary downward-only (vertical, un-stimulated) gas wells was cheap to drill and produce, despite a number of finding risks like imperfect success rates. On the other hand, the nation's vast unconventional gas and oil resources have long been documented, but they were deemed too expensive to produce because well stimulation would be required at high cost (as was believed at the time).[18]

As Kuuskraa points out: "Today, unconventional gas (particularly high quality, liquids-rich shale gas) forms the low-cost portion of the natural gas cost/supply curve."[19]

Exhibit 2-11. Illustrative Price-Quantity Curve for Overall U.S. Natural Gas Supply



Source: Kuuskraa, 2014, before EPRI (see Footnote 6).

In summary to this discussion, the AESC 2015 forecast of avoided gas costs in New England has as its overarching assumption that shale gas is here to stay as a dominant component of U.S. gas supplies, comprising at least 50% of the nation's gas supply through the planning horizon.[20] Even despite lowered energy price expectations, shale gas will continue to depress underlying North American natural gas prices for at least two decades (see discussion below), will replace other supplies of gas as well as fuel oil and coal, and will obviate otherwise inevitable LNG imports.

2.4 The Marcellus and Utica Shales

The Marcellus/Utica shale field has become the nation's largest gas producing field, with no exceptions. Centered in Pennsylvania, Ohio and West Virginia, the Marcellus and Utica shales (herein, Marcellus/Utica) are estimated to hold one of the largest gas fields discovered in the history of the global industry, i.e., about 410 trillion cubic feet (Tcf) of undeveloped technically recoverable gas. For perspective, the Marcellus/Utica is estimated to hold about twice the recoverable gas resources of Alaska's North Slope. Improving technology and field practices tailored to the Marcellus/Utica have

[18] For example, see EIA and Gas Research Institute reports, and legislative history of the Natural Gas Policy Act of 1978.

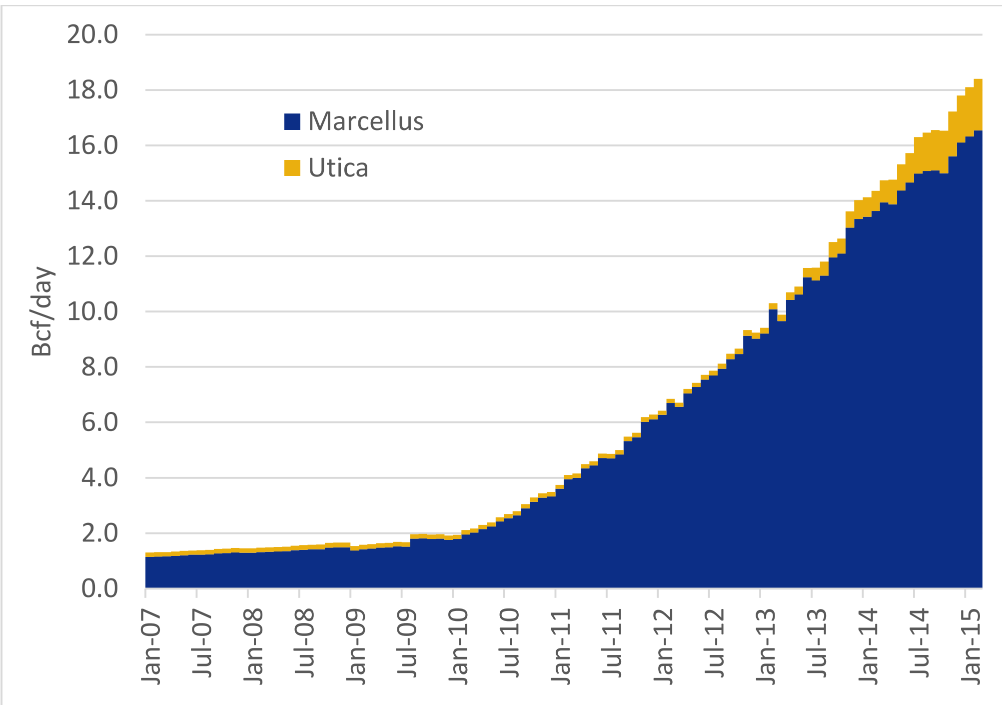
[19] Ibid. Kuuskraa before EPRI, November 2014.

[20] Discussion of health and safety impacts of the major shale production technique, hydraulic fracturing combined with horizontal drilling, may be found in later portions of this chapter.

enabled this gas to be produced at lower costs than most other gas plays in the US, including other shale fields.

Even though it is now already producing more than twice as much gas as any other field in the U.S., shale or otherwise, Marcellus/Utica production is continuing to increase (see Exhibit 2-12). Gas production has been rising by about 1 Bcf/day every three months since 2011, and is likely in our view to reach an average daily production range of about 20-25 Bcf/day by 2020. By contrast, Alaska's proposed North Slope gas pipeline was to have delivered from 4 Bcf/day to 7 Bcf/day of gas, depending upon various pipeline configurations that have been offered in the past nearly four and one half decades since North Slope oil and gas was discovered in 1968.

Exhibit 2-12. Marcellus/Utica Shale Gas Production Growth, Million cf/day



Source: EIA Drilling Productivity Report, January 2015.

As a result of unexpectedly major volumes of natural gas produced in the Marcellus/Utica, a number of gas pipeline flows have been reversed in the U.S. in order to transport gas out of the Marcellus/Utica shale to Chicago, Central Canada, and even to Louisiana and Texas.

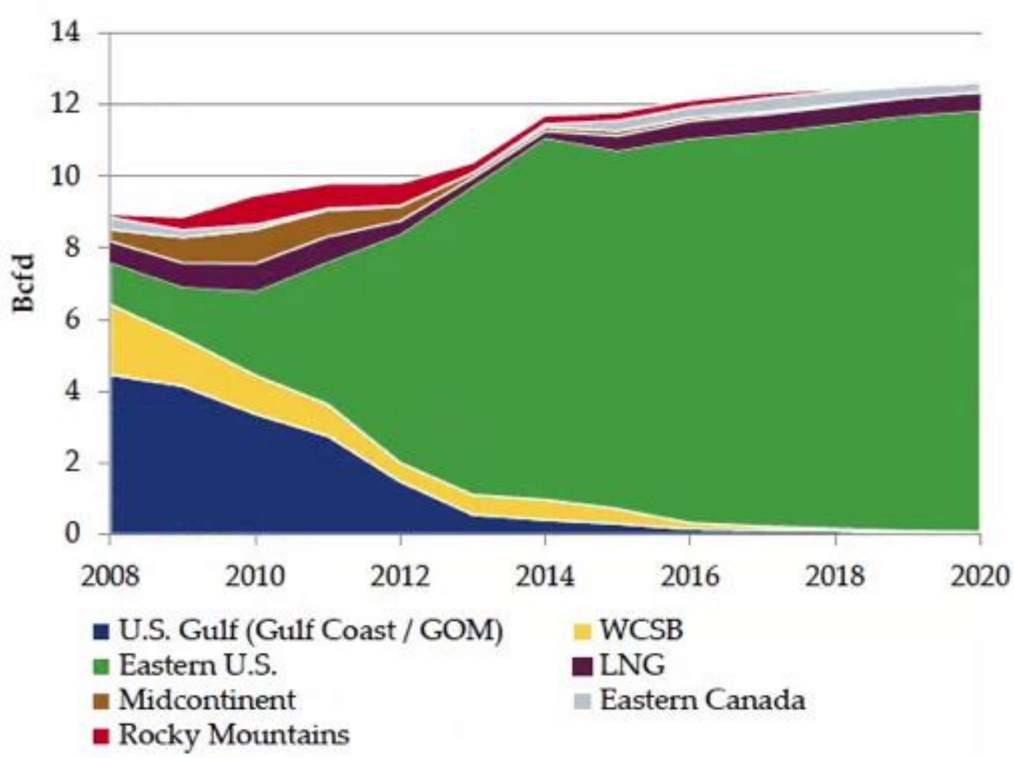
The foregoing developments are having important spillover effects on New England's gas supply sources:

- First, Marcellus/Utica gas is largely displacing New England's traditional gas supplies from U.S. southwestern producing areas including Louisiana and Texas.

- At the same time, as described above, the international gas import point at Niagara through which Canadian gas has for thirty years entered New York State, bound in part for New England, was recently reversed and Marcellus/Utica gas is currently flowing into Central and Eastern Canadian markets. This gas is increasingly displacing gas produced in the Western Canadian Sedimentary Basin (WCSB) which, for decades, supplied essentially all of this region's gas requirements via the TransCanada pipeline system mainline.
- Thus, since Central and Eastern Canada is increasingly consuming Marcellus/Utica gas instead of WCSB gas as shown in Exhibit 2-5, most of New England's gas supplies from Canada, e.g., via the Iroquois and Portland Natural Gas pipelines, is actually Marcellus/Utica gas as well – and all of it is on the margin. In other words, whether New England wholesale buyers move gas on the Algonquin or Tennessee Gas pipelines from New York State, or they import pipeline gas from Central Canada (Ontario and Quebec), they are in reality acquiring gas mostly from the Marcellus/Utica producing region.

AESC 2015 assumes that production from the Marcellus/Utica shales will continue to increase and to supply an increasing portion of the New England market over time, eventually supplying almost the entire pipeline (i.e., non-LNG) market through the following two decades, and then largely beyond then through the end of the planning horizon (see Exhibit 2-13, from OEB/Navigant 2014)

Exhibit 2-13. Sources of Gas Supply in the U.S. Northeast Region, Including New England



Source: 2014 Mid-Year Outlook, from Ontario Energy Board, 2014 Natural Gas Market Review, Navigant Consulting, Inc., December 2014, page 36.

In addition, as was assumed in the AESC 2013 forecast of avoided gas costs, AESC 2015 anticipates that New England will continue to rely on imported LNG to help meet its winter peak gas demand requirements for a limited number of days.

2.5 Long-Run Avoided Cost of Gas Supply

The AESC 2015 Base Case and High Gas Case forecasts from January 2017 onward rely on Henry Hub gas price projections contained in the Energy Information Administration's Annual Energy Outlook (AEO) 2014 Reference Case.[21] The AESC 2015 Low Gas Case sensitivity forecast relies on the AEO 2014 High Oil and Gas Resource Case (HRC). These forecasts were selected based upon our review of the AEO 2014 suite of forecasts, as well as on runs of the World Gas Model housed at Deloitte and at the James A. Baker III Institute for Public Policy at Rice University (Baker-WGM), current futures market prices of gas and basis, and insights from other research agencies and consulting firms**.**

Unlike AESC 2013, AESC 2015 does not adjust AEO 2014 forecasts for marginal well economics or compliance with anticipated tighter regulation of fracturing, as no such corrections are needed. This decision is based upon the reviews described above, on our understanding that these factors have been internalized in EIA's contemporary rounds of AEO forecasts, and on recent data.

2.5.1 Reliance on AEO 2014 Reference Case

EIA's annual domestic energy forecasting process involves an annual cycle consisting of analysis activity conducted internally and through use of contractors. The process takes place largely during the summer preceding the date of (and release of) AEO forecasts, thus the bulk of work in preparing the AEO 2014 Reference Case took place predominantly during Summer 2013. The EIA's analysis involves preparing and testing necessary updates to, and changes in the National Energy Modeling System (NEMS), including numerous runs and reruns of the updated model. Throughout this process, a series of peer reviews are conducted with industry experts and stakeholders. This series of activities normally intensifies during the summer and fall preceding EIA's issuance of the early release of its Reference Case, normally in mid-December. The AEO 2015 preparation cycle has been delayed to accommodate the more than 50% decline in crude oil prices that took place in the latter half of 2014, as well as other recent developments.

In the High Oil and Gas Resource Case (HRC), the EIA makes a number of assumptions about the unconventional gas and oil resource base that, together, expand recoverable gas volumes well beyond

[21] The AESC 2015 High Gas Case Henry Hub price is the AEO 2014 Reference Case plus 15%, which reflects the minimum increase in gas prices in the AEO 2014 Low Oil and Gas Resource Case over the AEO 2014 Reference Case.

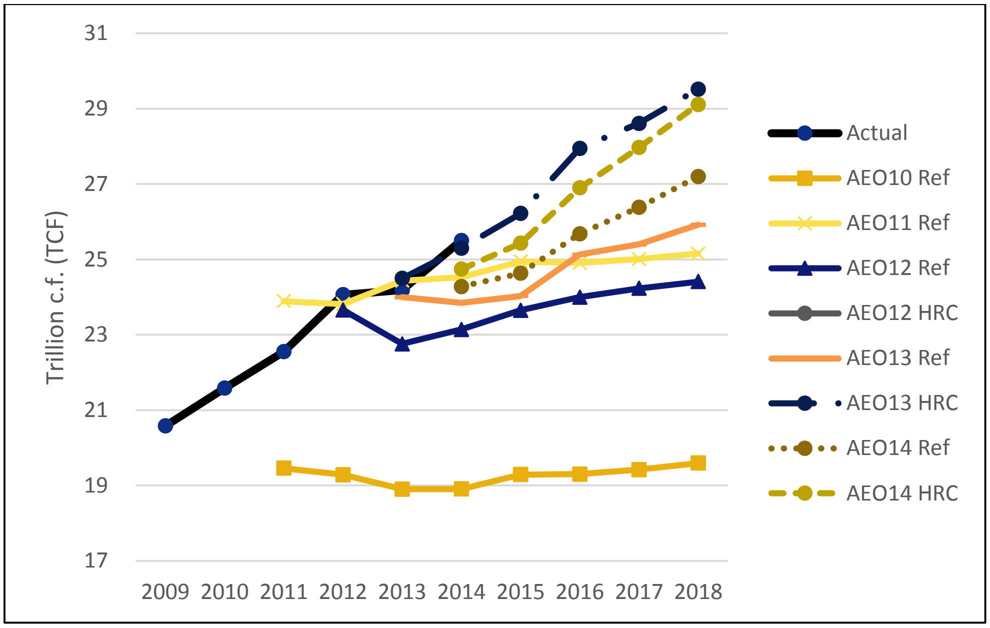
those assumed in the Reference Case. The HRC makes no other changes to the AEO Reference Case assumptions, e.g., contains no differences in assumptions concerning existing drilling laws and regulations, macro-economic conditions, or about other fuels. [22] Importantly, the HRC assumes that the estimated ultimate recovery (EUR) of shale and tight sands gas is 50% higher than in the Reference Case and the number of wells left to be drilled is 100% higher. In the AEO 2013 and AEO 2014 versions, the HRC forecasts project significantly lower gas prices than the corresponding Reference Cases.

In our analysis, the HRC series has been a closer predictor of the growth in shale gas production than has the Reference Case series. As shown in Exhibit 2-14, AEO Reference Cases in recent years have been consistently low in their projections of U.S. dry gas production, while the HRC series has come closer to reality. The situation with respect to AEO forecasts of gas prices has not been as clear as it has been with volumes however. For example, we note that, in some years, AEO Reference Cases have come closer to forecasting actual gas prices than the HRC cases. As shown in Exhibit 2-14, the EIA forecasts that appear to have come closest to projecting actual prices have been the AEO 2013 Reference Case – which was the driving forecast in the AESC 2013 report – and the AEO 2014 HRC.[23]

[22] The EIA defines the HRC as follows: "Estimated ultimate recovery per shale gas, tight gas, and tight oil well is SO% higher and well spacing is 50%lower (or the number of wells left to be drilled is 100% higher) than in the Reference case. In addition, tight oil resources are added to reflect new plays or the expansion of known tight oil plays and the estimated ultimate recovery for tight and shale wells is increased 1% per year to reflect additional technological improvement. Also includes kerogen development, tight oil resources in Alaska, and 50% higher undiscovered resources in lower 48 offshore and Alaska than in the Reference case." See, for example: http://www.eia.gov/oiaf/aeo/tablebrowser/.

[23] Note that, through the late 2020s, the AEO 2013 Reference Case and the AEO 2014 High Oil & Gas Resource Case are almost identical in terms of their projected Henry Hub gas price; after that, these diverge, as the AEO 2014 High Oil & Gas Resource Case decreases to meet NYMEX market general expectations.

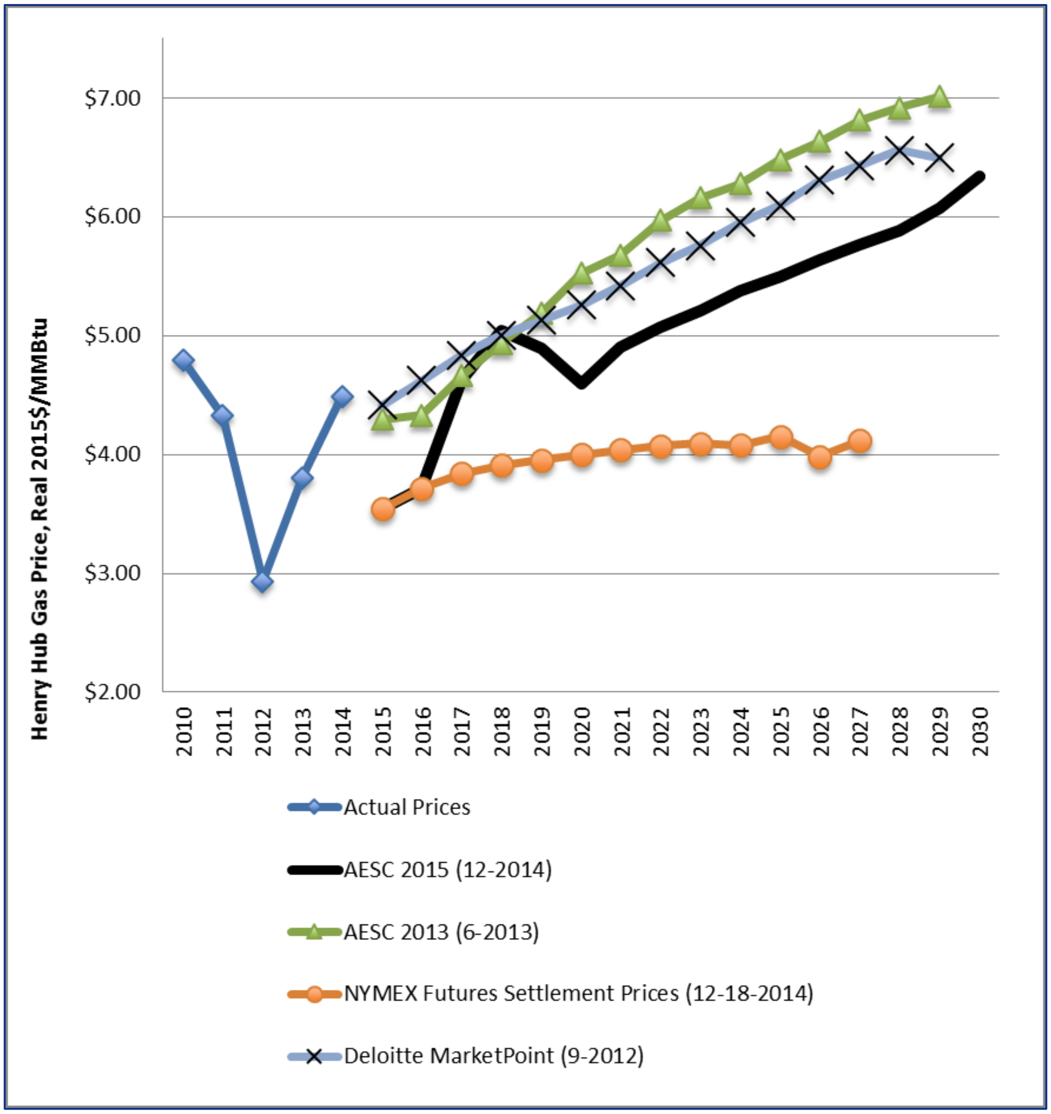
Exhibit 2-14. Comparison of U.S. Gas Production Forecasts in Recent AEO Forecasts vs. Actual Gas Production



Consequently, AESC 2015 opts on the conservative side and derives its Henry Hub gas price assumptions largely from the AEO 2014 Reference Case. It must be pointed out, however, that no statistical proof could substantiate selection of any particular case in a meaningful way on the basis of price, in light of the wide risks and uncertainties confounding all Henry Hub gas price forecasts at a time when:

- Gas production is growing rapidly.
- Production is moving away from the traditional southwestern producing regions, to the Marcellus/Utica region.
- Crude oil prices are highly unstable, having fallen almost suddenly by about 50% in the latter half of 2014.
- Coal competition with natural gas remains sharp.
- LNG exports are poised to begin in about a year, starting with initial exports of U.S. LNG from the Sabine Pass LNG terminal in November 2015.

Exhibit 2-15. Comparison of Annual HH Prices – Actuals, AEO Forecasts and December 2014 NYMEX Futures



In addition, as if the foregoing uncertainties were not great enough, around the time the AESC 2015 report was prepared, the EIA announced it intended to delay early release of its AEO 2015 Reference Case until March 2015.

2.5.2 Marginal Production Cost of Natural Gas from Shale

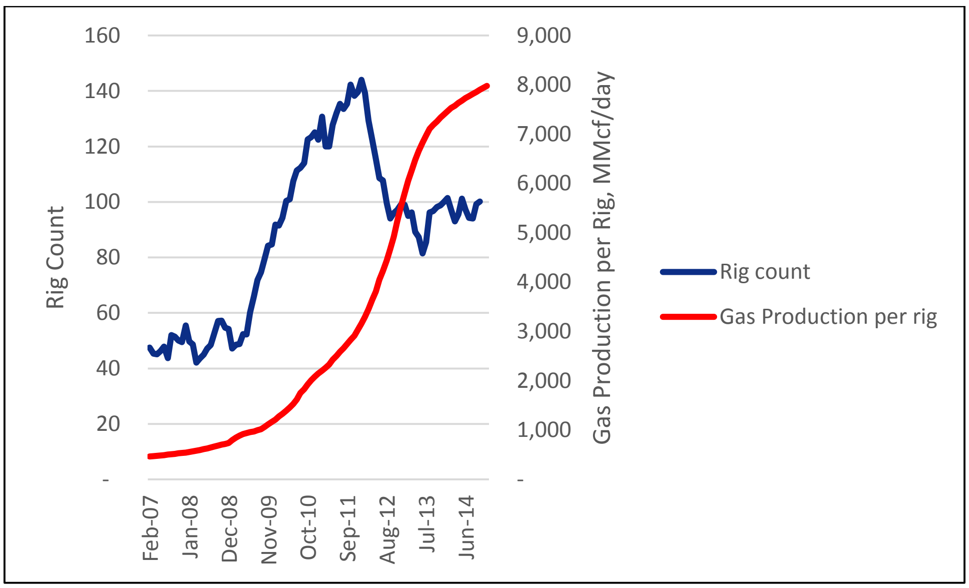
Since the AESC 2013 report was prepared and issued, EIA has expanded the data it provides that are related to the marginal cost of gas production from dry-gas prone and liquids-prone shale plays. In particular, data contained in EIA's new monthly publication, the Drilling Productivity Report (DPR), suggests considerable economies are evolving in production from each of these kinds of shale fields.

The DPR series was begun in October 2013 to address the paradox of rapidly rising gas production per well, and rising gas production overall, in the Marcellus despite a sharply falling rig count in 2011-2012.

Analysts of U.S. shale gas activities had long assumed that falling gas prices would result in a falling rig count, which would then, in turn, quickly reduce gas production. Fundamental reasons for accepting this sequence – and its reverse: rising prices lead to rising rig counts, which lead to more gas production – include the relatively small scale of individual shale well drilling operations and their steeply production decline rates on an individual basis. In addition, the speed with which rigs can be moved, deployed and removed have been a factor. But the key missing element in understanding why and how shale gas production could grow so rapidly has been the increase in rig productivity, i.e., production of gas per drilling rig, per unit of time, brought about by improved technology, tighter operating practices, and increased drilling efficiency.

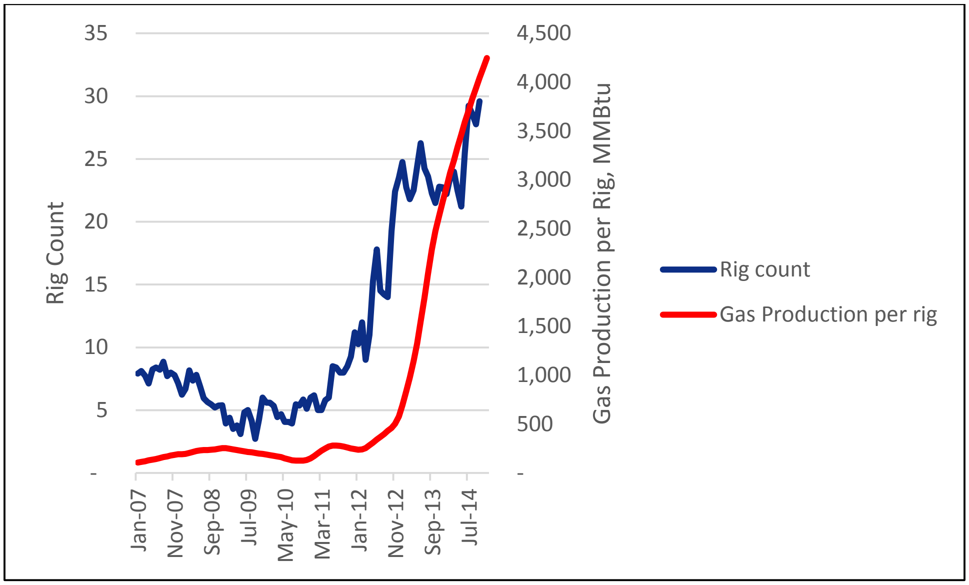
The dramatic growth in drilling productivity in the Marcellus and Utica regions, shown in Exhibit 2-16 and Exhibit 2-17, explains why production is rising despite the declining rig count.

Exhibit 2-16 Rig Count vs. Rig Productivity: Marcellus Shale



Source: EIA Drilling Productivity Report, November 2014.

Exhibit 2-17 Rig Count vs. Rig Productivity: Utica Shale



The increases in gas production shown in those two exhibits have been realized in other shale formations as well, and are echoed in rising oil production statistics as well as for gas. Unlike a "learning curve" in the usual sense, these advances are more a reflection of technological, management and operating improvements that have been tailored to each producing field.

Inclusion of rising rig productivity has been a major, necessary correction to U.S. gas price forecasts. In particular, we understand that the current version of EIA's NEMS model is taking the foregoing kinds of drilling productivity improvements into consideration in development of the AEO 2015 forecast. The NEMS Model contains an Oil & Gas Module, which is used to project gas production based on costs of developing resources in each U.S. gas-producing region. NEMS' Oil & Gas Module anticipates continued improvements in rig and program efficiencies as drilling moves beyond core areas in each shale field.

In its comprehensive documentation report, EIA summarizes its approach in the following general statement:

> The general methodology relies on a detailed economic analysis of potential projects in known crude oil and natural gas fields, enhanced oil recovery projects, developing natural gas plays, and undiscovered crude oil and natural gas resources. The projects that are economically viable are developed subject to the availability of resource development constraints which simulate the existing and expected infrastructure of the oil and gas industries. The economic production from the developed projects is aggregated to the regional and the national levels. (EIA 2011)

In its 2013 methodology update, which describes methodology underlying the AEO 2014 cases, the EIA indicates that the Oil & Gas Module contains production cost data in all categories, much like a group of natural gas supply curves. A gas supply curve refers to a price-quantity curve that contains the marginal cost of producing additional volumes of gas from that field or play covered in that curve. A gas supply curve in this manner is implicit in each of the 85 gas-producing fields listed in its AEO 2014 assumptions report, which includes ten subfields of the Marcellus, Utica, Devonian and other nearby shales. In each case, the EIA's estimate includes production costs for marginal wells throughout the entire unproved technically recoverable tight/shale oil and gas resources, by play. The EIA's gas supply methodology, therefore, embeds the costs of producing each component of the resource, sequenced by rising costs – starting with the low-cost core interior, through the next higher cost fields in the area, and on to the higher marginal cost portions, then the highest cost components.

As a consequence, therefore, there is no longer any reason to add or subtract any special factors to adjust EIA's forecasts for marginal well economics – these are embedded in EIA's supply analyses underpinning the AEO suite of forecasts, including each component of the Marcellus/Utica shales.

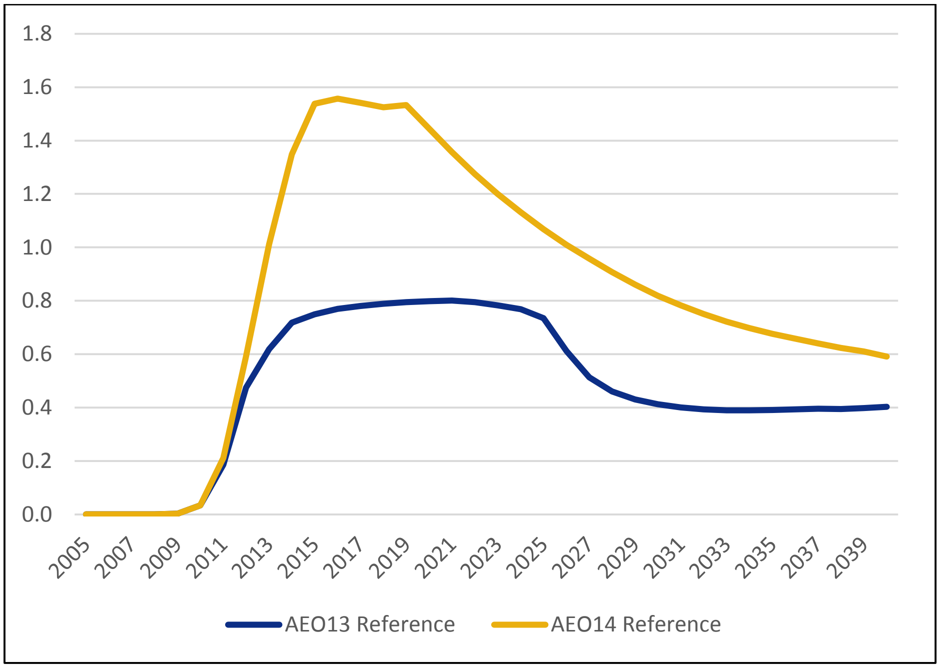
2.5.3 Inherent Limitations in AEO Reference Cases

Despite its widespread usefulness and acceptance, AEO Reference Case forecasts are necessarily bound to reflect law and regulations in effect at the time of the forecast.[24] In addition to assumptions about the economy, assumptions concerning technology and the extent of recoverable oil and gas resources in the Reference Case are consistent with understandings that are in existence or viewed as most likely, at the time the analysis is prepared, e.g., summer and autumn of each year for the following year's forecast. As discussed above, considerable uncertainties surround any energy forecast, let alone one produced amidst the aggressive pace of change taking place in the U.S. oil and gas industry in all respects. As a consequence, EIA's numerous sensitivity cases – particularly the High Oil and Gas Resource Case ("HRC") – take on particular significance.

[24] In the AEO 2014 Reference Case, real GDP grows at an average annual rate of 2.4% from 2012 to 2040. Crude oil prices are projected to rise to about $141/barrel (2012 dollars) in 2040. Note that the AESC 2015 forecast includes a downward adjustment to oil price projections in AEO 2014 Reference Case, as described in the accompanying section on fuel oil avoided cost assumptions, methodology and forecasts.

For example, contrast the analysis of tight oil production in the Eagle Ford by Dana Van Wagener (Wagener, EIA April 2014) with the most recent edition of EIA's Drilling Productivity Report shown in Exhibit 2-18. These differences demonstrate how difficult it is to project rising production and falling costs of shale resource development at a time of when both features – production volumes and production costs – are changing rapidly.

Exhibit 2-18. Eagle Ford Crude Oil Production in the Reference Case, 2005-40 (million bbl/day)



Source: Wagener, EIA April 2014; see preceding footnote.

As Wagener demonstrates (see Exhibit 4 2), the AEO 2013 Reference Case projected the Eagle Ford crude oil production would level off at less than 800,000 barrels per day for about a decade; then, the AEO 2014 Reference Case projected the Eagle Ford would level off at just over 1.5 million barrels per day. Timely EIA data indicate the Eagle Ford is currently producing 1.7 million barrels per day as of December 2014. Similar under-estimates of shale oil and gas production in EIA's reference cases are numerous – especially for gas production from the Marcellus/Utica shales.

The foregoing argues convincingly for caution in the use of the AESC 2015 forecast of avoided gas costs in New England because this forecast relies extensively on the AEO 2014 Reference Case.

2.5.4 Summary of Forecasting Issues in AESC 2015

The AESC 2015 Base Case and High Case forecasts rely on the AEO 2014 Reference Case (High Case is a 15% upward price adjustment from the AEO Reference Case),while the AESC 2015 low gas Case relies on the AEO 2014 High Oil & Gas Resource Case (HRC). Over the past several years the AEO HRC series have more closely tracked the pace of gas production increases in the recent past than have the Reference

Cases. AEO Reference Case forecasts prior to and including AEO 2014 have tended to underestimate production from shale gas and, in some cases, over-estimate wellhead prices from those plays.

Crude oil prices decreased by 50% in a matter of months during the second half of 2014. As described in Chapter 3), experienced analysts advise that prices may fall even lower amidst a gathering price war. But like prior price wars, peace is likely to 'break out' as most OPEC member budgets (and some non-OPEC budgets as well, e.g., the Russian Federation) strain to the breaking point, forcing cooperative action.[25] If domestic crude oil prices were to remain in the $60-$70 per barrel range for the next five years, drilling activity in some strongly crude-prone, high-cost plays may decrease markedly, e.g., the Bakken, Niobrara and Canadian oil sands regions, as these areas generally do not have the benefit of natural gas sales to help offset lower crude prices. Likewise, drilling in the liquids-rich Eagle Ford and Utica plays will not fall of as greatly because of their prolific gas production and excellent market access. Drilling in the Marcellus Shale may also be affected, but to a lesser extent, as the Marcellus is a dry gas play, thus it is not clear that low oil prices will have a material impact on production from that field.

With regard to LNG exports, AESC 2015 agrees with AESC 2013 assessment of the gas price impact of LNG exports. The only significant new study issued since then was EIA's report of October 2014,[26] which corroborates the conclusions in AESC 2013, namely, that the consumer price effects of LNG exports will be modest. But in any event, lower crude oil prices may reduce expected LNG exports from the U.S. because global natural gas prices are typically linked under long-term contracts to crude oil prices. This is the case in a number of likely receiving markets for LNG from the U.S., including Japan, South Korea, Central Europe, parts of Western Europe, and elsewhere. As global oil prices fall, therefore, global gas market prices beyond North America fall as well, and the economic margin tightens, reducing the gap between U.S. gas prices (plus liquefaction and shipping) and other gas prices internationally. Medlock, Hartley (Rice/Baker Institute) and others have argued that high costs of liquefaction and transportation of US gas to these markets would make some LNG exports uneconomic depending on how low world crude prices fall.27

2.6 Incremental Gas Production Costs Related to Compliance with Emerging Hydraulic Fracturing/Horizontal Drilling Regulations

Analysts have identified a number of potential sources of additional costs gas producers might incur in the future in order to comply with existing, impending or potential regulations governing hydraulic

[25] See, for example, Verleger (October 2014) and others in current discussions. Verleger sees little risk to the Marcellus as crude prices fall briefly, potentially to as low as $35 or $40 per barrel, but then recovery to the $60 to $70 range.

[26] EIA, "Effect of Increased Levels of Liquefied Natural Gas Exports on U.S. Energy Markets," October 29, 2014.

[27] See, for example, Kenneth B. Medlock, "A Discussion of US LNG Exports in an International Context," Center for Energy Studies, James A Baker III Institute for Public Policy Adjunct Professor, Department of Economics Rice University, January 11, 2013 presentation before the National Capital Area Chapter of the U.S. Association for Energy Economics.

fracturing/horizontal drilling.[28] These potential sources of additional costs primarily involve water and wastewater treatment and disposal regulations, regulations governing the handling and/or elimination of toxic materials, and the need to reduce greenhouse gas (GHG) emissions and the wellhead and in the gas pipeline and distribution grid. AESC 2015 assumes that the long-term AEO 2014 Reference Case gas market forecast adequately reflects these potential additional costs, for the reasons discussed below.

2.6.1 Water and Wastewater Treatment and Disposal

In most basins, gas-bearing shale seams are located far beneath groundwater basins, e.g., shale seams are at depths ranging from 6,000 to 12,000 feet, while groundwater basins are typically at bottom depths of no more than 2,000 or 2,500 feet. Non-porous bedrock separates the two layers, i.e., shale seams are below even deep groundwater aquifers, thus preventing material from one layer from mixing into the other. Sealed drill-pipes routinely traverse aquifers to avoid direct contact with groundwater, although occasional instances of groundwater contamination caused by ruptured drill-pipe have been reported. Moreover, naturally occurring fractures or fissures in the bedrock may inadvertently provide transport channels among strata. In relatively rare instances where transport through the bedrock has been available, fracking pressures were suspected of driving native hydrocarbons from shale seams up into groundwater aquifers.

During the early years of the shale revolution, reports of benzene and other drinking water contamination near shale gas fracking operations prompted environmental regulators to restrict shale-drilling operations in some locations until a better understanding of the processes at work could be gained. In one celebrated case, New York City's water supply, which is derived from aquifers beneath five counties in the eastern fringe of the Marcellus Basin and transported through tunnels in the bedrock, was deemed sufficiently threatened to necessitate suspension of shale gas drilling operations in all five counties, and ultimately throughout the State.

In response to these concerns, the US Environmental Protection Agency (EPA) commenced an in-depth analysis of the foregoing issues with the goal of determining if the agency needs to regulate shale gas drilling operations under the U.S. Safe Water Drinking Act. In one widely-reported instance, a driller in Wyoming (Encana) conducted hydraulic fracturing (herein, "fracking") operations into shallow shale seams located quite near the aquifer, with the predictable result that groundwater became

[28] The AESC 2013 Forecast added to its gas price forecast a "fracturing best practices upward adjustment" rising to $.54 per MMBtu by 2021 and remaining at that amount through the planning horizon. However, despite its useful review of literature available at the time, this report offered no source documenting any such estimate, apart from an unreferenced 2010 report by the consulting firm of Tudor, Pickering. Any such 4-5 year old estimate would necessarily predate the rise in shale gas production in the US, particularly in the somewhat more recent Marcellus or Utica basins, and could not comprehend drilling improvements and efficiencies since then.

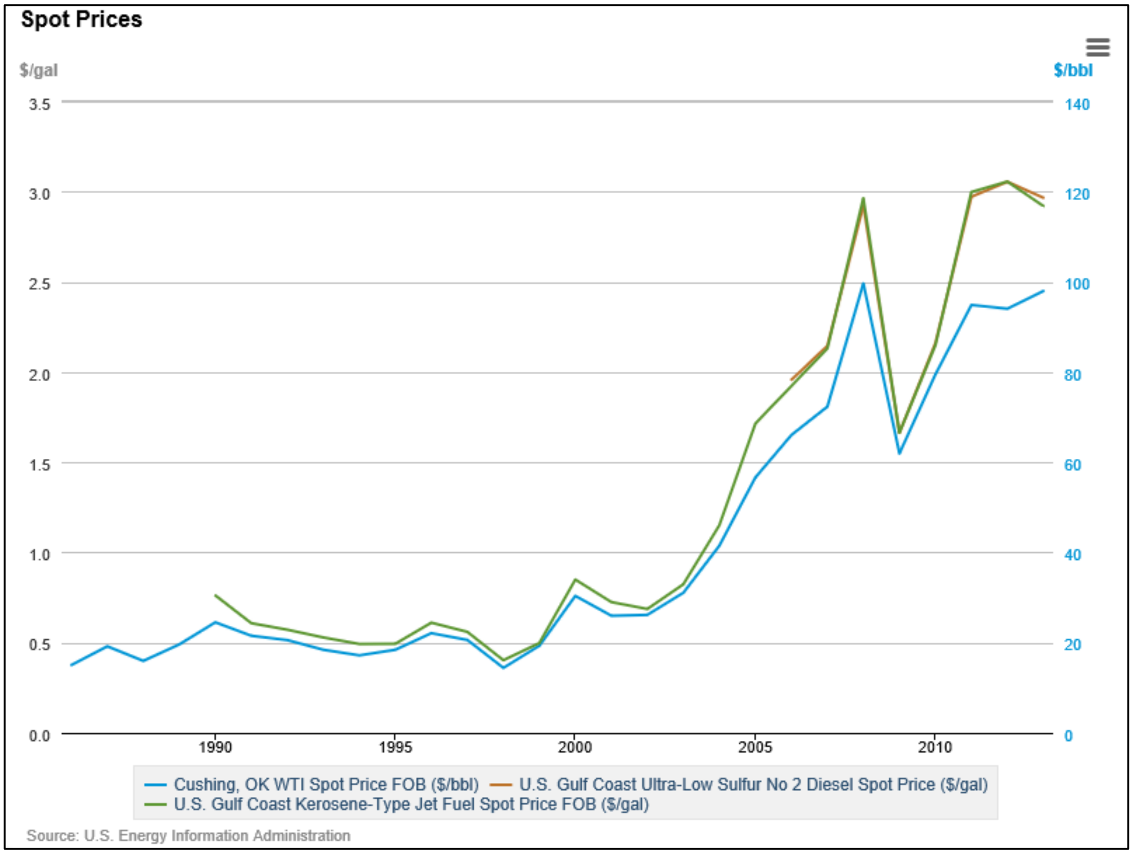
contaminated with materials contained in fracking waters and shale-borne substances. The EPA's report termed the incident exceptional.[29]

Fracking fluids consist largely of water and sand (as a propping agent), although some drillers also use a variety of other substances, including 1-2 percent concentrations of biocides, gels, and organic substances to improve performance. Some of the fluids injected into shale seams in fracking operations re-emerge in return water from wells under fairly high pressures ("flowback"). Flowback consists of much the same materials that went into the well, plus various other solids, hydrocarbons, and other materials resident within the shale seam. If not fully recycled, flowback is effectively an industrial effluent that must be treated and disposed of properly.

Before the price of liquids increased to very high values in 2011-2012 (as shown in Exhibit 2-19), flow-back in some drilling operations was handled in ways that contributed to wasting valuable liquid materials: some flow-back was spread on land away from aquifers to prevent leaching into groundwater, some was disposed of in adjacent waterways, and some was trucked off-site to public wastewater treatment plants for disposal to the extent of available capacity. The sheer volumes of flowback wastewaters, together with reported instances of impermissible wastewater disposal practices, excessive truck traffic, and the like, prompted regulators to examine shale gas operations more closely to ensure compliance with the U.S. Clean Water Act and other federal, state and local laws. More recently, as producers turned sharply to liquids-prone shale plays – particularly the Eagle Ford, Bakken, and others in relatively arid regions – they have been required to recycle flowback waters with greater frequency and intensity in order to maximize recovery of condensates, including benzene and other valuable liquids, and to use local water supplies more efficiently. In so doing, producers have also effectively minimized pathways to the groundwater associated with improper disposal of flowback wastewaters.

[29] Jim Martin, Region 8 Administrator, U.S. Environmental Protection Agency (EPA),before U.S. House of Representatives Committee on Science, Space, and Technology, Subcommittee on Energy and the Environment, Hearing on Ground Water Research at Pavillion, Wyoming, February 1, 2012, "It should be noted that fracturing in Pavillion is taking place in and below the drinking water aquifer and in close proximity to drinking water wells – production conditions different from those in many other areas of the country." (Martin testimony, page 4)

Exhibit 2-19. Crude Oil and Selected Petroleum Product Prices in Markets Adjacent to U.S. Southwestern Shale Regions



In summary, gas drilling operations have radically changed since the onset of the shale revolution, when many of the initial concerns surrounding "fracking" became voiced. Pennsylvania, Ohio, and other Marcellus/Utica states have tightened regulation, while gas prices have remained low all the while.

2.6.2 Methane Leakage

Methane, a greenhouse gas (GHG) that is the primary component of natural gas, is understood to be a far more powerful GHG than carbon dioxide, exceeding the strength of CO_2 in this respect by factors variously estimated to be 20-25 over a 100 year cycle.[30]

Overall, the present status of knowledge about natural gas and methane as a GHG was summarized in a working paper issued in 2013 by the World Resources Institute,[31] as follows:

[30] Steffen Jenner and Alberto J. Lamadrid, "Shale gas vs. coal: Policy implications from environmental impact comparisons of shale gas, conventional gas, and coal on air, water, and land in the United States," Energy Policy 53 (2013) 442-453.

[31] James Bradbury, Michael Obeiter, Laura Draucker, Wen Wang, and Amanda Stevens, "Clearing the Air: Reducing Upstream Greenhouse Gas Emissions from U.S. Natural Gas Systems," World Resources Institute, Working Paper, April 2013.

> 1. Fugitive methane emissions from natural gas systems represent a significant source of global warming pollution in the U.S. Reductions in methane emissions are urgently needed as part of the broader effort to slow the rate of global temperature rise.
>
> 2. Cutting methane leakage rates from natural gas systems to less than 1 percent of total production would ensure that the climate impacts of natural gas are lower than coal or diesel fuel over any time horizon. This goal can be achieved by reducing emissions by one-half to two-thirds below current levels through the widespread use of proven, cost-effective technologies.
>
> 3. Fugitive methane emissions occur at every stage of the natural gas life cycle; however, the total amount of leakage is unclear. More comprehensive and current direct emissions measurements are needed from this regionally diverse and rapidly expanding energy sector.
>
> 4. Recent standards from the Environmental Protection Agency (EPA) will substantially reduce leakage from natural gas systems, but to help slow the rate of global warming and improve air quality, further action by states and EPA should directly address fugitive methane from new and existing wells and equipment.
>
> 5. Federal rules building on existing Clean Air Act (CAA) authorities could provide an appropriate framework for reducing upstream methane emissions. This approach accounts for input by affected industries, while allowing flexibility for states to implement rules according to unique local circumstances. (Bradbury et al, 2013)

In response to increased gas drilling and a wide variety of methane emission estimates from numerous sources, the EPA issued on April 17, 2012, New Source Performance Standards (NSPS) governing GHG emissions from oil and gas drilling and producing activities. Under the rule, shale well drilling operations are required to use "reduced emissions" or "green completion" equipment to capture gas and condensate that comes up with hydraulic fracturing flowback, preventing their release into the air and making the valuable hydrocarbons available to the producer for sale. During a transition period that was scheduled to end on January 1, 2015, producers had the option to flare, although green well completions are preferred for multiple reasons.

- They provide the same reduction in Volatile organic compounds (VOCs) as flaring. But while flaring allows the emission of smog-forming nitrogen oxides, green well completions do not.
- By capturing a valuable resource rather than wasting it, green well completions make that resource available for sale or use by the producing company. According to the EPA, green well completions were already used on about 50 percent of wells at the time the draft rule was issued.

EPA estimates the total annualized engineering costs of the final NSPS will be $170 million. When estimated revenues from additional natural gas and condensate recovery are included, the annualized engineering costs of the final NSPS are estimated to be -$15 million, assuming a wellhead natural gas price of $4/thousand cubic feet (Mcf) and condensate price of $70/barrel (measured in 2008 dollars).[32] Industry sources also report a reduction in the cost of gas associated with green completions. In this respect, the WRI authors went on to conclude: "Fortunately, most strategies for reducing venting and leaks from U.S. natural gas systems are cost-effective, with payback periods of three years or less." (Bradbury et al, 2013).

In summary, recent EIA Annual Energy Outlooks take into consideration the relevant regulatory and other structural components needed to forecast avoided costs of gas in New England. In particular, the TCR team is unaware of any credible research or analysis published subsequent to AESC 2013 that supports its assumption that AEO forecasts are not accurately reflecting the cost of compliance with environmental and greenhouse gas regulations governing shale gas production. On the contrary, the EPA has projected positive economics associated with its requirement for green completions as a means of controlling and reducing GHG emissions from shale gas well drilling operations. In addition, actual gas production experience in 2013 and 2014 has been dispositive in this regard.

2.7 Uncertainty and Risk in Projecting Wholesale Gas Market Prices

As noted earlier, the major factors driving gas demand and supply, and hence wholesale gas market prices, include:

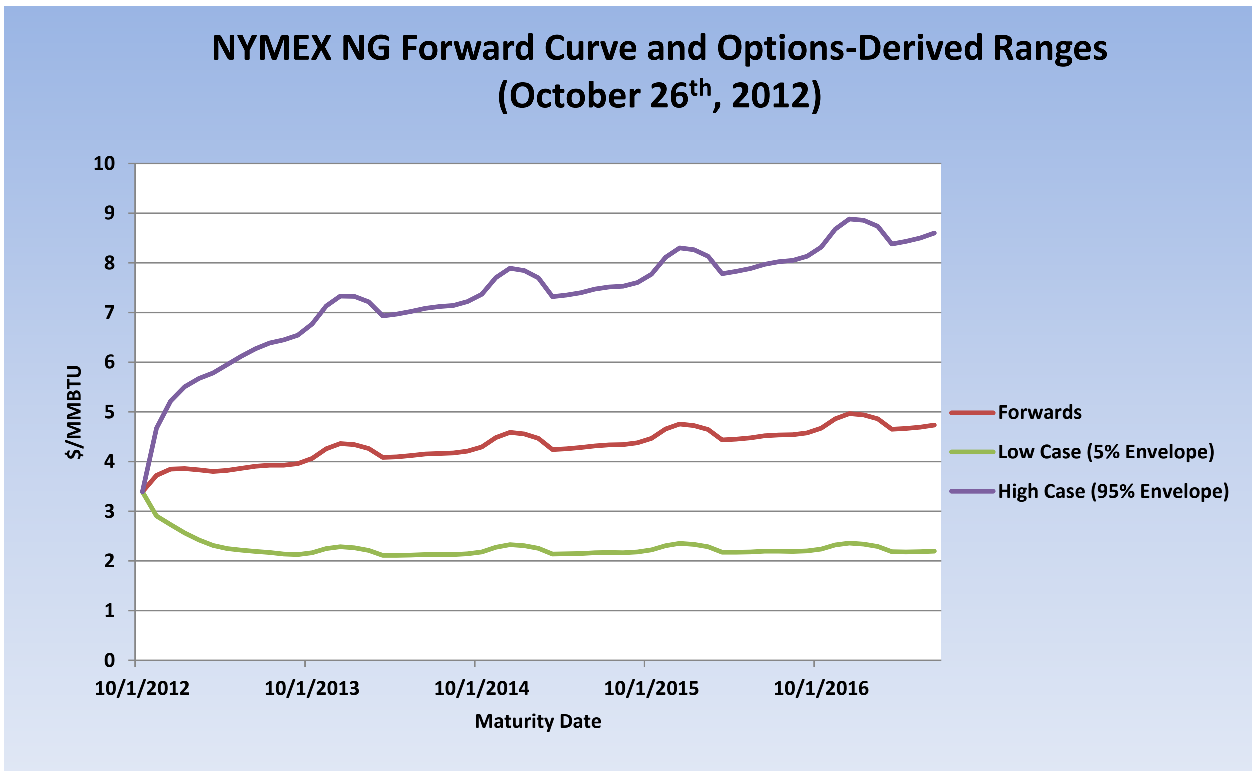
- Gas resources, reserves, production and the technologies that underlie each of these
- The availability of gas transportation via two million miles of gas pipelines and distribution mains in North America
- Regional, national and, increasingly, international economic activity
- Advances in technologies for gas production, transportation and use, e.g., notably in the past decade, respectively, horizontal drilling, advanced LNG systems, and high-efficiency gas-fired electricity generation using combined-cycle combustion turbines (CCGTs)
- Price elasticity of natural gas in each use and cross-elasticity with oil, electricity and other competing fuels
- Infrastructure expansion, including pipeline and storage capacity

[32] U.S. Environmental Protection Agency, Regulatory Impact Analysis, Final New Source Performance Standards and Amendments to the National Emissions Standards for Hazardous Air Pollutants for the Oil and Natural Gas Industry., Office of Air and Radiation, Office of Air Quality Planning and Standards, April 2012.

Variations in forecasts based upon those assumptions is inevitable due to the uncertainty associated with projecting future values of those driving factors.

Sensitivity analyses around the range of natural gas commodity economics is the best way to assess risks inherent in the forecast, and will be included in the AESC 2015 report. Stibolt (Galway Group, 2012) and other analysts comment widely on the risks in forecasting gas market prices, observing that the 90% confidence interval may be as high as the range of $3 to $8 per MMBtu.[33] While these levels of risk are prevalent in most energy forecasts over the past few decades, AESC 2015 captures the uncertainties by choice of High and Low Cases that are more closely articulated to actual market assumptions that the kind of wide range Stibolt (2012) and other have been able to compute from analysis of gas options market prices.

Exhibit 2-20. Range of Implied Risk in Natural Gas Prices



Source: Robert D. Stibolt, "Perspectives on World Natural Gas Markets," Galway Group, L.P., in presentation before the 31st USAEE/IAEE North American Conference, Austin, TX, November 6, 2012.

[33] Robert D. Stibolt, "Perspectives on World Natural Gas Markets," before the IAEE-USAEE Energy Conference, Austin, TX, November 2012. Analysis of implied volatility based on NYMEX natural gas option prices.

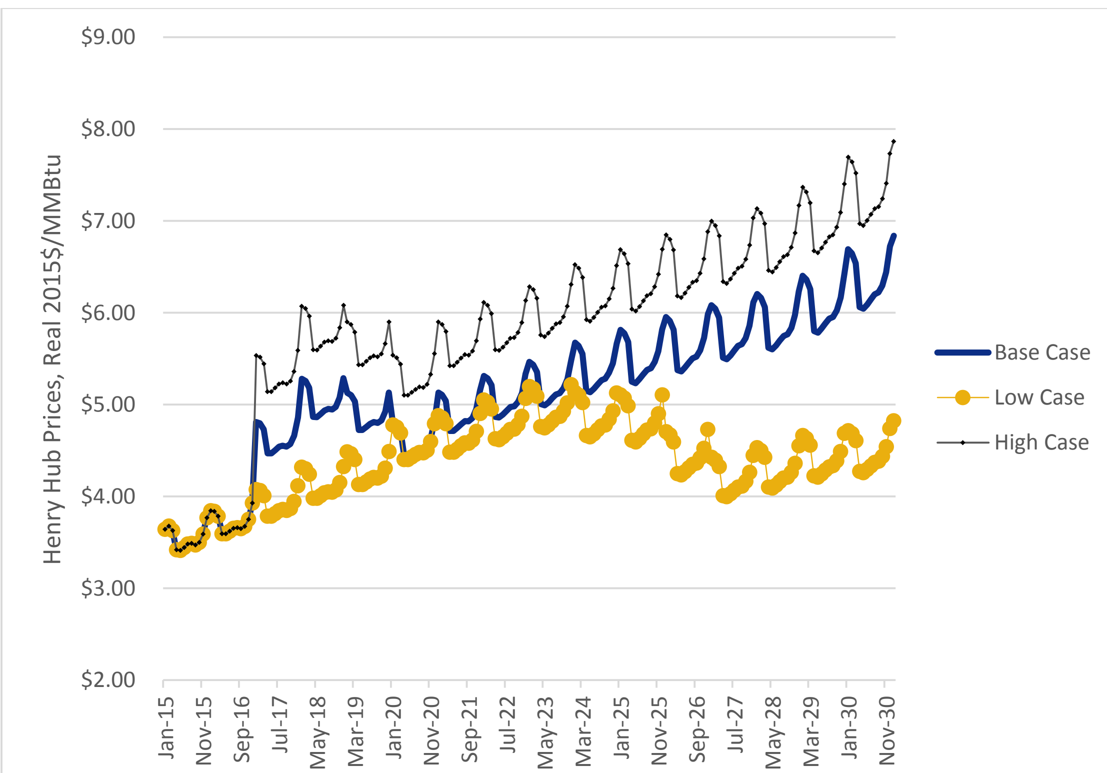
2.8 Gas Price Volatility and/or Uncertainty of Gas Prices

Volatility is a measure of the randomness of variations in prices over time as affected by short-term factors such as extreme temperatures, hurricanes, supply systems disruptions, etc. It is not a measure of the underlying trend in the price over the long-term. AESC 2015 forecasts of natural gas production prices under base, high, and low cases provide projections of expected average natural-gas prices in any month of any year. Actual gas prices are quite volatile and in any future month, week, or day may vary considerably around the expected annual average prices forecast in each of those three cases. Consistent with prior AESC studies, we do not forecast the actual monthly or weekly prices that would reflect historical price volatility primarily because we are forecasting prices used to evaluate avoided costs in the long term.

2.9 AESC 2015 Forecast of Gas Prices Henry Hub

The AESC 2015 forecast of gas prices at Henry Hub for the three cases shown in Exhibit 2-21 was developed as described below.

Exhibit 2-21. AESC 2014 Forecast of Monthly Henry Hub Gas Prices, 2015$/MMBtu



2.9.1 Base Case Forecast of Henry Hub Gas Prices

In developing the AESC 2015 Base Case Henry Hub price forecast, the TCR Team considered a number of available forecasts, as discussed above. The Base Case Henry Hub price forecast relies on the AEO 2014

Reference Case annual Henry Hub price forecast to 2031 and NYMEX monthly Henry Hub futures settlement prices to 2027 at December 18, 2014, as follows:

a. For the months from January 2015 to December 2016, AESC 2015 monthly Henry Hub prices equal NYMEX monthly Henry Hub futures, as above (converted to real 2015$).

b. For the months from January 2017 to January 2031, AESC 2015 equals AEO 2014 Reference Case annual Henry Hub price forecast, converted to real 2015$, and restated to monthly prices.

c. From January 2017 through December 2027, annual AEO 2014 Reference Case Henry Hub prices were converted to monthly prices using monthly variations in NYMEX Henry Hub futures prices throughout.

d. From January 2028 to January 2031, annual AEO 2014 Reference Case Henry Hub prices were converted to monthly prices using monthly variations in NYMEX Henry Hub futures prices during 2027.

e. For all remaining months to December 2045, Henry Hub prices are extrapolated from the above forecast for 2027-2030.

The foregoing procedure resulted in the AESC 2015 Base Case projection of monthly gas prices at Henry Hub from January 2015 through January 2031.

Comparison to other Forecasts of Annual Henry Hub Prices

Exhibit 2-22 compares the AESC 2015 Base Case projections of Henry Hub prices (i.e., the AEO 2014 Reference Case), with NYMEX as of December 18, 2014 and public forecasts from other sources reported in AEO 2014. The AESC 2015 Base Case forecast for 2025 is higher than the NYMEX value and the average of the public forecasts from AEO 2014.

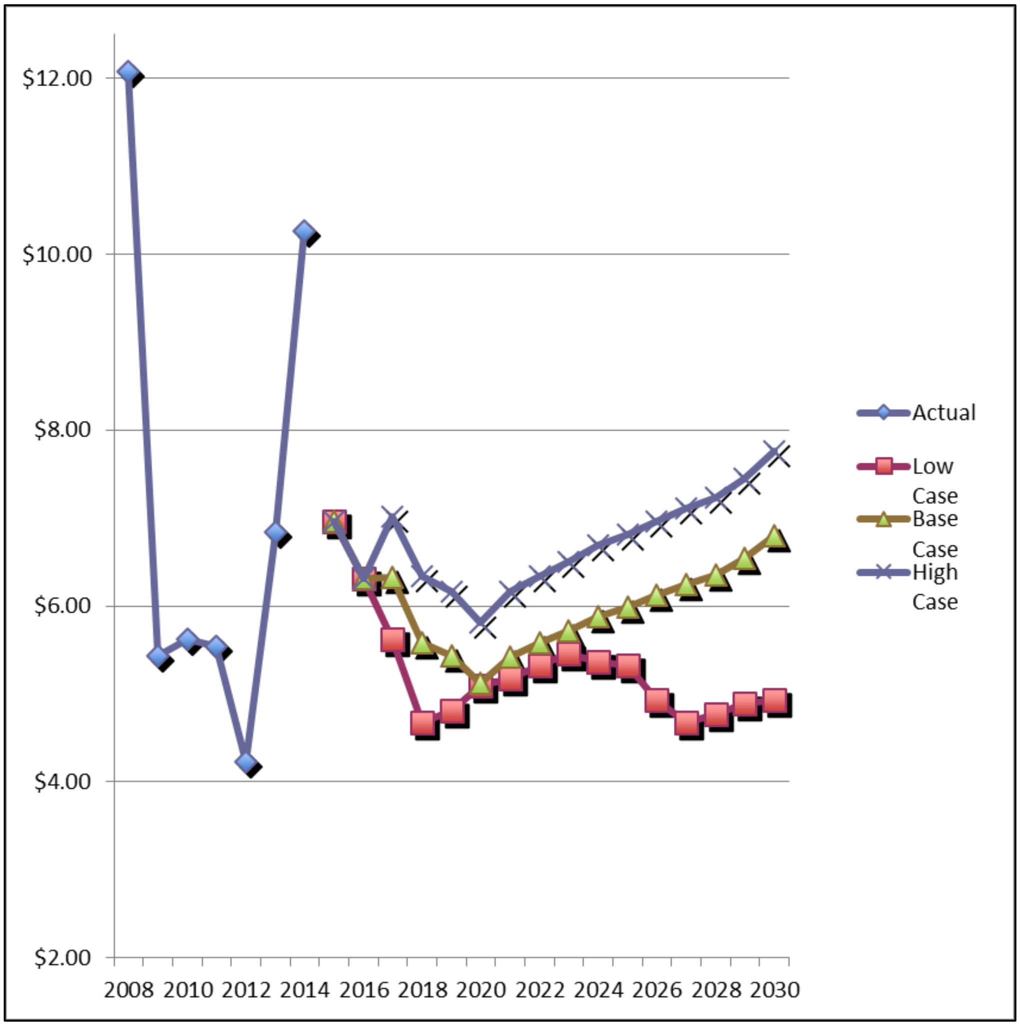
Exhibit 2-22. Comparison of Projections of Annual Henry Hub Prices (2015$/MMBtu)

		Henry Hub $2015/MMBtu		
		2015	**2025**	**2035**
NYMEX	NYMEX 12/18/2014	3.54	4.07	NA
Non-AEO Forecasts	IHSGI	NA	4.12	4.65
	EVA	NA	5.98	6.79
	ICF	NA	5.72	7.24
	BP	NA	0.00	0.00
		0.00	0.00	0.00
	Average Non-AEO Forecast	#DIV/0!	5.27	6.23
AEO	AEO 2014 Reference Case	3.93	5.50	7.27
AESC 2015	AESC 2015 Base Case	3.55	5.50	NA

2.9.2 Low and High Price Case Forecasts of Henry Hub Gas Prices

The AESC 2015 Low and High Cases reflect differing assumptions about the factors driving the national gas supply market. In the High Case, the AEO 2014 Reference Case Henry Hub gas price forecast is increased by 15%; in the Low Case, the AEO 2014 High Oil & Gas Resource (HRC) is substituted altogether for the Reference Case, and converted to monthly prices based on the same variations in NYMEX Henry Hub gas futures prices, as described above. Exhibit 2-23 compares all three AESC 2014 forecasts of avoided gas costs in New England, showing annual average prices.

Exhibit 2-23. AESC 2015 Avoided Gas Cost Forecasts - Base, High and Low Cases for Annual Wholesale Customers on Algonquin (2015$ per MMBtu)



The procedure employed to develop the AESC 2015 High Price Case forecast of monthly Henry Hub gas prices is identical to the foregoing, except we increase each of the forecast Henry Hub prices in the AEO 2014 Reference Case forecast by 15%. This level of increase is based on our judgment. It is less than the average 20% increase under the AEO 2014 Low Oil & Gas Resource Case because we believe the AEO

2014 Reference Case already is, if anything, on the high side. Thus, choosing a 15% increase for the AESC 2015 High Case is, in our judgment, a very high price case.

2.10 Wholesale Gas Costs in New England

AESC 2015 includes a forecast of the avoided wholesale cost of gas in New England based on an analysis of the market fundamentals expected to drive that cost over the study period. In addition to the projected cost of gas at Henry Hub, therefore, those fundamentals include the projected demand for gas in New England for electric generation and for retail end-uses, the projected quantity of imports of gas from Atlantic Canada and of LNG, production in the Marcellus/Utica shale regions, and the projected level of pipeline capacity that will be available to deliver gas from the Marcellus/Utica shales into New England throughout the planning horizon. (The projected demand for gas in New England for electric generation will be driven by numerous factors, including the long run projected price of fuel oil relative to the price of natural gas, and the level of financial penalties ISO-NE may impose on generating units which fail to meet their capacity performance obligations.)

Regional gas pricing in New England, and elsewhere east of the Mississippi is adapting to reflect the increasing role of Marcellus/Utica shale gas production, as described earlier in this chapter. In this section, we review the way wholesale natural gas market mechanisms operate in the U.S. as they affect New England, and then review basic assumptions about how they will function and what factors will drive gas prices going forward through the planning horizon of this report.

In essence, the way the gas market works is that competing suppliers and buyers in New England and elsewhere negotiate and establish gas prices for each day, or for the month ahead, at hubs in spot markets. They take into consideration information about hub prices, geography, service differentiation, weather, pipeline capacity availability, expected electricity and other gas demands, and other factors. As production and demand changes take place, the nexus of gas demand and supply can vary greatly from point to point throughout the gas pipeline grid over days, seasons, and decades. The flexibility and depth of hub-based spot markets has been, and will continue to be a significant enabling factor in the continued development and rise of shale gas production, which is often variable on a day-to-day basis.

In the following sections, we review assumptions about commercial mechanisms, price drivers, and pipeline capacity as they affect future avoided costs of gas to power plants and LDCs.

2.11 Factors Driving Wholesale Avoided Costs in New England

Forecasting avoided gas costs in New England necessarily involves determination of future prices of gas from the marginal source of gas production, pipeline rates to New England gas receipt points and basis to New England pricing points. Our assumptions concerning these elements are discussed in this section.

2.11.1 Pipeline Rates to New England

As discussed above, shippers on Algonquin, TGP and other pipelines pay for gas transportation services according to rate schedules contained in each pipeline's tariff. Pipeline rates are generally set on a cost of service basis and approved by the FERC (by state regulatory commissions and boards in the case of LDCs) following rate proceedings involving shippers and numerous other interested parties. Some pipelines have sought to charge market-based rates to their shippers, i.e., basis, but the FERC has to date not generally approved such formulations.

Rates paid for pipeline transportation services depend on the class of shipper:

- Firm shippers pay demand charges that are fixed, effectively pipeline capacity reservation charges, plus commodity and fuel charges that are variable, i.e., vary with the volume of gas that is shipped. Under current rate design principles, fixed charges recover nearly all the pipelines' costs of service.
- Non-firm (interruptible, general, and numerous other categories) pay variable charges only, although such rates are also designed to recover costs (i.e., they are greater than the variable charges paid by firm shippers).

Firm shippers on New England's gas pipelines include LDCs, and some electric power plants and gas marketing companies.

As in prior years' AESC reports, the AESC 2015 forecast assumes power plants bid into the New England pool based on the spot market value of gas, i.e., on the local spot price. During winter months, therefore, spot prices in New England are historically quite high as demand for house heating is at its highest and available pipeline capacity must be supplemented with gas in storage in the form of liquefied natural gas (LNG), with imported LNG, and propane-air, as discussed in earlier sections of this report. During other months, when pipeline capacity is available, high-cost LNG is not needed, demand is relatively low, and prices fall to levels just above supply hub prices, i.e., Marcellus/Utica regional hub prices plus pipeline fuel charges (typically only a few percent of supply region prices).

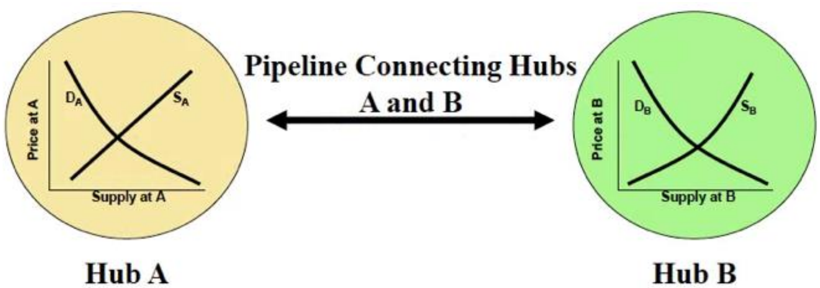
As a result of the foregoing, actual pipeline rates only partly or indirectly drive difference in market prices between gas supply regions and consuming regions. This point is key in New England, and is elaborated on below.

2.11.2 Gas Price Basis Differentials to New England

As discussed in section 3, liquid hubs are defined as those where trading volumes, numbers of participants, choices of supplies and demands, and market depth are all sufficient to establish fair commodity market prices that are set by the forces of supply and demand. Examples in the U.S. gas industry include Henry Hub, Texas Eastern M-3 (Tetco M-3), and many others including, in New England, Algonquin Citygates and Tennessee Zone 6 (Dracut). The defining characteristic of a gas hub (or pricing point) is the immediate or short-term availability of liquid markets, i.e., to the buyers, a number of alternative supplies and suppliers of natural gas, and, to the sellers, a number of alternative demands and buyers of gas. Hence, the forces of supply and demand are able to establish an immediate market clearing price at every point in time, or every day, depending on how much trading is conducted. Conditions for a successfully functioning hub include continual supply-demand imbalances, large and small, and the freedom for parties to transact at will to reconcile these imbalances. Thus, as pointed out above, there is always a buyer for gas supplies, and likewise, there is always a seller of gas – thus market clearing prices are able to establish on an economic basis (i.e., the price that balances supply and demand), even if such prices change from time to time in response to changing supply-demand balances and imbalances, even within a day's trading at major gas hubs.

Gas price basis differentials, sometimes shortened to "basis," refer to the difference between the price of gas at one liquid hub and another, each defined in the foregoing sense. As shown in Exhibit 2-24, illustrative hubs A and B are each liquid pricing points, in other words, the interaction of gas supply and demand at each hub (shown in the diagram as price-quantity curves at each hub) determine clearing prices in spot or short-term markets. This takes place independently of transportation rates on one or another pipeline, even a pipeline that may connect the two hubs.

Exhibit 2-24. Illustration of Basis Differentials in the U.S. Gas Industry



For example, in Exhibit 2-24, Hub A might be Texas Eastern Zone M-3 ("Tetco M-3") and Hub B might be Algonquin Citygates ("AGTCG"), both liquid gas hubs. The Algonquin pipeline's route of transportation connects Lambertville, NJ (within Tetco M-3) with a number of gas utilities in New England, whose receipt points are located at what are known as "city gates" for each LDC, i.e., points where Algonquin delivers gas to the LDC. Even though Algonquin's firm rate is approximately \$.23 per MMBtu to transport gas along its length from Lambertville to LDC city gates in New England, that does not force AGTCG versus Tetco M-3 basis to equal \$.23 because gas supply and demand are setting the instant price at each point. Sometimes basis is worth more than the pipeline's rate, e.g., in winter peaks, and sometimes it is worth less than the rate, e.g., in mild weather. Indeed, AGTCG-Tetco M-3 basis is rarely exactly (or even close to) Algonquin's filed rate.

It should be noted that most points of gas commerce are <u>not</u> actually located at hubs. For example, the meter of hundreds of gas-fired power plants, thousands of individual apartment complexes and large commercial establishment – these kinds of locations rarely would constitute hubs because they have no physical alternative source of gas supply. All their gas comes from one place, namely, the other side of the meter and typically, from only one vendor – thus none of the above hub-like supply-demand commercial mechanisms described above are possible.

Indeed, whole regions may fall into this category, if they are entirely dependent on the neighboring region for all or most of their gas supply. The entire six-state New England region was for many years in such a situation – all of its gas supplies crossed the New York State or Canadian border; New England was literally at the end of the line (the pipeline). Following completion of pipeline infrastructure from elsewhere – the Iroquois, M&NP, and Portland (PNGTS) pipelines, AGTCG finally became a pricing point, where supply and demand established the price of gas, and whose price became reported in trade press. At that point, New England basis became a relevant commodity – i.e., the price of gas at AGTCG minus, for example, Henry Hub. Until then, gas prices in New England were set by an outside liquid hub, e.g., Henry Hub, Transco Zone 6 New York, or AECO in Alberta, and then buyers would directly add on the pipeline's or pipelines' transportation rates, much as the price of gas supplied to a university or office building in Houston equals the nearby liquid hub price, plus the LDC's distribution rate.

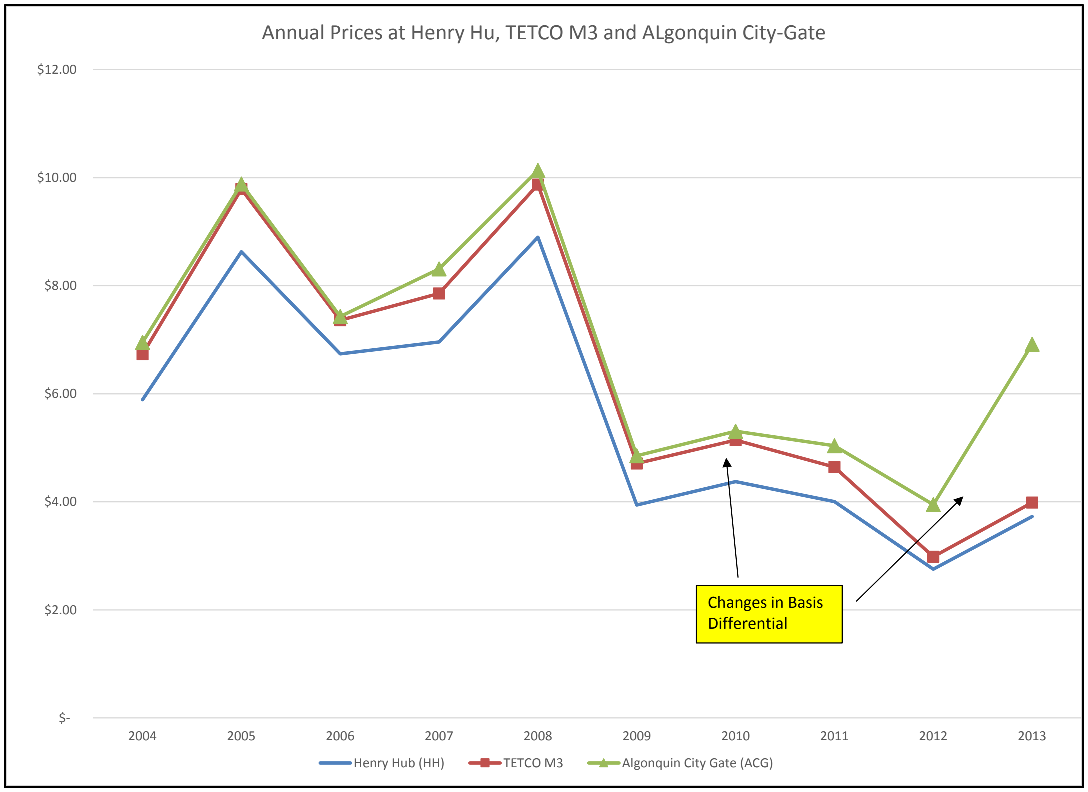
The point is that sometimes and for some buyers in New England, New England basis sets the price of gas locally, and sometimes it does not – therefore, basis is important to understand and forecast, as well as pipeline rates.

More recently, a major question in forecasting gas markets in New England is: relative to which hub, representing which producing region, should basis in New England be measured? We expect production from Marcellus/Utica will drive gas supply costs in New England, but it is not clear which Marcellus/Utica hub will be most prominent in setting gas prices in New England. There are presently several gas hubs and pricing points in the Marcellus/Utica region, including Tetco M-3, which is highly liquid, as well as Leidy (on the Transco Pipeline), Dominion South Point, and others. Only a thorough study of liquidity, outside the scope of this report, and time, will determine if another hub as prominent as Henry Hub is likely to emerge, and which one it will be.[34]

The change in basis between average annual wholesale prices in New England, the Marcellus/Utica area, and Henry Hub over the past 10 years is illustrated in **Exhibit** 2-25. Wholesale prices in New England are represented by the Algonquin city-gate in the exhibit, while the annual average price of gas from the Marcellus/Utica shale region is represented by the Tetco M-3 hub. From 2004 through 2010, basis between New England and Henry Hub and Tetco M-3 and Henry Hub were each quite stable, at approximately $0.88 and $1.08 on average respectively. Since 2011 prices those basis differentials have changed, with Tetco M-3 prices declining more than Henry Hub prices and prices in New England increasing.

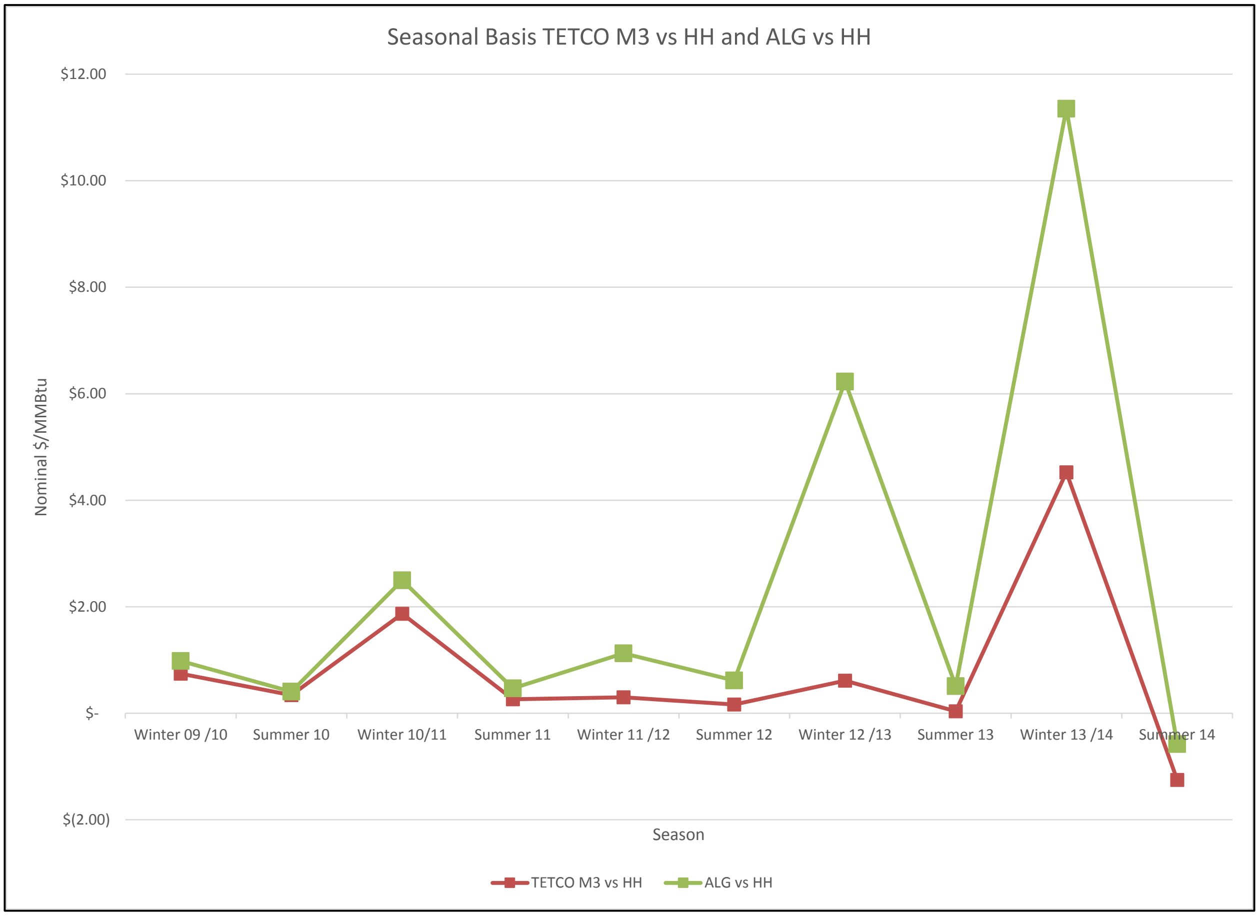
[34] Henry Hub was largely unheard of outside the local industry, and gas prices there were neither surveyed nor reported by gas trade press until 1989, just after NYMEX announced in its CFTC filing that Henry Hub was selected as the point of physical deliveries in its forthcoming gas futures contract.

Exhibit 2-25. Annual Average Prices, Henry Hub, TETCO M3 and Algonquin City Gate, 2004 – 2013 ($/MMBtu)



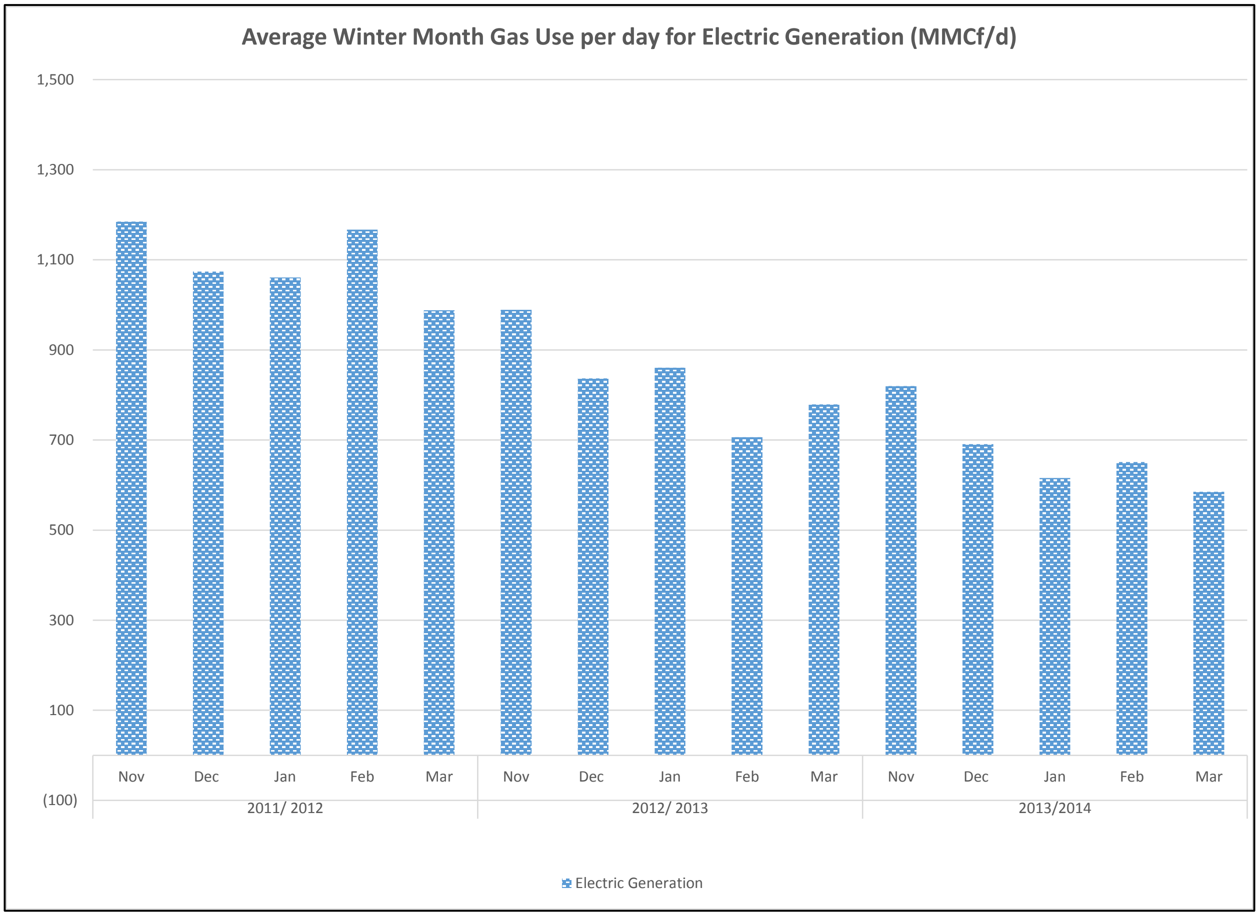
These recent changes in basis are more evident, and dramatic, when viewed by season. Those differentials, plotted in Exhibit 2-26, illustrate the "basis blowouts" which New England experienced in the winters of 2012/2013 and 2013/2014.

Exhibit 2-26. Seasonal Basis to HH



The "basis blowouts" which New England experienced in the winters of 2012/2013 and 2013/2014 do not appear to be caused by a dramatic increase in gas use for electric generation in those two winters relative to prior winters. As indicated in Exhibit 2-27, gas use for electric generation in the winter months of November through March in those two winters was less than in the winter of 2011/2012, when there was no basis blow out. Instead, as discussed earlier, the basis blowout in the past two winters appears to have been driven by the sharp decline in gas deliveries into eastern New England and the corresponding dramatic increase in the supply that had to be delivered into western New England from Marcellus/Utica and other producing areas west of New England.

Exhibit 2-27. Average Gas Use per Day for Electric Generation in Winter Months (MMcf/day)



2.12 Pipeline Capacity Delivering Gas to, and in, New England

One of the major factors driving the basis differential between wholesale gas prices at market hubs in New England and the Marcellus/Utica is the lack of adequate pipeline capacity to deliver gas from producing areas into New England in winter months. In order to develop the AESC 2015 forecast of basis in New England over the study period, we reviewed the projects proposing to add pipeline capacity between the Marcellus/Utica region and New England, as well as to add pipeline capacity within New England.

At the present time, there are five gas pipeline systems that deliver gas into New England. These are listed in Exhibit 2-28 together with their firm contracted capacities serving New England.

Exhibit 2-28. Existing Gas Pipelines in New England, November 2014

Pipeline System	Firm Contracted Capacity Serving New England (Bcf/d)	Enters New England From:	Major Upstream Gas Supplies
Pipelines primarily receiving gas in western New England			
Algonquin	1.1	New York State	Marcellus/Utica
Kinder Morgan/Tennessee (TGP)	1.3	New York State	Marcellus/Utica, U.S. Southeast
Iroquois Gas Transmission	0.2	New York State	Western Canadian Sedimentary Basin (WCSB), Marcellus/Utica
Sub-total	**2.6**		
Pipelines primarily receiving gas in eastern New England			
Maritime & Northeast Pipeline (M&NP)	0.9	New Brunswick, Canada	Sable Island, Canaport LNG import terminal
Portland Natural Gas Transmission System (PNGTS)	0.2	Quebec (P.Q.), Canada	Western Canadian Sedimentary Basin (WCSB); Marcellus/Utica
Sub-total	**1.1**		
Total	**3.7**		

Source: ICF, "Assessment of New England's Natural Gas Pipeline Capacity to Satisfy Short and Near-Term Electric Generation Needs: Phase II"," ISO New England, December 16, 2013, Exhibit 2-3, pg. 12.

The total capacity of the existing gas pipelines serving New England is approximately 3.7 Bcf/day, as seen in Exhibit 2-28. (Note that this total does not include the aggregate 2.2 Bcf/d capacity of the Distrigas LNG terminal plus gas utility peak shaving facilities.[35]). Of that total, approximately 2.6 Bcf/day of pipeline capacity is available to deliver gas received from west of New England. In contrast, maximum average gas use per day in January and February for both residential, commercial and industrial load and electric generation has been approximately 3.3 Bcf/day. Thus, if the region wanted the ability to acquire all of its maximum winter month average daily supply from west of New England, it would need another 0.5 Bcf/day of capacity delivering into western New England. (Note emphasis, because maximum gas use per day is much higher when based on gas utility "design day" requirements and electric industry peak winter day demand.) [36]

2.12.1 Proposed Gas Pipeline Expansions in New England

Numerous pipeline capacity expansions have been proposed to deliver added gas supplies to LDCs and power plants in New England. These are listed in Exhibit 2-29. The total pipeline infrastructure that would be added in New England for all of these proposed projects, if completed, would be within the range of 2.3 Bcf/day to 5.4 Bcf/day.

[35] ICF, "Assessment of New England's Natural Gas Pipeline Capacity to Satisfy Short and Near-Term Electric Generation Needs: Phase II"," ISO New England, December 16, 2013, Exhibit 2-3, pg. 12.

[36] Ibid., Exhibit 2-5, page 14

Exhibit 2-29. Proposed Gas Pipeline Capacity Expansions To, and Within, New England

Pipelines primarily receiving gas in western New England				
Project	**Capacity, Bcf/day**	**Planned in-service**	**Status as of December 2014**	**Shippers**
Tennessee – Connecticut Expansion	0.072	16-Nov	Precedent Agreements executed; FERC filing anticipated by EOY 2014.	Connecticut Natural Gas; Southern Connecticut Gas, Yankee Gas
Algonquin Incremental Market ("AIM")	0.342	16-Nov	FERC Filing in February 2014; Draft EIA issued on 8/8/14.	LDC affiliates of UIL, NU, National Grid, Nisource; Cities of Norwich and Middleborough, MA
PNGTS – Continent-to-Coast ("C2C")	0.165	16-Nov	Open Season closed 1/2014, since extended due to uncertainty over availability of upstream capacity.	None announced to date
Spectra – Atlantic Bridge	0.100 to 0.600	17-Nov	In negotiations	Unitil Corp.
Spectra & Northern Utilities – Access Northeast	1	18-Nov	Announced 9/14. Solicitation of interest held fall 2014	None announced to date
Kinder Morgan/Tennessee – Northeast Energy Direct	0.600 to 2.200	18-Nov	Precedent Agreements executed for 0.5 Bcf/day, others In negotiation; Pre-Filed to the FERC in July 2014.	Various New England LDCs (approx. 500 MMcf/day as of 11/2014)

Source: New England Gas Association (NEGA, November 2014).

In addition to the projects listed in Exhibit 2-29, and in some cases to support their operations, gas pipeline capacity upstream (to the west) of New England must be increased (NEGA, 2014). For example, Cabot Oil & Gas and Williams are developing the 120-mile Constitution Pipeline, to extend from Susquehanna County, PA, to the IGTS and TGP systems in Schoharie County, N.Y. The sponsors of that pipeline plan to have it in operation for the 2015-2016 winter (proposed capacity is 650 MMcf/day, and Cabot and Southwestern Energy are announced shippers). The Constitution Pipeline could help serve gas demands in New England, New York, and Central Canada. This and other proposed "upstream" pipeline projects are listed in Exhibit 2-30.

Exhibit 2-30. Proposed New Pipeline Capacity Upstream of New England

Project	Capacity, Bcf/day	Planned in-service	Status as of December 2014	Shippers
Cabot/Williams Constitution Pipeline	0.65	Late 2015	Authorized by FERC 12/2/14	Extend from Susquehanna County, PA to the Iroquois Gas and Tennessee Gas pipeline systems in Schoharie, N.Y.
Iroquois Gas - Wright Interconnect Project (WIP)	0.65	2015	Authorized by FERC 12/2/14	Enable delivery of 0.65Bcf/d from Constitution Pipeline into Iroquois and Tennessee.
Tennessee - Niagara Expansion	0.158	Nov. 2015	Filed with FERC Feb. 2014	Designed to provide transportation from Marcellus Shale to TGP's interconnect with TCPL in Niagara, N.Y.
Iroquois Gas - South-to-North Project	0.3	Nov. 2016	Open season Dec. 2013 – Jan. 2014	Reverse flow on Iroquois from Iroquois' existing interconnects with Dominion Transmission in Canajoharie, NY and Algonquin Gas Transmission in Brookfield, CT, as well as the proposed Constitution Pipeline in Wright, NY.

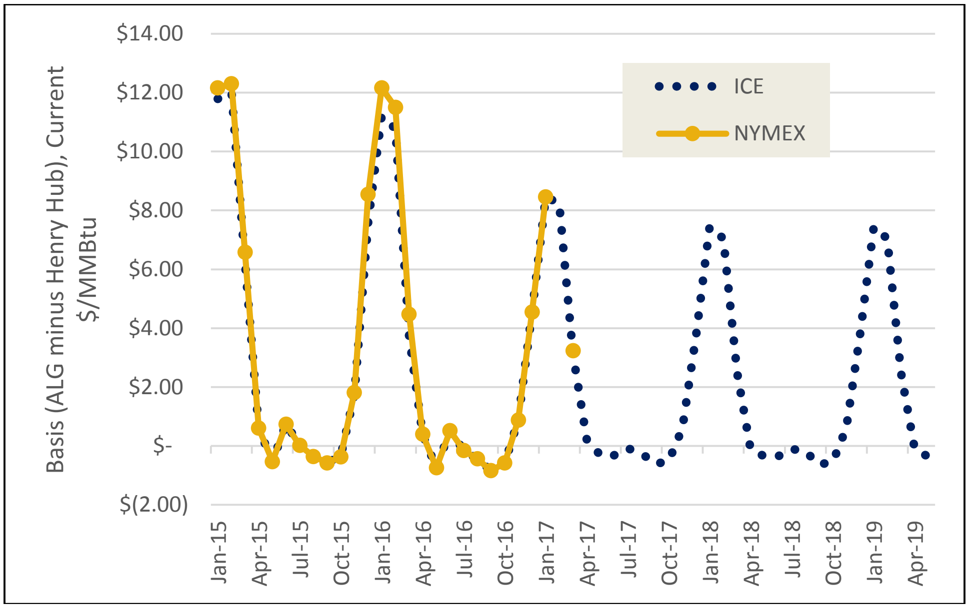
2.12.2 Projection of Basis Differentials to New England.

AESC 2015 projected the basis between Algonquin Citygates and Henry Hub ("ALG HH basis") using different methods for three different segments of the study period. Those three segments are January 2015 through October 2017, November 2017 through October 2019, and November 2019 onward.

January 2015 through October 2017

AESC 2015 projected ALG-HH basis through October 17 based on an average of NYMEX and ICE basis futures as of December 15, 2014 presented in Exhibit 2-31. Small differences between settlement prices for ALG-HH basis on each exchange indicate some liquidity exists in these contracts. The marked rise in ALG-HH basis futures during winter months is consistent with past behavior, but not necessarily a valid forecast. AESC 2015 relied on these futures for the near-term months when trading volumes are the highest. Basis futures, like any futures, represent the market for a commodity (ALG-HH basis in this case), i.e., the nexus of traders' views on this value. The decrease in winter basis spikes (less intensive "blow-outs" starting Winter 2016-2017) suggests that the market is anticipating some degree of future gas pipeline construction into the New England region. For hub pricing purposes, deliveries to PNGTS and Vermont Gas are equated to TGP based on current market directions.

Exhibit 2-31. Algonquin Citygates Basis Futures, ICE and NYMEX, $/MMBtu Relative to Henry Hub



November 2017 through October 2019

AESC 2015 basis projections for the period November 2017 through October 2019 assume that additional pipeline capacity will be added to serve the New England market in November 2017 and November 2018 respectively:[37] The assumed capacity additions are the Tennessee-Connecticut Expansion, the Algonquin Incremental Market (AIM) expansion, and the portion of the Kinder Morgan/Tennessee Northeast Energy Direct expansion to which LDCs have agreed to subscribe and are likely to subscribe, in our judgment. Thus, AESC 2015 anticipates that proposed pipeline expansions for which shippers have entered into binding precedent agreements will be built, plus about 10 percent. In all, as indicated in Exhibit 2-32, AESC 2015 assumes that approximately 1 Bcf/day of new pipeline capacity will enter service in New England during this period.

[37] *Source: Exhibit 4-6 in Task 2A Gas Assumptions, 12-15-2014 v2).*

Exhibit 2-32. Anticipated Gas Pipeline Capacity Expansions to New England

Project	Capacity, MMcf/day	Rationale
Tennessee-Connecticut Expansion	72	Subscribed.
Algonquin Incremental Market (AIM)	342	Subscribed.
Kinder Morgan/Tennessee – Northeast Energy Direct	600	500,000 MMBtu per day of the offered capacity range has been subscribed; an additional volume of at least 100,000 MMBtu per day of subscription is anticipated.
Other capacity		As economical (see below)
Total	Approx. 1,000	Approx. total subscribed.

AESC 2015 projects that the addition of approximately 1 Bcf/day of pipeline capacity will reduce New England basis in peak months significantly, indeed, to 30% below the ALG-HH basis levels anticipated by traders as reflected in futures prices for this period, as of December 14, 2014 (which were shown in Exhibit 2-31).

After November 2017, when we assume the AIM and Tennessee Connecticut Expansion together add 0.4 Bcf/day, AESC 2015 projects a 46% drop in peak month basis relative to the 2016/2017 winter. After November 2018, when we assume the Northeast Energy Direct project or its equivalent adds another 0.6 Bcf/day in November 2018, AESC 2015 projects peak winter month basis to drop by another 44%. These capacity additions are not expected to have nearly as great an impact on basis in off-peak months. In all, AESC 2015 assumes the capacity additions, shown in Exhibit 2-32, will restore New England winter basis to levels more consistent with earlier, pre-blow-out winters.

AESC 2015 projects Tennessee Zone 6 HH basis to be slightly lower than ALG HH basis and Iroquois HH basis to be lower than Tennessee's. These projections are supported by basis data[38] and by the fact that the Tennessee and Iroquois pipelines each receive Marcellus/Utica gas along a more direct and less costly route than the Texas Eastern-Algonquin combination. In addition, Iroquois predominantly serves the more competitive New York Metropolitan area, thus will not sustain the higher basis levels characteristic of Algonquin.

AESC 2015 assumes that gas utilities will use most, if not all, of the additional pipeline capacity available to them to meet load growth on their systems, thereby not increasing the ability of gas fired generators

[38] Platts IFGMR monthly Market Center Spot Gas Prices.

to acquire gas from Marcellus/Utica during winter months. In particular, we reasonably anticipate that, once gas utilities in MA, CT and ME acquire additional capacity they will “build out” their systems in order to grow their load by adding more customers because they have indicated their intent to do so by entering into binding Precedent Agreements for new pipeline capacity.

AESC 2015 is projecting the addition of 1 Bcf/day of pipeline capacity will reduce basis in peak months based on its assumption gas fired generators will be able to use a portion of that additional pipeline capacity for several years. That assumption, in turn, rests upon an assumption that it will take several years before growth in retail gas use will require New England gas utilities to use one hundred percent of their entitlements to this additional capacity. The latter assumption rests on the following high-level comparison of projected average peak winter month demand in New England, excluding VT,[39] and projected capacity able to deliver gas from Marcellus/Utica during winter months. We prepared that comparison based on the following:

An estimate the capacity available to deliver gas from Marcellus into New England each year from 2011 through 2023. This estimate assumes that by 2015 Marcellus Gas will be able to flow into the PNGTS system from TCPL. (See for example, December 2014 report by Navigant for Ontario that discusses increasing supply of Marcellus gas flowing into Ontario and then eastward on the TCPL system). We focus on capacity available to deliver gas from Marcellus into New England because of the dramatic decline in supply from LNG imports to New England and from production from eastern Canada delivered via MN&P.

Compare that estimate to projected load under two different Growth Cases, the AEO 2014 Reference Case forecast for New England and a higher growth case based on public projections from CT[40] and ME respectively.

Calculate average gas use/day by gas utilities and by electric generators in the peak winter months of December, January and February for the winter of 2011/2012. We use 2011/2012 data because those months had close to normal Heating Degree Days per data for the NGRID system.

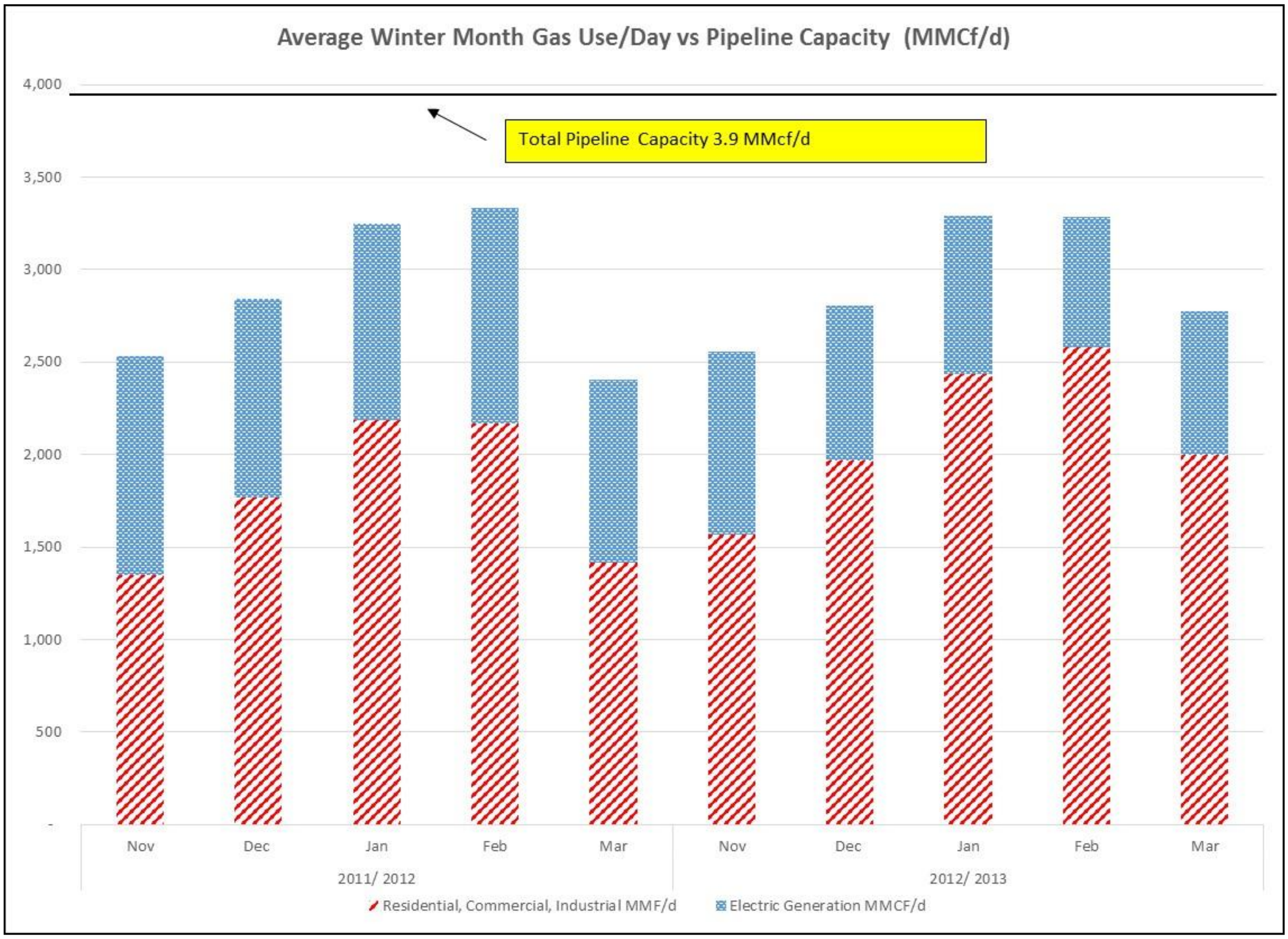
a. Project average gas use/day by gas utilities and by electric generators in the peak winter months for each of the two load growth cases. The projection assumes average gas use/day in those 3 months growths at the same rate as annual gas use.
b. Compare the average gas use /day to the estimate of capacity available to deliver gas from Marcellus into New England each year.

[39] VT is excluded because it is not connected to the rest of the New England pipeline grid. It acquires all of its supply via TCPL.

[40] Connecticut’s Gas Local Distribution Companies Joint Natural Gas Infrastructure Expansion Plan, June 14, 2013. http://www.dpuc.state.ct.us/DEEPEnergy.nsf/c6c6d525f7cdd1168525797d0047c5bf/4539e0715c01bd9a85257b8d005af2a/$FILE/Gas%20Expansion%20Plan%20vFINAL.pdf

As discussed earlier, and indicated in Exhibit 2-33, the spikes in basis in the winter of 2012/2013 was not due to insufficient total pipeline capacity serving New England. Instead, it was due to insufficient pipeline capacity able to deliver gas from west of New England.

Exhibit 2-33. Average Winter Month Gas use per Day vs. Pipeline Capacity



Our comparisons, presented in Exhibit 2-34 and Exhibit 2-35 indicate that under either load growth projection it does not appear that gas utilities will use 100% of the additional new pipeline capacity capable of delivering gas from west of New England on average during the three peak winter months for many years. Instead, it appears that a significant portion of the additional new capacity will be available to deliver gas for electric generation.

Exhibit 2-34. AEO 2014 Reference Case Load Forecast

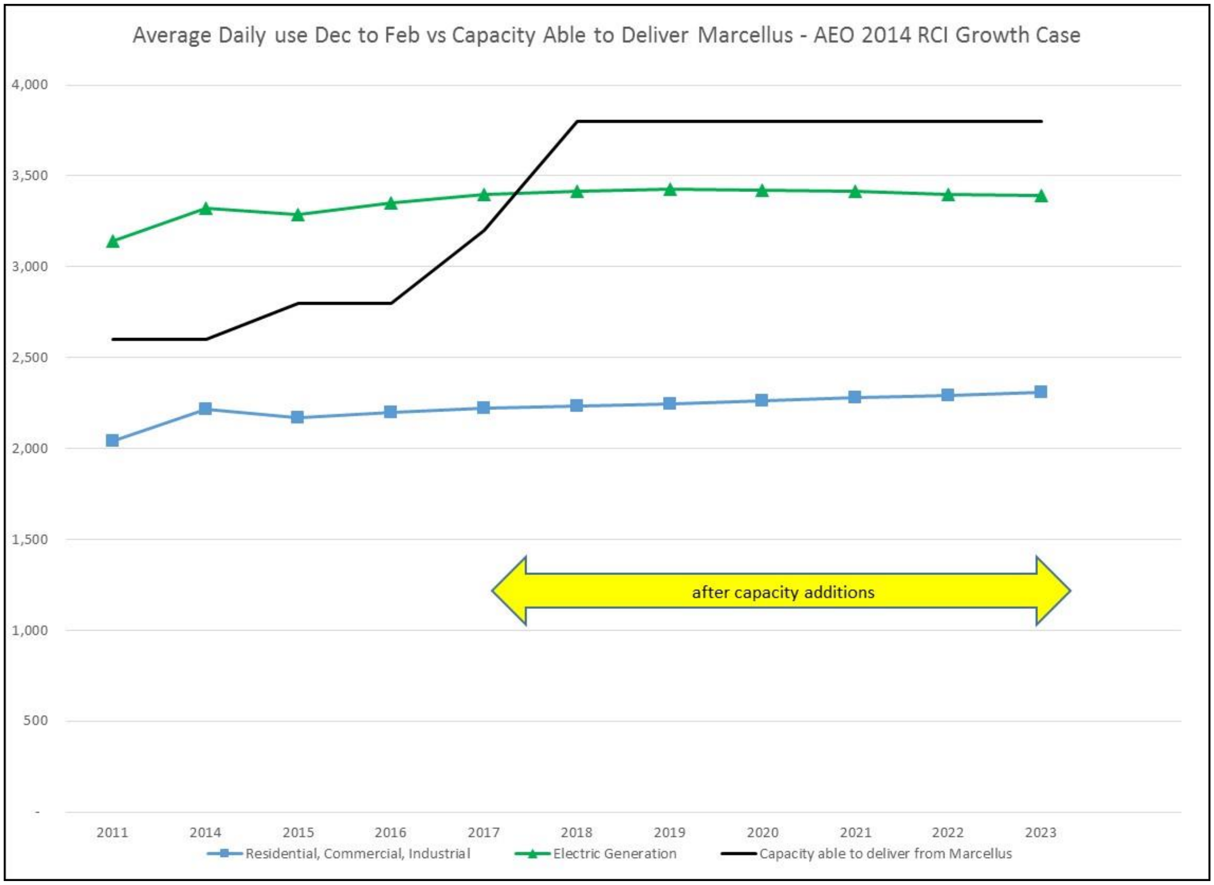
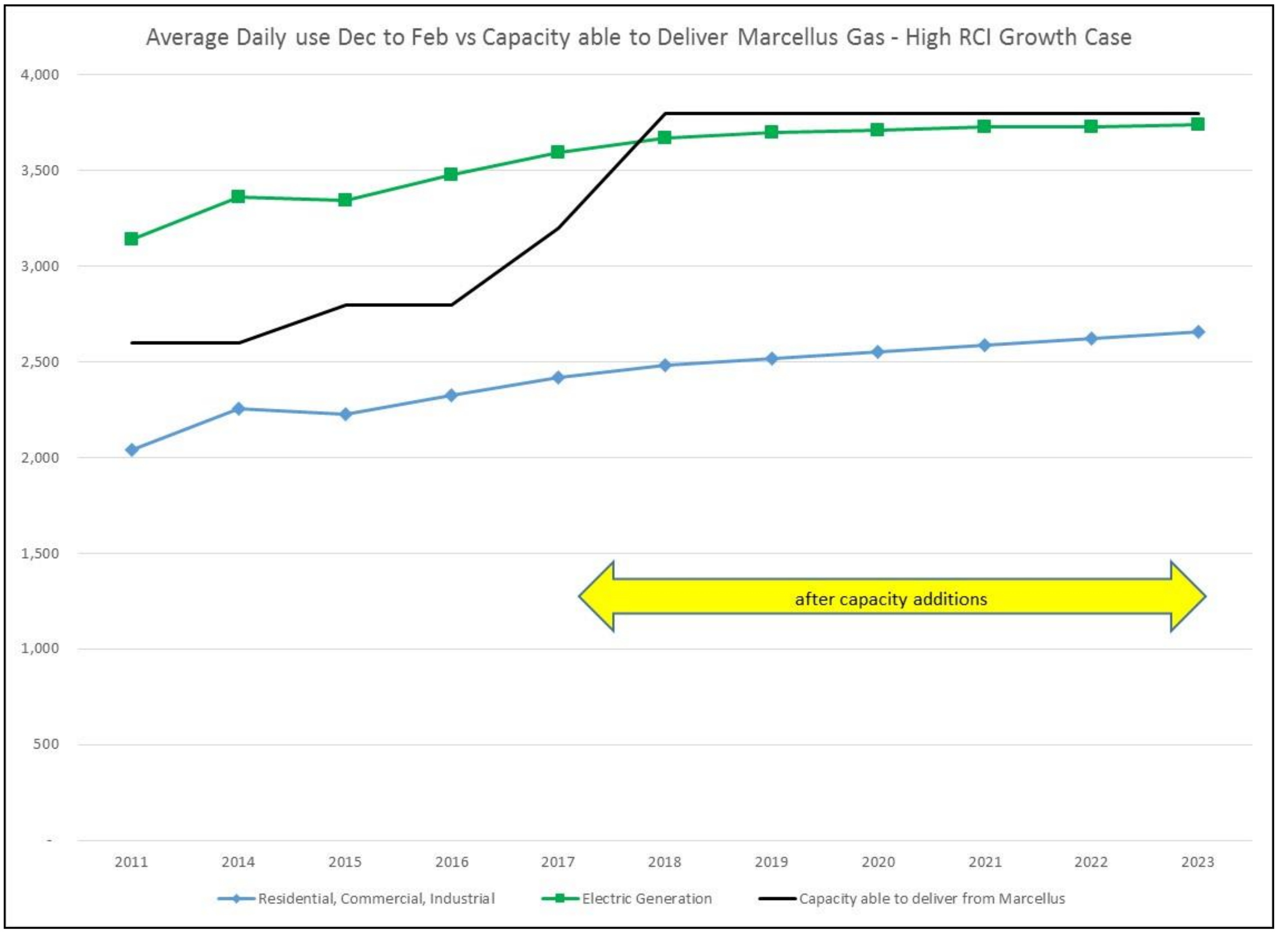


Exhibit 2-35. High Gas Utility Load Forecast



Instead, even with high gas utility load growth, it appears the addition of 1 Bcf/day of capacity by November 2018 would significantly increase the quantity of pipeline capacity available to deliver gas for electric generation on average during the three peak winter months.

It is reasonable to assume that up to 1 Bcf/day of capacity will be added within that timeframe based upon the number of projects competing to add pipeline capacity into New England, as listed in Exhibit 2-29, and the visibly high peak-period gas prices experienced in New England. This assumption is consistent with the discussion of New England market conditions for capacity and supply presented in the CT gas utilities' infrastructure expansion plan, pages 88 to 91.[41]

November 2019 onward

From 2020-2031, ALG, Tennessee and Iroquois HH basis remain at lower levels as above, inflated in nominal dollars in the Base Case to reflect the 0.4% annual average demand increase inherent in the

[41] ibid.

AEO 2014 Reference Case. In other words, real ALG-HH basis and Tennessee Henry Hub basis are both expected to decline in the 2020s because low gas demand, increasing efficiency of peak gas consumption, and increasingly mild weather will all act to prevent – on average – basis blow-outs.

2.13 Avoided Natural Gas Costs by End Use

2.13.1 Introduction and Summary

The avoided cost of gas at a retail customer's meter has two components: (1) the avoided cost of gas delivered to the local distribution company (LDC) and (2) the avoided cost of delivering gas on the LDC system (the "retail margin"). Natural gas avoided costs are presented with and without the retail margin.

AESC 2015 developed avoided natural gas cost estimates for three regions: Southern New England (Connecticut, Rhode Island, and Massachusetts), Northern New England (New Hampshire and Maine), and Vermont. Exhibit 2-36 provides the fifteen year levelized estimates assuming no avoided distribution margin, with comparisons to the corresponding values from AESC 2013. VT requested that AESC 2015 calculate its avoided costs for a different set of costing periods.

Exhibit 2-36. Comparison of Avoided Gas Costs by End-Use Assuming No Avoidable Retail Margin, AESC 2015 vs. AESC 2013 (15-year levelized, 2015$/MMBtu except where indicated as 2013$/MMBtu)

	RESIDENTIAL				COMMERCIAL & INDUSTRIAL			ALL
	Non Heating	Hot Water	Heating	All	Non Heating	Heating	All	RETAIL END USES
Southern New England (CT, MA, RI)								
AESC 2013 (2013$)	6.08	6.57	6.73	6.60	6.26	6.58	6.44	6.53
AESC 2013 (b)	6.29	6.80	6.97	6.83	6.48	6.81	6.66	6.76
AESC 2015	6.00	6.53	6.70	6.56	6.20	6.54	6.39	6.48
2013 to 2015 change	-5%	-4%	-4%	-4%	-4%	-4%	-4%	-4%
Northern New England (ME, NH)								
AESC 2013 (2013$)	6.03	7.53	8.02	7.62	6.58	7.54	7.12	7.39
AESC 2013 (b)	6.24	7.80	8.30	7.89	6.82	7.81	7.37	7.65
AESC 2015	6.00	7.69	8.25	7.80	6.63	7.71	7.24	7.54
2013 to 2015 change	-4%	-1%	-1%	-1%	-3%	-1%	-2%	-1%

	Design day	**Peak Days**	**Remainin g winter**	**Shoulder / summer**
Vermont				
AESC 2013 (2013$)	$ 389.03	$ 20.68	$ 8.68	$ 6.32
AESC 2013 (b)	$ 402.76	$ 21.41	$ 8.98	$ 6.54
AESC 2015	$ 523.08	$ 21.83	$ 7.51	$ 6.19
2013 to 2015 change	30%	2%	-16%	-5%

Factor to convert 2013$ to 2015$ 1.0353

Note: AESC 2013 levelized costs for 15 years 2014 - 2028 at a discount rate of 1.36%.
AESC 2015 levelized costs for 15 years 2016 - 2030 at a discount rate of 2.43%.

This set of AESC 2015 avoided natural gas cost estimates for Southern and Northern New England are generally lower than the AESC 2013 estimates, primarily due to the difference between the AESC 2015 projection of gas prices at Henry Hub and the AESC 2013 projection. The estimates for VT are also generally lower, except for the design day costs, which are higher due to a higher projection of Vermont Gas System (VGS) marginal transmission costs.

Exhibit 2-37 provides the fifteen year levelized estimates assuming some level of avoided distribution margin for Southern and Northern New England, again with comparisons to the corresponding values from AESC 2013. The exhibit does not include a comparison for VT because of its use of different costing periods and different end use load shapes.

Exhibit 2-37. Comparison of Avoided Gas Costs by End-Use Assuming Some Avoidable Retail Margin, AESC 2013 vs. AESC 2011 (15-year levelized, 2013$/MMBtu except where indicated as 2011$/MMBtu)

	RESIDENTIAL				COMMERCIAL & INDUSTRIAL			ALL
	Non Heating	Hot Water	Heating	All	Non Heating	Heating	All	RETAIL END USES
Southern New England (CT, MA, RI)								
AESC 2013 (2013$)	6.67	7.17	8.30	8.12	6.88	7.74	7.44	7.80
AESC 2013 (b)	6.91	7.42	8.59	8.41	7.13	8.01	7.70	8.07
AESC 2015	6.62	7.89	8.32	8.13	6.81	7.68	7.37	7.35
2013 to 2015 change	-4%	6%	-3%	-3%	-4%	-4%	-4%	-9%
Northern New England (ME, NH)								
AESC 2013 (2013$)	6.53	8.04	9.35	8.91	7.04	8.40	7.86	8.17
AESC 2013 (b)	6.76	8.32	9.68	9.23	7.29	8.70	8.14	8.46
AESC 2015	6.52	8.86	9.64	9.15	7.11	8.61	8.01	6.88
2013 to 2015 change	-4%	6%	0%	-1%	-3%	-1%	-2%	-19%

Factor to convert 2013$ to 2015$ 1.0353

Note: AESC 2013 levelized costs for 15 years 2014 - 2028 at a discount rate of 1.36%.
AESC 2015 levelized costs for 15 years 2016 - 2030 at a discount rate of 2.43%.

2.13.2 Retail End Use Load Shapes

The shape of the retail gas load has a major impact on the cost of natural gas supplied and thus the avoided natural gas costs. End uses of natural gas at the retail level are distinguished by two major types of end-use, heating related load which is driven by temperature and has a low annual load factor and non-heating load which tends to have a flat shape and hence a relatively high load factor. AESC 2015 bases its analyses on a representative utility with a heating load accounting for 70 percent of its total annual load and a non-heating load accounting for the remaining 30 percent. (Residential sector water heating has a load shape that is approximately 75 percent temperature related and 25 percent non-temperature related.

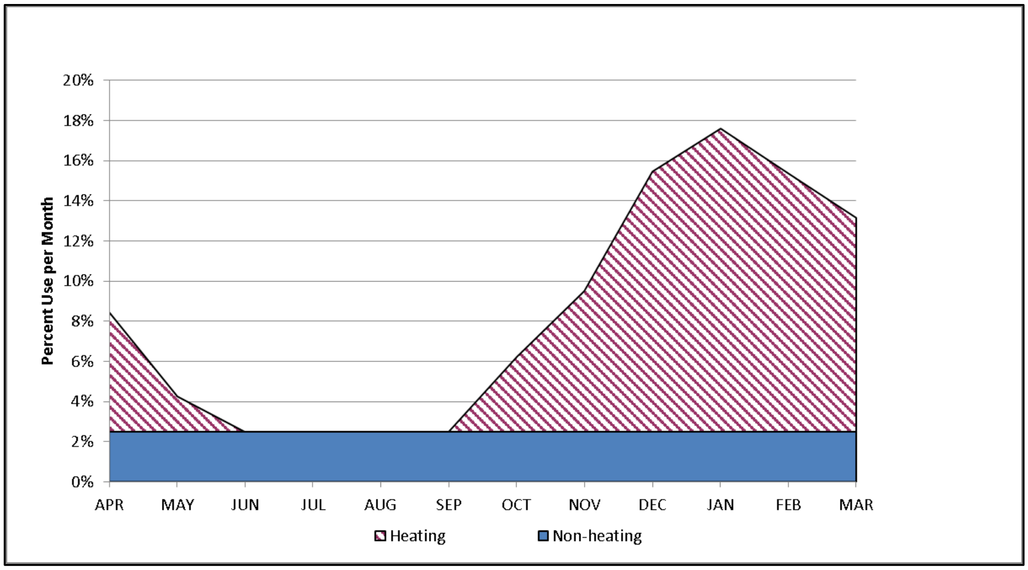
The level of gas use by month for each major type of end-use is shown in table and chart form below. Exhibit 2-38 shows the percentage of annual load in each month for heating and non-heating loads respectively. Exhibit 2-39 plots those loads by month. (This load data is from data provided by National Grid (MA) for AESC 2011 and is consistent with load data Study Group utilities provided for AESC 2015. It will be updated as necessary based on data utilities provide for AESC 2015.)

Exhibit 2-38. Percentage of Annual Load in Each Month for Heating and Non-Heating Loads

Load Type		APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Non-Heating	(a)	8.33%	8.33%	8.33%	8.33%	8.33%	8.33%	8.33%	8.34%	8.34%	8.34%	8.34%	8.33%
	30%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Heating	(b)	8.50%	2.50%	0.00%	0.00%	0.00%	0.00%	5.30%	10.00%	18.50%	21.60%	18.40%	15.20%
	70%	5.95%	1.75%	0.00%	0.00%	0.00%	0.00%	3.71%	7.00%	12.95%	15.12%	12.88%	10.64%
Heating + Non-heating	(c)	8.45%	4.25%	2.50%	2.50%	2.50%	2.50%	6.21%	9.50%	15.45%	17.62%	15.38%	13.14%

(a) Constant load all year; rounding altered in the winter months to maintain 100% use for the year.
(b) Distribution of the heating (low load factor) load among the months of the year based on data provided by National Grid (MA).
(c) Weighted average for each month at 70% heating load shape and 30% non-heating load shape.

Exhibit 2-39. Chart of Annual Load in Each month for Heating and Non-Heating Loads

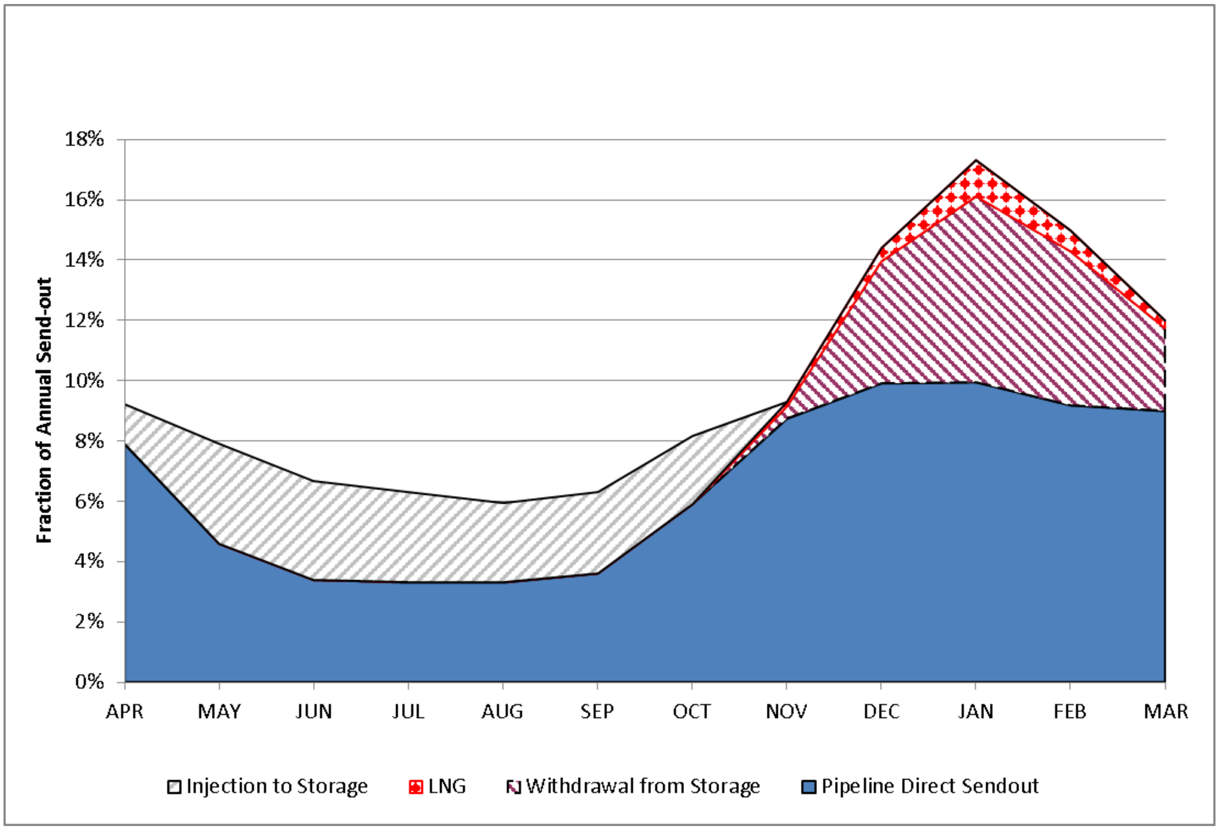


Because of the size of the gas load during the winter (defined as November through March in the gas industry) relative to the summer, and because the variation in daily load during winter months due to variation in daily temperatures, LDCs develop a portfolio of supplies in order to provide reliable service at reasonable cost over time. These portfolios comprise three major categories of delivery and storage resources: long-haul pipeline transportation, underground storage, and LNG or propane facilities. AESC 2015 calculates the avoided cost of gas delivered into the distribution system of a representative New England local distribution company from the avoided cost of each resource in each month and the relative quantity of each resource that an LDC uses in each month.

As illustrated in Exhibit 2-40, LDCs use their long-haul pipeline transportation to supply load directly in each month of the year. In addition, in summer months LDCs use a portion of that pipeline transportation capacity to deliver gas from producing areas for injection into underground storage, and sometimes for liquefaction and injection into LNG tanks. In winter months LDCs meet customer load with gas delivered by pipeline directly from producing areas and from underground storage.

LDCs use gas from LNG and propane facilities delivered directly into their distribution systems to meet daily peaking and seasonal requirements during the months of heaviest load, mostly December through February.[42]

Exhibit 2-40. Sendout from Resources by Month.



2.13.3 Avoided Costs of Representative Gas Supply Resources

New England LDCs use three basic supply resources to meet the requirements of their customers. These resources are (1) gas delivered directly from producing areas via long-haul pipelines, (2) gas withdrawn from underground storage facilities (most of which are located in Pennsylvania) and delivered by pipeline, and (3) gas stored as liquefied natural gas and/or propane in tanks located in the LDC service territories throughout New England.

Except for Vermont AESC 2015 used a representative New England LDC to determine the fraction of customer requirements met from each resource each month and the fraction of storage refill in each of

[42] The data underlying the representative LDC sendout by source is data from LDCs used in AESC 2011. It will be updated as necessary based on data utilities provide for AESC 2015.

the summer months, April through October. Vermont has only one LDC, VGS, and a somewhat different supply mix. AESC 2015 calculates the avoided costs for VGS in a separate section using the characteristics of VGS.

Our analysis assumes that LDCs have optimized the mix of supply sources and thus long-term energy efficiency. The characteristics of a representative New England LDC we use in our analysis are shown in Exhibit 2-41 below. That exhibit presents the numerical data presented earlier in Exhibit 2-40 as a graphical representation.

Exhibit 2-41. Sendout Characteristics of Representative LDC

	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	Annual
Fractions of LDC Send-out by Source Each Month													
Pipeline Deliveries, Long-haul	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	93.9%	68.8%	57.5%	61.2%	74.9%	78.8%
Underground Storage	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.6%	28.2%	35.6%	34.0%	23.0%	18.5%
LNG & Propane Peaking	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.5%	3.0%	6.9%	4.8%	2.1%	2.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Fraction of Annual Sendout each Month	7.9%	4.6%	3.4%	3.3%	3.3%	3.6%	5.9%	9.3%	14.4%	17.3%	15.0%	12.0%	100.0%
Monthly Sendout as a Fraction of Peak Month	45.7%	26.6%	19.7%	19.1%	19.1%	20.8%	34.1%	53.8%	83.2%	100.0%	86.7%	69.4%	
Fraction of Underground Storage Injection by Month	7.1%	17.9%	17.6%	16.2%	14.3%	14.6%	12.3%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%

For each gas supply resource we identify the costs of acquiring the resource and the cost of delivering that resource to the LDC.

- For long-haul pipeline deliveries the cost components are: (a) gas purchase costs, (b) the FT service demand rate, and (c) the variable transportation cost. The variable transportation cost includes the variable transportation commodity rate charged by the pipeline, and the cost of gas retained by the pipeline for compressor fuel use and "lost and unaccounted for" gas.

- For deliveries from off-system underground storage resources, which include firm transportation service from the storage to the LDC, the cost components are: (a) the cost of gas purchased for injection, (b) the fixed storage and transportation service charges, and (c) the variable storage and transportation service charges, which includes the storage and transportation fuel costs.

- For on-system peaking resources, we assume there is only a variable cost component. In the case of LNG peaking, which is the predominant type of on-system peaking for LDCs in Southern New England and Northern New England, the variable cost is the purchased gas cost and the cost of gas consumed for liquefaction and vaporization. For propane-based peaking, which is the only type of on-system peaking in Vermont, the variable cost is assumed to be the propane price.

Gas Purchase Cost and Resource Service Cost Assumptions

For this avoided-cost analysis we assume that the marginal gas purchase cost is the monthly price of gas at the Henry Hub. We draw those from our forecast of monthly Henry Hub prices.

As in AESC 2013, we assume that the marginal source of gas to New England LDCs from the Henry Hub is transportation and storage on either of the Tennessee Gas Pipeline (TGP), for LDCs in Northern and Central New England, or the route of Texas Eastern Transmission (TETCO) and Algonquin Gas Transmission (AGT), for LDCs in Southern New England. AESC 2015 developed its projected costs of marginal supply resources for Southern and Northern New England by updating the AESC 2013 projections to reflect the AESC 2015 forecast of Henry Hub prices.

AESC 2015 developed its projected costs of marginal supply resources for Vermont in consultation with staff of VGS. AESC 2015 identified, and developed the marginal costs for, four resources corresponding to the VGS supply resources and the four Vermont four costing periods. The four resources are baseload supply from Dawn via TCPL, storage withdrawals from Dawn storage via TCPL, propane peak shaving and new pipeline capacity, both upstream of and on VGS. Exhibit 2-42 shows the projected costs by year for each of those resources.

Exhibit 2-42. Projected Costs of Marginal Gas Supply Resources in Vermont (2015$/MMBtu)

VT	Delivered Cost of Marginal Resource (2015$ per MMBtu)			
	Baseload (Summer and Winter)	80-Day	10-Day	Peak Day
Marginal resource	Dawn via TCPL	MI / Dawn Storage via TCPL	LP Peakshaving	Marginal Transmission (Upstream + Downstream) + Winter Baseload
Days	275	80	9	1
	a	b	c	d
2015	$ 4.55	$ 6.65	$ 15.66	$ 521.44
2016	$ 4.76	$ 7.03	$ 16.65	$ 521.65
2017	$ 5.65	$ 7.92	$ 18.45	$ 522.54
2018	$ 5.52	$ 7.72	$ 19.70	$ 522.41
2019	$ 5.95	$ 8.31	$ 20.19	$ 522.84
2020	$ 5.60	$ 7.91	$ 20.70	$ 522.49
2021	$ 5.94	$ 8.34	$ 21.24	$ 522.83
2022	$ 6.09	$ 8.46	$ 21.79	$ 522.98
2023	$ 6.21	$ 8.56	$ 22.37	$ 523.10
2024	$ 6.41	$ 8.80	$ 22.91	$ 523.30
2025	$ 6.51	$ 8.91	$ 23.41	$ 523.40
2026	$ 6.67	$ 9.08	$ 23.84	$ 523.56
2027	$ 6.78	$ 9.18	$ 24.37	$ 523.67
2028	$ 6.89	$ 9.30	$ 24.80	$ 523.78
2029	$ 7.08	$ 9.49	$ 25.24	$ 523.97
2030	$ 7.35	$ 9.76	$ 25.60	$ 524.24
15yr Level	$ 6.16	$ 8.51	$ 21.83	$ 523.05

2.14 Avoided Distribution Cost by Sector

The avoided cost for each end-use by sector is the sum of the avoided cost of the gas sent out by the LDC and the avoidable distribution cost, called the avoidable LDC margin, applicable from the citygate to the burner tip.

Estimates of the portion or amount of distribution cost that is avoidable due to reductions in gas use from efficiency measures vary by LDC. Some LDCs have estimated this amount as their incremental or marginal cost of distribution; that is, the change in cost of distribution incurred as demand for gas increases or decreases. The conclusion was that the incremental cost of distribution depends upon the load type and the customer sector. For low load factor or heating loads, more of the embedded cost for each sector is incremental or avoidable than for high load factor or non-heating loads. The incremental or avoidable cost is measured as a percent of the embedded costs. For AESC 2015, we measure the embedded cost as the difference between the city-gate price of gas in a state and the price charged each of the different retail customer types: residential, commercial/industrial, and all retail customers.[43] The embedded distribution cost for each of the two regions, Southern New England and Northern New England, were the weighted average distribution costs among the relevant states where the weighting is the volume of gas delivered to each sector in each state.

Exhibit 2-43 shows the estimated avoidable LDC margin percentage and avoidable costs, in 2013$ per MMBtu, by each of the end-use types and customer sectors for each region in New England.

Exhibit 2-43. Estimated Avoidable LDC Margins (2013$/MMBtu)

	LDC Average Retail Margin + City-Gate Cost (a)	Avoidable LDC Margin (a)		
		Non-heating (High Load Factor)	Heating (Low Load Factor)	All
		%	%	
Avoidable Margin (percent) (b)				
Residential		8.0%	21.0%	20.4%
Commercial & Industrial		15.0%	28.0%	24.0%
All Retail				22.0%
Southern New England (c)		2015$/MMBtu		
Average City Gate Price	6.975			
Residential	7.709	0.62	1.62	1.57
Commercial & Industrial (e)	4.082	0.61	1.14	0.98
All Retail (f)	5.805			1.28
Northern New England (d)				
Average City Gate Price	8.454			
Residential	6.590	0.53	1.38	1.34
Commercial & Industrial (e)	3.198	0.48	0.90	0.77
All Retail (f)	3.676			0.81
Vermont				
Average City Gate Price	8.010			
Residential	9.087	0.73	1.91	1.85
Commercial & Industrial (e)	3.740	0.56	1.05	0.90
All Retail (f)	4.349			0.96

(a) Average of Margins among states for 2009-2013 weighted by the delivered volumes in each state.
(b) Based on LDC marginal cost studies from National Grid (MA).
(c) Southern New England is Massachusetts, Connecticut, and Rhode Island.
(d) Northern New England is New Hampshire and Maine.
(e) An average of the margins weighted by the commercial and industrial use delivered volumes.
(f) An average of residential, commercial and industrial margins weighted by associated volumes.

[43] The citygate gas prices and the prices charged to each retail customer sector are reported by the EIA for each state each year. In AESC 2015 the cost used is the average for 2009-2013, the most recent five years for which data is available.

Some LDCs assume they will not avoid any distribution costs due to reductions in gas use from efficiency measures. The avoided cost of gas by end-use for an LDC with no avoided distribution cost is their avoided cost of gas delivered to their citygate.

2.14.1 Total Avoided Gas Costs by End Use

Exhibit 2-44 through **Exhibit** 2-48 show the total avoided costs per year per MMBtu for the retail end-uses categorized by the end-use type and customer sector for Southern New England, Northern New England, and Vermont. The levelized avoided cost is the cost for which the present value at the real rate of return of 2.43 percent has the same present value as the estimated avoided costs for the 15-year period 2016 through 2030 at the same rate of return.

Exhibit 2-44 through Exhibit 2-46 present the avoided cost by end-use for utilities at which it is assumed that no LDC retail margin is avoidable.

Exhibit 2-44. Avoided Cost of Gas Delivered to LDCs by End-Use Load Type Assuming No Avoidable Retail Margin, Southern New England (2015$/MMBtu)

	RESIDENTIAL				COMMERCIAL & INDUSTRIAL			ALL
	Non	Hot			Non			RETAIL
Year	Heating	Water	Heating	All	Heating	Heating	All	END USES
2015	4.45	4.90	5.06	4.94	4.61	4.92	4.78	4.87
2016	4.66	5.16	5.33	5.19	4.85	5.17	5.03	5.12
2017	5.36	6.02	6.24	6.07	5.60	6.02	5.85	5.96
2018	5.84	6.47	6.68	6.51	6.07	6.48	6.30	6.42
2019	5.89	6.40	6.57	6.44	6.08	6.42	6.27	6.36
2020	5.53	6.02	6.19	6.05	5.72	6.03	5.89	5.98
2021	5.83	6.34	6.51	6.37	6.02	6.35	6.20	6.30
2022	5.91	6.41	6.58	6.45	6.10	6.42	6.28	6.38
2023	6.00	6.50	6.67	6.53	6.19	6.51	6.37	6.45
2024	6.19	6.70	6.87	6.74	6.38	6.71	6.56	6.65
2025	6.31	6.80	6.97	6.83	6.50	6.81	6.68	6.76
2026	6.41	6.92	7.09	6.95	6.60	6.93	6.78	6.87
2027	6.49	7.00	7.17	7.03	6.68	7.01	6.86	6.95
2028	6.60	7.10	7.27	7.14	6.79	7.11	6.97	7.07
2029	6.80	7.30	7.46	7.34	6.99	7.30	7.17	7.26
2030	7.08	7.58	7.74	7.61	7.27	7.58	7.45	7.54
Levelized (a)	6.00	6.53	6.70	6.56	6.20	6.54	6.39	6.48
Simple Average	6.06	6.58	6.76	6.62	6.26	6.59	6.44	6.54

(a) Years 2016-2030 (15 years) at disciount rate of 2.430%
b Distribution system loss and unbilled 2%

Exhibit 2-45. Avoided Cost of Gas Delivered to LDCs by End-Use Load Type Assuming No Retail Margin, Northern New England (2015$/MMBtu)

	RESIDENTIAL				COMMERCIAL & INDUSTRIAL			ALL
Year	Non Heating	Hot Water	Heating	All	Non Heating	Heating	All	RETAIL END USES
2015	4.12	5.54	6.01	5.63	4.65	5.55	5.15	5.41
2016	4.64	5.30	5.52	5.34	4.88	5.31	5.13	5.24
2017	5.70	6.16	6.31	6.19	5.87	6.16	6.04	6.12
2018	5.98	6.76	7.02	6.82	6.28	6.77	6.55	6.69
2019	5.86	7.80	8.44	7.93	6.58	7.83	7.28	7.63
2020	5.48	7.41	8.06	7.54	6.20	7.45	6.90	7.25
2021	5.78	7.75	8.41	7.88	6.52	7.78	7.24	7.58
2022	5.87	7.85	8.51	7.98	6.61	7.88	7.33	7.67
2023	5.95	7.93	8.60	8.07	6.69	7.96	7.40	7.76
2024	6.14	8.16	8.84	8.30	6.90	8.19	7.62	7.98
2025	6.24	8.27	8.95	8.41	7.00	8.30	7.73	8.09
2026	6.35	8.40	9.08	8.53	7.11	8.43	7.85	8.22
2027	6.44	8.49	9.17	8.63	7.21	8.52	7.95	8.32
2028	6.54	8.60	9.29	8.74	7.31	8.63	8.05	8.42
2029	6.73	8.79	9.48	8.93	7.51	8.82	8.24	8.61
2030	7.01	9.07	9.76	9.21	7.78	9.10	8.52	8.89
Levelized (a)	6.00	7.69	8.25	7.80	6.63	7.71	7.24	7.54
Simple Average	6.05	7.78	8.36	7.90	6.70	7.81	7.32	7.63

(a) Years 2016-2030 (15 years) at disciount rate of 2.430%
b Distribution system loss and unbilled 2%

Exhibit 2-46. Avoided Cost of Gas Delivered to LDCs by End-Use Load Type Assuming No Retail Margin, Vermont (2015$/MMBtu)

Year	Design day	Peak Days	Remaining winter	Shoulder / summer
Days	1	9	141	214
	a	b	c	d
2015	$ 521.44	$ 15.66	$ 5.74	$ 4.55
2016	$ 521.62	$ 16.65	$ 6.04	$ 4.73
2017	$ 522.53	$ 18.45	$ 6.93	$ 5.64
2018	$ 522.94	$ 19.70	$ 7.00	$ 6.05
2019	$ 522.80	$ 20.19	$ 7.27	$ 5.91
2020	$ 522.50	$ 20.70	$ 6.92	$ 5.61
2021	$ 522.80	$ 21.24	$ 7.29	$ 5.91
2022	$ 522.97	$ 21.79	$ 7.43	$ 6.08
2023	$ 523.11	$ 22.37	$ 7.55	$ 6.22
2024	$ 523.28	$ 22.91	$ 7.76	$ 6.39
2025	$ 523.40	$ 23.41	$ 7.87	$ 6.51
2026	$ 523.53	$ 23.84	$ 8.03	$ 6.64
2027	$ 523.67	$ 24.37	$ 8.14	$ 6.78
2028	$ 523.78	$ 24.80	$ 8.26	$ 6.89
2029	$ 523.97	$ 25.24	$ 8.45	$ 7.08
2030	$ 524.24	$ 25.60	$ 8.72	$ 7.35
15yr Level	$ 523.08	$ 21.83	$ 7.51	$ 6.19

Exhibit 2-47 and Exhibit 2-48 are projections of avoidable cost by end-use for utilities in Southern New England and Northern New England for which some LDC retail margin is avoidable.

Exhibit 2-47. Avoided Cost of Gas Delivered to an End-Use Load, Assuming Some Retail Margin is Avoidable, Southern New England (2015$/MMBtu)

	RESIDENTIAL				COMMERCIAL & INDUSTRIAL			ALL
Year	Non Heating	Hot Water	Heating	All	Non Heating	Heating	All	RETAIL END USES
2015	5.06	6.27	6.68	6.51	5.23	6.06	5.76	6.42
2016	5.28	6.53	6.95	6.76	5.46	6.31	6.01	6.62
2017	5.98	7.38	7.85	7.64	6.21	7.17	6.82	6.62
2018	6.45	7.84	8.30	8.08	6.68	7.62	7.28	6.72
2019	6.50	7.77	8.19	8.01	6.69	7.56	7.25	6.96
2020	6.14	7.39	7.81	7.63	6.33	7.17	6.87	7.25
2021	6.45	7.71	8.13	7.94	6.63	7.49	7.18	7.59
2022	6.53	7.78	8.20	8.02	6.71	7.56	7.26	7.84
2023	6.62	7.87	8.28	8.10	6.80	7.65	7.35	7.99
2024	6.81	8.07	8.49	8.31	6.99	7.85	7.54	8.19
2025	6.92	8.17	8.59	8.41	7.11	7.96	7.66	8.31
2026	7.03	8.28	8.70	8.52	7.21	8.07	7.76	8.45
2027	7.11	8.36	8.78	8.60	7.29	8.15	7.84	8.63
2028	7.22	8.47	8.89	8.72	7.41	8.25	7.95	8.76
2029	7.41	8.67	9.08	8.91	7.60	8.45	8.15	8.88
2030	7.69	8.94	9.36	9.19	7.88	8.73	8.43	8.98
Levelized (a)	6.62	7.89	8.32	8.13	6.81	7.68	7.37	7.77
Simple Average	6.68	7.95	8.37	8.19	6.87	7.73	7.42	7.85

(a) Years 2016-2030 (15 years) at disciount rate of 2.430%
b Distribution system loss and unbilled 2%

Exhibit 2-48. Avoided Cost of Gas Delivered to an End-Use Load, Assuming Some Retail Margin is Avoidable, Northern New England (2015$/MMBtu)

	RESIDENTIAL				COMMERCIAL & INDUSTRIAL			ALL
Year	Non Heating	Hot Water	Heating	All	Non Heating	Heating	All	RETAIL END USES
2015	4.65	6.71	7.39	6.97	5.13	6.45	5.92	5.95
2016	5.17	6.47	6.90	6.68	5.36	6.20	5.89	6.15
2017	6.22	7.33	7.69	7.54	6.35	7.06	6.80	6.15
2018	6.51	7.93	8.40	8.16	6.76	7.67	7.32	6.25
2019	6.38	8.97	9.83	9.27	7.06	8.73	8.05	6.49
2020	6.01	8.58	9.44	8.89	6.68	8.34	7.66	6.78
2021	6.31	8.92	9.79	9.22	7.00	8.68	8.00	7.12
2022	6.40	9.02	9.89	9.33	7.09	8.77	8.09	7.37
2023	6.47	9.10	9.98	9.41	7.17	8.86	8.17	7.52
2024	6.66	9.33	10.22	9.64	7.38	9.09	8.39	7.72
2025	6.77	9.44	10.33	9.75	7.48	9.20	8.50	7.84
2026	6.87	9.57	10.46	9.88	7.59	9.32	8.61	7.98
2027	6.96	9.66	10.56	9.98	7.69	9.41	8.71	8.16
2028	7.07	9.77	10.67	10.08	7.79	9.53	8.82	8.29
2029	7.26	9.96	10.86	10.27	7.98	9.72	9.01	8.41
2030	7.54	10.24	11.14	10.55	8.26	10.00	9.29	8.51
Levelized (a)	6.52	8.86	9.64	9.15	7.11	8.61	8.01	7.30
Simple Average	6.57	8.95	9.75	9.24	7.18	8.70	8.09	7.38

(a) Years 2016-2030 (15 years) at disciount rate of 2.430%
b Distribution system loss and unbilled 2%

2.14.2 Comparison of Avoided Retail Gas Costs with AESC 2013

Exhibit 2-49 and Exhibit 2-50 show the end-use avoided costs of gas use in AESC 2015 as compared to AESC 2013 assuming no avoided margin and some avoided margin respectively. The end-use avoided costs of gas use in AESC 2015 are generally less than estimated in AESC 2013 for all three regions in New England.

Exhibit 2-49. Comparison of AESC 2015 and AESC 2013 Avoided Cost of Gas Delivered to Retail Customers by End Use Assuming NO Retail Margin Avoidable (2015$/MMBtu, unless noted)

	RESIDENTIAL				COMMERCIAL & INDUSTRIAL			ALL RETAIL END USES
	Non Heating	Hot Water	Heating	All	Non Heating	Heating	All	
Southern New England (CT, MA, RI)								
AESC 2013 (2013$)	6.08	6.57	6.73	6.60	6.26	6.58	6.44	6.53
AESC 2013 (b)	6.29	6.80	6.97	6.83	6.48	6.81	6.66	6.76
AESC 2015	6.00	6.53	6.70	6.56	6.20	6.54	6.39	6.48
2013 to 2015 change	-5%	-4%	-4%	-4%	-4%	-4%	-4%	-4%
Northern New England (ME, NH)								
AESC 2013 (2013$)	6.03	7.53	8.02	7.62	6.58	7.54	7.12	7.39
AESC 2013 (b)	6.24	7.80	8.30	7.89	6.82	7.81	7.37	7.65
AESC 2015	6.00	7.69	8.25	7.80	6.63	7.71	7.24	7.54
2013 to 2015 change	-4%	-1%	-1%	-1%	-3%	-1%	-2%	-1%

	Design day	**Peak Days**	**Remainin g winter**	**Shoulder / summer**
Vermont				
AESC 2013 (2013$)	$ 389.03	$ 20.68	$ 8.68	$ 6.32
AESC 2013 (b)	$ 402.76	$ 21.41	$ 8.98	$ 6.54
AESC 2015	$ 523.08	$ 21.83	$ 7.51	$ 6.19
2013 to 2015 change	30%	2%	-16%	-5%

Factor to convert 2013$ to 2015$ 1.0353

Note: AESC 2013 levelized costs for 15 years 2014 - 2028 at a discount rate of 1.36%.
AESC 2015 levelized costs for 15 years 2016 - 2030 at a discount rate of 2.43%.

Exhibit 2-50. Comparison of AESC 2015 and AESC 2013 Avoided Cost of Gas Delivered to Retail Customers by End-Use Assuming SOME Retail Margin Avoidable (2015$/MMBtu, unless noted)

	RESIDENTIAL				COMMERCIAL & INDUSTRIAL			ALL
	Non Heating	Hot Water	Heating	All	Non Heating	Heating	All	RETAIL END USES
Southern New England (CT, MA, RI)								
AESC 2013 (2013$)	6.67	7.17	8.30	8.12	6.88	7.74	7.44	7.80
AESC 2013 (b)	6.91	7.42	8.59	8.41	7.13	8.01	7.70	8.07
AESC 2015	6.62	7.89	8.32	8.13	6.81	7.68	7.37	7.35
2013 to 2015 change	-4%	6%	-3%	-3%	-4%	-4%	-4%	-9%
Northern New England (ME, NH)								
AESC 2013 (2013$)	6.53	8.04	9.35	8.91	7.04	8.40	7.86	8.17
AESC 2013 (b)	6.76	8.32	9.68	9.23	7.29	8.70	8.14	8.46
AESC 2015	6.52	8.86	9.64	9.15	7.11	8.61	8.01	6.88
2013 to 2015 change	-4%	6%	0%	-1%	-3%	-1%	-2%	-19%

Factor to convert 2013$ to 2015$ 1.0353

Note: AESC 2013 levelized costs for 15 years 2014 - 2028 at a discount rate of 1.36%.
AESC 2015 levelized costs for 15 years 2016 - 2030 at a discount rate of 2.43%.

2.15 Avoided Natural Gas Capacity Costs

The AESC 2015 scope of work requires a recommendation as to whether a separate natural gas capacity value should be developed and introduced into program administrator benefit-cost models. The scope of work further requests, depending on the recommendation, an estimate of peak-day $/MMBtu (capacity value). This section provides that recommendation and also provides a projection of avoided peak-day costs.

AESC 2015 does not recommend development of a separate natural gas capacity value until the program administrators demonstrate a need to evaluate gas efficiency measures that reduce peak day sendout only, rather than reducing gas commodity use plus peak day sendout. This recommendation is based upon the same reasons discussed in prior AESC studies, in particular AESC 2011 pages 4-17 through 4-19. The primary reason is pragmatic, and arises from the key differences between the gas industry and the electric industry relative to the calculation of, and application of, avoided capacity costs as summarized below.

First, the electric industry has demand response measures which reduce peak demand in a few high use hours each year and thereby primarily avoid capacity costs. In contrast, the gas industry does not appear to have measures which reduce gas use solely on a peak day. (In this regard it is important to recognize that gas utilities acquire peaking resources to meet their “design day” requirements which is a needle peak demand on 1 day with exceptional colder-than-normal temperatures that occur perhaps only once in 30 years. They acquire a different set of winter season supply resources to meet their requirements in in each month of a colder-than-normal design winter).

Second, the avoided "capacity value" of gas efficiency programs that reduce gas use with different load profiles is embedded in the avoided costs by end-use that we have developed. The avoided capacity cost of efficiency measures that reduce gas used for heating end-uses consists of avoided pipeline capacity costs, avoided storage service capacity costs and avoided peaking resource capacity costs. All of those avoided capacity costs are included in the avoided cost of heating uses that we provided, and they reflect the load factor at which utilities use each of those sources of capacity. The same applies for efficiency measures that reduce gas use for residential water heating or for non-heating purposes.

To the extent some program administrators do want an avoided cost of peak day use, we provide projections in Exhibit 2-51 for Southern New England (SNE), Northern New England (NNE) and Vermont. These estimates are based upon the same resource assumptions as in AESC 2013, i.e., avoided on system LNG liquefaction and vaporization for SNE and NNE, and propane peaking in Vermont.

Exhibit 2-51. Avoided Cost of Peak Day Use

AVOIDED PEAK DAY COSTS
(2015$/Dekatherm)

	Southern New England (1)	Northern New England (1)	Vermont (2)
2015	$ 10.69	$ 10.69	$ 521.44
2016	$ 8.31	$ 8.31	$ 521.65
2017	$ 9.49	$ 9.49	$ 522.54
2018	$ 10.16	$ 10.16	$ 522.41
2019	$ 10.41	$ 10.41	$ 522.84
2020	$ 9.99	$ 9.99	$ 522.49
2021	$ 10.60	$ 10.60	$ 522.83
2022	$ 10.75	$ 10.75	$ 522.98
2023	$ 10.90	$ 10.90	$ 523.10
2024	$ 11.38	$ 11.38	$ 523.30
2025	$ 11.54	$ 11.54	$ 523.40
2026	$ 11.79	$ 11.79	$ 523.56
2027	$ 11.94	$ 11.94	$ 523.67
2028	$ 12.07	$ 12.07	$ 523.78
2029	$ 12.26	$ 12.26	$ 523.97
2030	$ 18.73	$ 18.73	$ 542.13

Notes
1 Avoided resource is on-system LNG liquefaction / vaporization
2 Avoided resource is on-system propane peaking

2.16 Assessment of Alternative Natural Gas Costing Periods

The Study Group asked TCR to analyze the avoided natural gas cost results and assess whether alternative costing period definitions may more accurately and reasonably reflect the seasonal and hourly variation of marginal energy costs in comparison to the definitions presented in Task 3A 1 of the scope of work. This section describes our analysis of alternative costing period definitions for natural gas costs, and our recommendations based on that analysis.

The key point from our analysis is that the current natural gas costing periods for the residential, commercial and industrial ("RC&I") sectors are fundamentally different from the current definitions of electric energy costing periods.

- Electric energy costing periods are currently defined in terms of the time period during which electric energy is used. Program administrators use the avoided electric energy costs for each time period to calculate the avoided cost of reductions in various types of electric energy end-use according to the shape of those reductions by time period.
- In contrast, natural gas costing periods for the RC&I sectors are currently defined in terms of the sector in which gas is used and the end-uses for which natural gas is used within that sector. As a result, the avoided natural gas costs resulting from the current natural gas costing periods reflect both the time period during which electric energy is used and the shape of the natural gas end-use.

Our analysis focuses on the costing periods for the residential, commercial and industrial ("RC&I") sectors for two reasons. First, our analysis did not find any problems with the natural gas costing periods used for electric generation. AESC 2015 and prior AESC studies estimate the average daily cost of natural gas for electric generation by month. That costing period and approach is reasonable for a long-term projection of avoided electric generation costs. Although the price of natural gas for electric generation varies by day within each month, in the long-term the daily prices in a given month are not materially different than the average price for that month. Second, the factors driving the avoided cost of gas for electric generation during a specific time period are different from those driving the avoided cost of gas for the RC&I sectors. The price of gas for electric generation is determined by the wholesale gas market in New England. In contrast, the avoided cost of gas for the RC&I sectors is determined by the wholesale gas market at production area hubs, such as the Henry Hub, plus the regulated costs of pipeline transportation, storage services and peaking facilities.

2.16.1 Current Natural Gas Costing Periods versus Electric Energy Costing Periods

The natural gas costing periods used in AESC 2015, and in prior AESC studies, are defined in terms of the sector in which gas is used and the end-uses for which natural gas is used within that sector. Task 3A1 defines the costing periods as:

a. Electric generation:
b. Commercial and industrial non-heating
c. Commercial and industrial heating

d. Residential heating

e. Residential water heating

f. Residential non-heating

g. All commercial and industrial

h. All residential

i. All retail end uses

In contrast, electric energy costing periods are currently defined in terms of the time period during which electric energy is used. Aggregate electric energy load, and electric energy prices, vary by season (winter, summer), by day of week (i.e. weekdays versus weekends), and by hour within weekdays (i.e. on-peak 7 am to 11 pm; off-peak 11 pm to 7 am). The electric energy costing periods used in AESC 2015, and in prior AESC studies, reflect those variations in load and price by time period. The four current electric energy costing periods are:

a. Winter (October – May), on-peak (weekdays 7 am to 11 pm)

b. Winter (October – May), off-peak (weekdays 11 pm to 7 am weekdays, weekends, and holidays)

c. Summer (June - September), on-peak (weekdays 7 am to 11 pm)

d. Summer (June - September), off-peak (weekdays 11 pm to 7 am, weekends, and holidays).

Natural gas load for the RC&I sectors in aggregate, and the costs of natural gas to serve that aggregate load, also vary by winter and summer. Winter in the gas industry is November through March (151 days) and summer is April through October (214 days). The cost of natural gas to serve that aggregate load varies by day during sub-periods within the winter, rather than by hour and by weekday versus weekend in the electric industry. Two commonly used sub-periods within the winter are peak days (i.e. top 10 coldest days) and shoulder days (i.e., remaining 141 days). For example, in this study Vermont Gas Systems has requested that we calculate avoided costs for four periods per year, i.e., a design day, 9 peak days, 80 shoulder days and 275 baseload days.

AESC 2015, and prior AESC studies, have developed annual avoided costs for the RC&I sectors in three steps, as illustrated in Exhibit 2-52. Step one is to identify the marginal resource used to supply load during the relevant gas industry costing period and the avoided cost of that resource. For example, the marginal resource in the 10 peak days may be a peaking service with a marginal cost of $8.62/MMbtu... Step two is to determine the portion of each RC&I end-use load that occurs in each gas industry costing period. For example, 2.7% of non-heating load may occur in the 10 peak days. Step three is to multiply the avoided cost in each costing period by the percentage load in that costing period, and add all the resulting costs by costing period to calculate the annual avoided cost for each end-use. For example, if .02 percent of residential heating load occurs during peak days and 99.9 percent occurs during shoulder days, the avoided cost of a reduction in residential heating load would be $6.60/MMBtu as illustrated in Exhibit 2-52.

Exhibit 2-52. Illustration of Avoided Costs by Sector and End-Use

Avoided Resource and Cost by Costing Period				Portion of Residential End-Use by Costing Period			Avoided Cost by Residential End-Use		
Costing Period	Days	% of year	Avoided Cost $/MMBtu	Non-heating load	Water heating load	Heating load	Non-heating load	Water heating load	Heating load
			a	b	c	d	e = a *b	e = a *c	e = a *d
Peak	10	2.7%	$ 8.62	2.7%	0.1%	0.2%	$ 0.24	$ 0.01	$ 0.02
Shoulder	141	38.6%	$ 6.60	38.6%	75.4%	99.8%	$ 2.55	$ 4.98	$ 6.59
Baseload	214	58.6%	$ 5.01	58.6%	24.5%	0.0%	$ 2.94	$ 1.23	$ -
Total	365	100.0%		100.0%	100.0%	100.0%	$ 5.72	$ 6.21	$ 6.60

Based on a review of gas utility filings and prior AESC studies, AESC 2015 recommends that Program Administrators consider changing the costing periods for natural gas in future AESC studies to three resource based costing periods – peak days (10), shoulder days (141) and baseload days (214). These costing periods would be methodologically consistent with those used to calculate avoided electric energy costs. Program administrators can then use the avoided gas costs for each time period to calculate the avoided cost of reductions in various types of gas end-use according to the shape of those reductions by time period.

In order to apply these resource based costing periods PAs would have to be able to determine the portion of each RC&I end-use load that occurs in each costing period. PAs should be able to obtain that load shape information from the gas utility supplying their service territory. Gas utilities typically have formulae for predicting gas use per customer by month for each major rate class. For example, a formula for residential heating use per customer might be zero base use per day + 0.012 Dth per heating degree day (HDD) while the formula for residential n0n-heating use per customer might be 0.04 Dth/day plus + zero Dth per HDD. PAs would use these formulae, plus the HDD per month, to project the load shape of each major end use.

Chapter 3: Avoided Costs of Fuel Oil and Other Fuels by Sector

3.1 Introduction

This draft deliverable presents our forecasts of avoided costs for petroleum products used in electric generation as well as in the residential, commercial, and industrial sectors in New England. All of these forecasts are driven by our forecast of crude oil prices. For the electricity generation sector, we forecast avoided costs of No. 2 (distillate) and No. 6 (residual). For the residential, commercial and industrial sectors we forecast avoided costs of those two grades and of propane. In addition, for the residential sector we also forecast avoided costs of other fuels used for heating purposes, specifically a biofuel blend (B20), kerosene, cordwood, and wood pellets.

The AESC 2015 forecasts for crude oil and petroleum fuels for electric generation are presented in Exhibit 3-1. Crude Oil and Fuel Prices for Electric Generation (2015$). The AESC 2015 forecasts for fuel oil and other fuels in the residential, commercial and industrial sectors are presented in Exhibit 3-2.

Exhibit 1 7 presents the AESC 2015 fifteen year levelized avoided costs for selected fuels in the residential and commercial sectors, as well as the comparable levelized costs from AESC 2013

3.2 Forecast of Crude Oil Prices

AESC 2015, like the AESC 2013 Study, recognizes that crude oil prices constitute the dominant component of petroleum product prices. The AESC 2015 forecast of crude oil prices begins with the forecast of crude oil (West Texas Intermediate or WTI) from the EIA AEO 2014 Reference case, which was prepared in the fall of 2013. Our analyses use prices of WTI for this comparison because it is reflects domestic markets, is actively traded, and its price in the past has been very close to that of the low-sulfur light crude used in EIA's Reference Case.

We then make a downward adjustment to the projected costs of crude and petroleum products to reflect changes in the outlook since AEO 2014 was prepared. That adjustment is based on our assessment of recent trends in U.S. oil production and the significant drop in oil prices in the last six months and revised outlook as reflected in current NYMEX futures prices.[44]

[44] AESC 2015 projections using NYMEX all rely on settlement prices as of December 18, 2014.

Exhibit 3-1. Crude Oil and Fuel Prices for Electric Generation (2015$)

Year		Crude Oil Prices				Electric Generation (1)	
		AEO 2014 Reference case WTI	WTI NYMEX Futures as of December 18 2014	AESC 2015 Forecast WTI		Distillate Fuel Oil	Residual Fuel Oil
		$/MMBtu	$/MMBtu	$/MMBtu	$/BBl	$/MMBtu	$/MMBtu
		2015$	2015$	2015$	2015$	2015$	2015$
2015		$ 16.21	$ 9.65	$ 9.72	$ 56.40	$ 12.77	7.11
2016		$ 15.90	$ 10.25	$ 10.34	$ 59.96	$ 13.37	7.38
2017		$ 16.10	$ 10.58	$ 11.46	$ 66.46	$ 14.44	7.91
2018		$ 16.31	$ 10.68	$ 12.23	$ 70.94	$ 15.38	8.42
2019		$ 16.72	$ 10.69	$ 12.54	$ 72.74	$ 15.76	8.64
2020		$ 17.14	$ 10.61	$ 12.85	$ 74.54	$ 16.13	8.94
2021		$ 17.59	$ 10.45	$ 13.19	$ 76.50	$ 16.51	9.20
2022		$ 18.04	$ 10.26	$ 13.53	$ 78.49	$ 16.90	9.62
2023		$ 18.52	$ 10.06	$ 13.89	$ 80.57	$ 17.25	9.88
2024		$ 18.97		$ 14.23	$ 82.52	$ 17.61	10.08
2025		$ 19.39		$ 14.54	$ 84.33	$ 17.93	10.29
2026		$ 19.74		$ 14.80	$ 85.86	$ 18.18	10.64
2027		$ 20.18		$ 15.13	$ 87.77	$ 18.52	10.99
2028		$ 20.53		$ 15.40	$ 89.32	$ 18.74	11.09
2029		$ 20.90		$ 15.68	$ 90.92	$ 19.02	11.50
2030				$ 15.90	$ 90.92	$ 19.02	11.50
Levelized Costs							
2016-2025	10			$12.80	$74.22	$16.04	$8.97
2016-2030	15			$13.55	$78.54	$16.82	$9.61

Exhibit 3-2. Avoided Costs of Fuel Oil and Other Fuels by Sector (2015$)

Year		Residential						Commercial		Industrial	
		Distillate Fuel Oil	Propane	Kerosene	B20	Cord Wood	Wood Pellets	Distillate Fuel Oil	Residual Fuel	Distillate Fuel Oil	Residual Fuel
		$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu
		2015$	2015$	2015$	2015$	2015$	2015$	2015$	2015$	2015$	2015$
2015		$ 15.35	$ 14.10	$ 16.75	$ 14.94	$ 5.44	$ 6.19	14.09	12.67	13.80	12.67
2016		$ 16.17	$ 15.29	$ 17.64	$ 15.73	$ 5.73	$ 6.52	14.91	13.41	14.67	13.41
2017		$ 17.51	$ 17.14	$ 19.10	$ 17.04	$ 6.20	$ 7.06	16.23	14.51	16.04	14.51
2018		$ 18.61	$ 18.38	$ 20.30	$ 18.11	$ 6.59	$ 7.50	17.28	15.37	17.09	15.37
2019		$ 18.99	$ 18.57	$ 20.72	$ 18.48	$ 6.73	$ 7.65	17.69	15.60	17.52	15.60
2020		$ 19.36	$ 18.70	$ 21.12	$ 18.84	$ 6.86	$ 7.80	18.05	15.89	17.88	15.89
2021		$ 19.74	$ 18.92	$ 21.53	$ 19.20	$ 6.99	$ 7.95	18.44	16.15	18.27	16.15
2022		$ 20.13	$ 19.09	$ 21.96	$ 19.58	$ 7.13	$ 8.11	18.85	16.57	18.70	16.57
2023		$ 20.48	$ 19.21	$ 22.34	$ 19.93	$ 7.25	$ 8.25	19.18	16.83	19.00	16.83
2024		$ 20.84	$ 19.37	$ 22.73	$ 20.27	$ 7.38	$ 8.40	19.49	17.03	19.29	17.03
2025		$ 21.16	$ 19.55	$ 23.09	$ 20.59	$ 7.50	$ 8.53	19.82	17.24	19.63	17.24
2026		$ 21.41	$ 19.70	$ 23.35	$ 20.83	$ 7.58	$ 8.63	20.08	17.60	19.89	17.60
2027		$ 21.75	$ 19.85	$ 23.73	$ 21.17	$ 7.71	$ 8.77	20.42	17.94	20.22	17.94
2028		$ 21.97	$ 19.98	$ 23.97	$ 21.38	$ 7.78	$ 8.85	20.63	18.04	20.42	18.04
2029		$ 22.25	$ 20.12	$ 24.27	$ 21.65	$ 7.88	$ 8.97	20.90	18.45	20.69	18.45
2030		$ 22.47	$ 20.25	$ 24.51	$ 21.87	$ 7.96	$ 9.06	$ 21.13	$ 18.65	$ 20.93	$ 18.65
Levelized Costs											
2016-2025	10	$19.20	$18.35	$20.94	$18.68	$6.80	$7.74	$17.90	$15.79	$17.71	$15.79
2016-2030	15	$20.01	$18.83	$21.83	$19.47	$7.09	$8.06	$18.70	$16.47	$18.51	$16.47

3.2.1 Increase in U.S. Tight Oil Production

Just as U.S. natural gas production increased steeply since 2009, so too has oil and liquids production. Since 2010, as documented in AESC 2013, drillers have been moving aggressively to shift their focus toward shale plays that have been more liquids-prone than dry-gas prone, e.g., preferring plays like the Eagle Ford, Permian, Bakken and Niobrara fields. These shifts have been motivated not only by high global oil prices, but also by the ready ability to sell and export co-produced natural gas liquids (and, more recently, condensates as well). In addition, producers have been able to improve cash flows by selling off by-product natural gas in shale fields where gas can be transported and stored using a base of existing infrastructure, e.g., especially in Texas, from the prolific Eagle Ford and Permian Basin oil-prone regions.

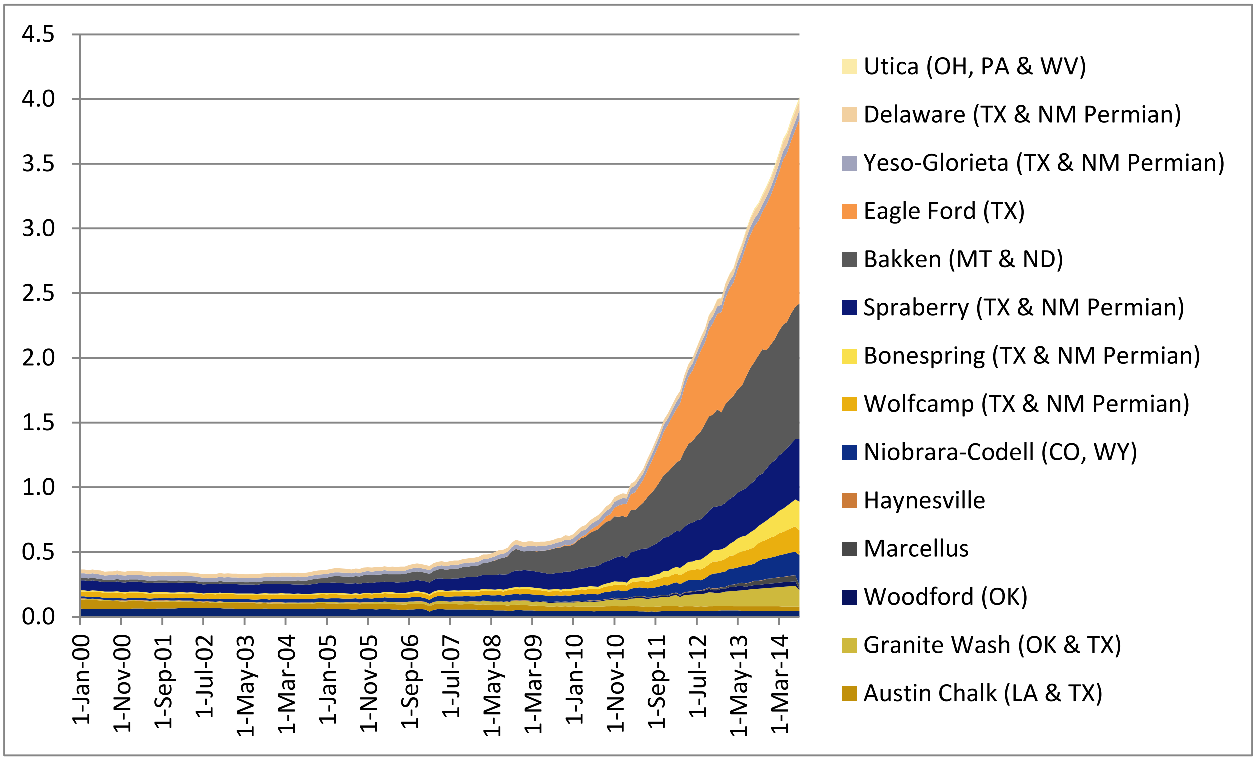
The resulting surge in production of oil and liquids is shown in

Exhibit 3-3. U.S. tight oil production[45] surpassed 4 million barrels per day (MBD) before the end of 2014, and appeared on its way to continue increasing in 2015, despite lower crude oil prices and a lower rig count.[46] U.S. tight oil production appears heading toward the 5-6 MBD range, as matters stood in December 2014.

[45] The term "tight oil" is loosely applied to a number of light crude oil and condensate liquids produced from shale wells.

[46] EIA, Today in Energy, "Despite lower crude oil prices, U.S. crude oil production expected to grow in 2015," January 2, 2015.

Exhibit 3-3. U.S. Monthly Tight Oil Production, by Field, million bbl/day



Source: EIA Administrator Adam Sieminski, in presentation before the US-Canada Energy Summit, Chicago, IL, October 17, 2014; compiled from state administrative data collected by DrillingInfo Inc. Data are through August 2014 and represent EIA's official tight oil & shale gas estimates, but are not survey data. State abbreviations indicate primary state(s).

Increased U.S .oil production since 2010 has, in turn, produced a corresponding and unexpected sharp decline in U.S. oil imports, thereby weakening global oil prices. Indeed, the decline in global crude oil prices that began in late summer 2014 has resulted in part from increased U.S. tight oil production, a linkage that has become clear since the AESC 2013 report. Moreover, global oil market participants observe the rate of U.S. oil production increases shown in

Exhibit 3-3 and, thereby, reasonably anticipate further reductions in U.S. oil importation.

At the same time U.S. oil production has been rising and oil imports have been declining, continuing economic weakness in Europe, Russia and the Asia Pacific region have contributed to relatively stagnant demand for petroleum products globally. In addition, structurally reduced oil demand in the U.S., hitherto the world's largest oil consumer, has resulted from increasingly stringent vehicle efficiency standards.[47] Thus, stagnant global oil demand and rising U.S. oil production have combined to weaken

[47] This includes tightening under both the Bush and Obama Administrations of U.S. Corporate Average Fuel Economy (CAFE) standards and corresponding penalties, as well as the DOE's Advanced Technology Vehicles Manufacturing (ATVM) loans which, again under both Administrations, have launched quantum improvements in hybrid and battery all-electric vehicle

global oil markets significantly – and both conditions are likely to persist into 2015. Eventually, cash-strapped OPEC countries will succeed in raising crude oil prices, although we do not expect OPEC will be able to restore crude prices to the levels seen from 2012 to 2014. Consequently, AESC 2015 projects levelized crude oil prices of $12.30 per MMBtu (2015$) over the next decade, as shown in Exhibit 3-1, which corresponds to a levelized price of $71.36 per barrel (2015$).

3.2.2 Impact of Lower Crude Oil prices in 2014

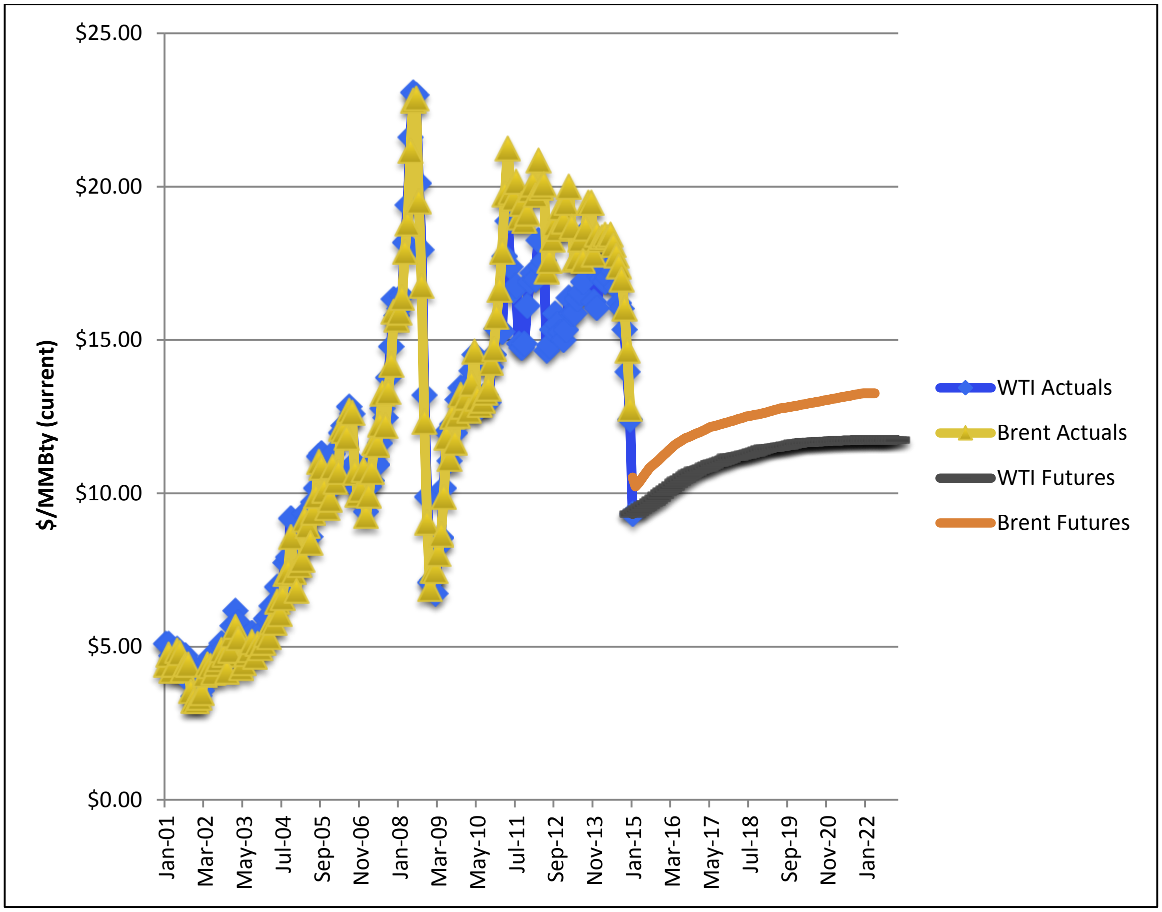
Following on the foregoing discussion of why crude oil price have fallen, analysts are currently debating a number of inter-related questions:

- Why, when, at what levels, and how many times will oil prices hit bottom?
- What will be the effects on U.S. tight oil production, and the U.S. economy?
- How will recent, less aggressive WTI crude forecasts play into future fuel oil prices for DFO and RFO, and competition with natural gas?

To appreciate the questions and think about the answers, one of the important distinctions in global crude prices is the difference between spot and futures (or forward) market prices. As demonstrated in Exhibit 3-4, global oil commodity futures markets anticipate that global and U.S. benchmark prices, respectively Brent and West Texas Intermediate (WTI), will for various reasons stabilize somewhat above current spot price levels. In general, crude markets anticipate somewhat recovered crude oil prices because of the rising need for cash on the part of some OPEC members, recovering demand, and increasing pressures to raise or at least stabilize prices.

technologies. See, for example, the EIA's discussion at http://www.eia.gov/todayinenergy/detail.cfm?id=7390 and the DOE's review at http://energy.gov/lpo/services/atvm-loan-program.

Exhibit 3-4. Monthly Prices of Natural Gas and Crude Oil – Actuals and Futures, 2001-2022



Source: CME-NYMEX, settlement prices at December 18, 2014; note figure plots past monthly spot prices for Henry Hub gas, WTI crude oil and Brent, as well as recent closing futures prices on CME-NYMEX for each of these same three commodities.

Even before global oil prices began to decline in 2014, U.S. tight oil producers were already aggressively moving to improve recovery and management technologies. Such drilling enhancements have reportedly reduced break-even points (BEP) and increasing per-barrel returns to producers.[48] No systematic, timely analyses of this effect are yet available in public literature, although early reports appear to suggest workable BEPs in the major tight oil-producing areas have variously fallen from crude oil prices of $50 per barrel to $70 per barrel, to as low as the $30 to $50 range.[49]

[48] In general, the break-even point is the point at which the discounted profit-to-investment ratio equals one, i.e., the net operating income over time of a project equals the sum of investments over time, taking into consideration the time value of money (Society of Petroleum Engineers, Petroleum Economics, see petrowiki.org/PEH%3APetroleum_Economics#cite_note-r9-8).

[49] Note October 2014 estimates of analysts at EIA, Morgan Stanley, GlobalData Ltd. cited in http://www.bloomberg.com/news/2014-10-14/u-s-shale-oil-output-growing-even-as-prices-drop-eia.html

Energy economist Phillip K. Verleger, a practicing oil market analyst for four decades, posits that, even if there is a repeat of the unbridled crude oil price collapse of 1989-1999, "…cash WTI decreases to $45 per barrel, while forward prices fall to around $72. Such declines would have important implications for North American crude production. [However] forward oil at $72 would probably provide sufficient incentive to maintain activity in the Bakken, Eagle Ford Shale, Julesburg, and Permian Basin shale."[50] Verleger wisely cautions that all such forecasts and analogies are fraught with risk.

In summary, we anticipate U.S. tight oil production will continue on a path to at least 5 MBD, and possibly as high as 8 MBD.[51] We anticipate this will force OPEC members finally to agree, perhaps in a series of meetings throughout the winter of 2014-2015, to reduced production quotas. Such agreement will, in turn, stabilize crude oil prices and avert a repeat of the 1998-1999 oil price war, or shorten (or prevent) a price war that might otherwise take place.

3.3 AESC 2015 WTI Forecast versus AEO 2014 Reference Case and December 2014 Futures Prices

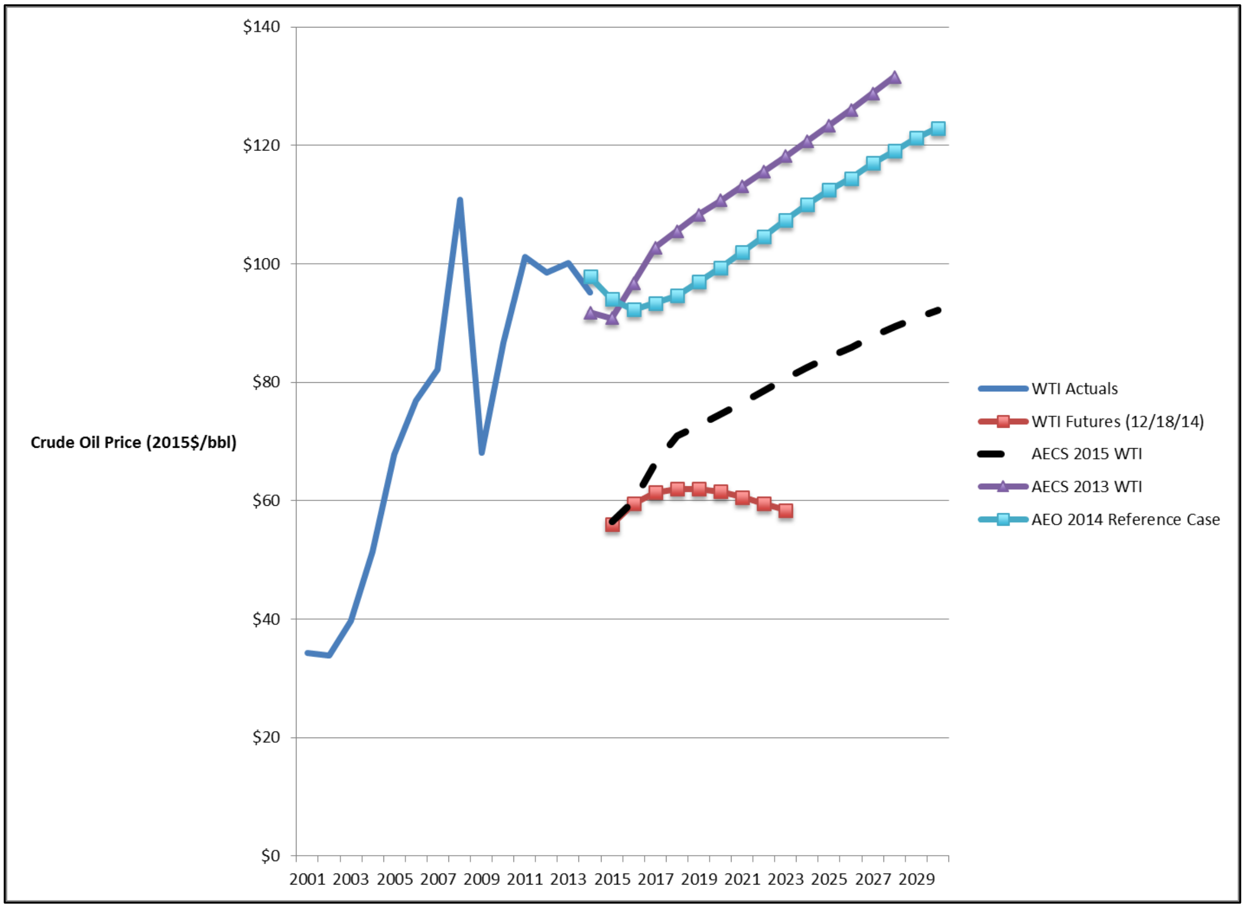
Our first step in developing a forecast of crude oil prices was to compare the EIA AEO 2014 Reference Case forecast of WTI prices with NYMEX futures prices for WTI as of December 18, 2014.

Just as in AESC 2013, this comparison revealed a significant difference between NYMEX futures for WTI in the medium to long term, and the AEO Reference Case forecast prices. That disparity is presented in **Exhibit** 3-5 which plots, in 2015 dollars per bbl, (1) actual WTI oil prices since 2001, (2) WTI futures through 2022, (3) AEO 2014 Reference Case forecasts, and (4) AESC 2013 and 2015 forecast prices through 2028 and 2030, respectively.

50 Phillip K. Verleger, "Notes at the Margin: Oil Price War 3.0," Vol XVIII, No. 42, October 13, 2014.

51 This range is consistent with the range of tight oil production increases in the AEO 2014 Reference Case and High Oil & Gas Resource Case, respectively.

Exhibit 3-5. WTI Crude Price History, Annual Average NYMEX Futures as of December 18, 2014, and AEO and AESC Forecasts (2015$ per bbl)



The exhibit shows that the AEO 2014 Reference Case projections of crude oil prices differ dramatically from NYMEX futures as of December 2014.

The AESC 2015 Base Case forecast of crude oil prices reflects an average 25% downward adjustment to the AEO 2014 Reference Case forecast to reflect changes in the oil market outlook since AEO 2014 was prepared. We make this level of adjustment in the crude oil and corresponding petroleum product price projections because we believe from our understanding of current and expected oil markets that forward oil prices throughout the AEO 2014 Reference Case are overstated by about 25% to 30%, hence an average 25% downward adjustment is conservative. AEO 2015 will not be released by EIA in time to include its oil market insights and forecast as price drivers for AESC 2015. Indeed, our understanding is that the early release of AEO 2015, previously scheduled for mid-December 2014 , has been held up for much these reasons, in particular, to afford EIA sufficient time to revise its crude oil and petroleum product price projections. We expect the AESC 2015 Base Case forecast of crude oil prices, to be generally consistent with oil market forecasts in the forthcoming AEO 2015 Reference Case.

With the foregoing in mind, the AESC 2015 forecast of WTI crude oil prices (the dashed line in **Exhibit** 3-5) begins in 2015 and 2016 with average annual NYMEX WTI crude settlement prices in each year, which, respectively equal 60% and 65% of the AEO 2014 Reference Case WTI crude oil price projections in these two years. During the long-term forecast years, 2018 through 2030, AESC 2015 crude prices equal 75% of the AEO 2014 Reference Case crude forecast, as described above. During 2017, the AESC 2015 price transitions to the long-term forecast level, equaling 72% of the AEO 2014 Reference Case WTI price forecast.

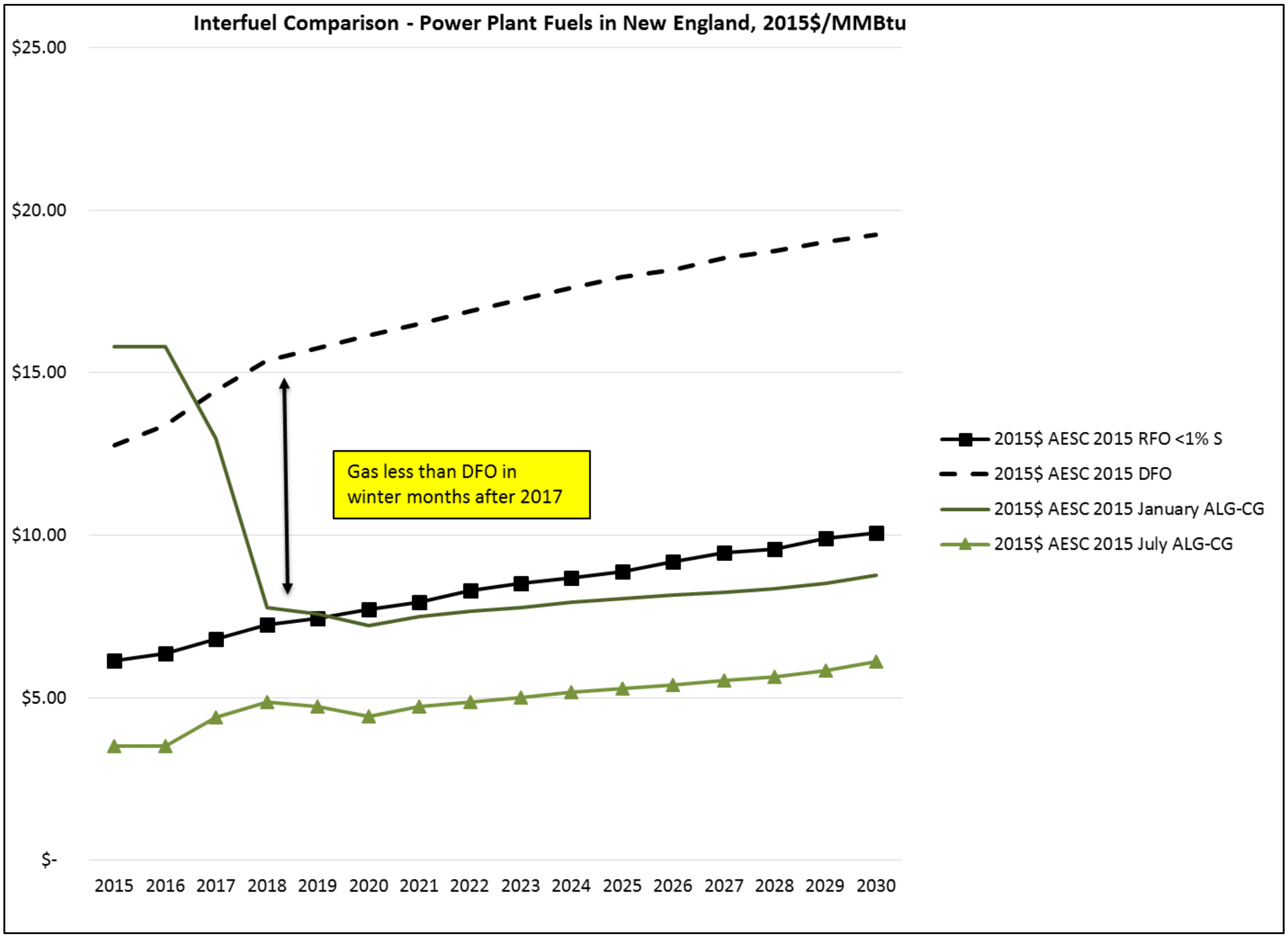
3.4 Avoided Costs of Fuel for Electric Generation

AESC 2015 provides forecasts of prices for distillate, residual, and coal for electricity generation in New England.

3.4.1 Forecast Prices of Distillate and Residual

AESC 2015 forecasts of distillate fuel oil (DFO) and residual fuel oil (RFO) for electric generation reflect the same level of discount from the corresponding AEO 2014 Reference Case projections for DFO and RFO to electricity generators in New England. As indicated in Exhibit 3-6, these projections indicate that DFO will be competitive with natural gas for electric generation in the winter months from 2015 through 2017. However, DFO is not projected to be competitive in the mid- to long-term, once additional pipeline capacity comes into service and natural gas basis to New England drops to levels seen prior to 2012.

Exhibit 3-6. Projected wholesale gas costs in New England vs. DFO and RFO



3.4.2 Forecast Prices of Coal

The AEO 2015 Reference Case assumes that coal in New England will remain unchanged in real term from the current levels. We consider this reasonable. The U.S. has substantial coal resources and coal prices have been relatively stable over a long time period without the volatility seen in oil and natural gas prices. While coal at the mine mouth is relatively cheap on an energy basis, it is expensive to transport and to burn. Coal is more expensive in New England because of the transportation costs, and represents a smaller fraction of annual electric generation in New England than most other parts of the U.S.

Coal demand is also unlikely to increase because of the age of existing coal-fired generation plants, various environmental concerns and anticipated retirements of coal-fired generation in many parts of the United States and specifically in New England. We use plant-specific actual coal prices as reported by SNL Energy for 2015. These coal prices in $/MMbtu are:

Brayton Point 1-3	$2.35
Bridgeport Harbor 3	$2.46
Merrimack 1-2	$4.04
Schiller 4&6	$3.81

3.5 Avoided Costs of Petroleum Prices in the Residential, Commercial, and Industrial Sectors

The AEO 2014 Reference Case provides forecasts of prices for distillate, residual fuel oil and propane in the residential, commercial, and industrial sectors in New England. The retail price of each fuel in each sector of a given state can be separated into two major components. The first component is the price of the underlying resource, crude oil. The second component is a margin, or the difference between the price of each fuel at the retail level and the crude oil price. The margin represents the aggregate unit costs of the refining process, distribution, and taxes attributed to the particular fuel by sector and state. As in AESC 2013, we developed our forecast of prices for fuels in each sector in two basic steps:

- First, we calculated the price margin implicit in the AEO 2013 forecast of the New England regional price for each fuel, expressed as a ratio to the crude oil price, and compared it to the historical price margin, calculated from historical price data.
- Second, we derived regional forecasts of New England prices for each fuel by multiplying our forecast of the crude oil price by the above product price ratios.

The AESC 2015 forecast of regional prices of petroleum and related products by sector is based on the following approaches:

- **No. 2 and 6 Fuel Oil:** The AEO 2015 Reference Case forecast of product prices for New England by sector were adjusted by the ratio of AESC 2015 crude oil forecast to AEO 2013 crude oil forecast.
- **No. 4 Oil:** We did not prepare a projection. No. 4 is a blend of distillate and residual and we had no data on the relative proportions of that blend.
- **B20:** The AEO 2015 forecast is based on the average ratio of B20 diesel and diesel prices in New England, as well as a review of data on bioheat available from heating oil dealer websites. We did not prepare a projection for B5 as that blend does not appear to have a material market share.

Since oil prices did not show meaningful variations by month or season, we did not develop monthly or seasonal price variations for petroleum products. Storage for petroleum products is relatively inexpensive and this also tends to smooth out variations in costs relative to market prices. For these reasons our forecast does not address volatility in the prices of these fuels.

3.5.1 Weighted Average Avoided Costs by Sector Based on Regional Prices

We developed weighted average costs of avoided petroleum-related fuels by sector by multiplying our projected regional prices for each fuel and sector by the relative quantities of each petroleum-related fuel that AEO 2015 projects will be used in that sector. The relative quantity of each petroleum-related fuel that AEO 2015 projects for each sector, expressed as percentages, will be presented in Appendix D. The resulting weighted average costs of avoided petroleum-related fuels by sector will also be presented in Appendix D.

3.5.2 Prices by State by Sector

To determine if there were material differences by state in the historical prices for any of these fuels in these sectors, we analyzed the actual prices by sector in each state from 1999 through 2012 using data from the EIA State Energy Data System (SEDS). This is the most complete and consistent source of state-level energy prices.

Given the uncertainty associated with future quantities of fuel use by state by sector, future policies on fuel taxes by state by sector, and other uncertainties, we concluded that no further precision would be obtained from an estimate of avoided petroleum-related fuel prices by sector by state.

3.6 Avoided Costs of Other Residential Fuels

AESC 2015 developed forecast avoided costs for propane, kerosene, cordwood and wood pellets.

- The avoided costs for propane are based on the AEO 2014 Reference case forecast and the AESC 2015 crude oil price forecast.
- The avoided costs for kerosene are based on AESC 2015 forecast of distillate in the residential sector and the historical average ratio between the price of kerosene and the price of distillate from EIA SEDS data.
- The avoided costs for cordwood and for wood pellets are based on AESC 2015 forecast of distillate in the residential sector, the historical average ratio between the price of cord wood and the price of distillate in the residential sector from EIA SEDS data, and the price of pellets versus of cord wood as reported by state agencies in Vermont, New Hampshire and Maine.

Exhibit 3-7 presents the AESC 2015 fifteen year levelized avoided costs for selected fuels in the residential and commercial sectors, as well as the comparable levelized costs from AESC 2013.

Exhibit 3-7. Avoided Costs of Retail Fuels (15 year Levelized, 2015$) - AESC 2015 vs. AESC 2013

Sector	Residential						Commercial	
Fuel	No. 2 Distillate	Propane	Kerosene	BioFuel	Cord Wood	Wood Pellets	No. 2 Distillate	No. 6 Residual (low sulfur)
AESC 2015 Levelized Values (2015$/MMBtu); 2016-2030	$ 19.20	$ 18.35	$ 20.94	$ 18.68	$ 6.80	$ 7.74	$18.70	$16.47
AESC 2013 Levelized Values (2015$/MMBtu); 2014-2028	$ 28.89	$ 29.16	$ 31.73	$ 30.35	$ 10.47	$ 17.45	$ 27.78	$ 16.80
AESC 2015 vs AESC 2013, % higher (lower)	-33.5%	-37.1%	-34.0%	-38.5%	-35.0%	-55.6%	-32.7%	-1.9%

Chapter 4: Embedded and Non-Embedded Environmental Costs

4.1 Introduction and Overview

This chapter discusses the values associated with mitigating the most significant airborne pollutants created by: 1) the combustion of natural gas, fuel oil, coal, and biomass for the purpose of electricity generation; and 2) the combustion of natural gas, fuel oil, wood, and kerosene for use in commercial, industrial, and residential sectors. These values, or environmental costs, have two components, referred to as "embedded" and "non-embedded" environmental costs.

Embedded environmental costs are environmental costs that are reflected in the market prices of fuels and/or of electric energy produced fuels. AESC 2015 embeds environmental costs explicitly as pollutant allowance prices which are in turn reflected in marginal electricity prices, i.e., avoided market costs. AESC 2015 also embeds environmental costs implicitly through its assumptions regarding the operating characteristics of generating units, and the characteristics of new units added to meet capacity. Those assumptions reflect the impact of environmental regulation on the investment and operating decisions by owners of generating units, e.g., to limit emissions through retrofits or to retire units.

Non -embedded environmental costs are environmental costs imposed on society by the use of these fuels, but not reflected in market prices.

This chapter discusses embedded and non-embedded environmental costs in five major sections:

- **Environmental Regulations: Embedded Costs:** This section identifies avoided costs associated with expected and existing NO_x, SO_2, and CO_2 regulations. These costs are embedded in the assumptions used by our electric market simulation model (pCA) to calculate avoided electric energy costs. Compared to the AESC 2013 assumptions, the AESC 2015 estimates for NO_x and CO_2 are lower by approximately 65% and 14% respectively. The estimate for SO_2 is essentially the same.
- **Non-Embedded Environmental Costs:** For AESC 2015, we anticipate that the non-embedded CO_2 cost will continue to be the dominant non-embedded environmental cost associated with marginal electricity generation in New England. This cost is not included in AESC 2015 avoided cost calculations for electric energy or other fuels. We provide recommendations for PAs to apply avoided non-embedded CO_2 costs in their evaluations of EE programs.
- **Value of Mitigating Significant Pollutants:** This section identifies and describes the most significant pollutants associated with electricity generation, end-use natural gas, and end-use fuel oil and other fuels. The section then provides the value associated with

mitigating those pollutants for end-use natural gas, fuel oil, and other fuels based on AESC 2015 NO_x, SO_2, and CO_2 emissions allowance prices per short ton (embedded costs), and the AESC 2015 recommended CO_2 (non-embedded) abatement cost. For end-use natural gas, fuel oil, and other fuels, the value of mitigating significant pollutants is non-embedded.

- **Discussion of Non-Embedded NO_x Costs:** This section addresses non-embedded NO_x costs, at the request of the Study Group, in order to increase awareness. Please note that we are *not* recommending that PAs use an additional non-embedded NO_x value beyond the embedded allowance prices discussed in this chapter. Instead, we recommend a methodology consistent with AESC 2013.
- **Compliance with State-Specific Climate Plans:** this section describes our review of state-specific regulations or climate plans that would directly impact the cost of electric generation over the study period.

Emissions from hydraulic fracturing are covered in Chapter 2.

4.2 Environmental Regulations: Embedded Costs

For all fuels, we estimate the embedded value associated with the mitigation of NO_x, SO_2, and CO_2 based on the allowance prices per short ton of emissions described and presented in this section. In addition, future environmental regulations will impact generator expenses, outages, and retirement decisions, which are inputs into our simulation model.

4.2.1 Cost of Complying with Existing and Expected SO_2, NO_x, and CO_2 Regulations

AESC 2015 applies the per-unit costs of complying with regulations governing the emissions of SO_2, NO_x and CO_2 in the pCA electricity market model simulations. pCA includes the unit costs associated with each of these emissions when calculating the generator offer prices used to make commitment and dispatch decisions. In this way, AESC 2015 projects market prices that reflect, or “embed,” the compliance costs for each type of emission, excluding mercury.

The per-unit compliance costs assumed for each pollutant are presented in Exhibit 4-1. NOx allowance prices have fallen considerably since AESC 2013, from approximately $28 per ton to approximately $10 per ton in AESC 2015. At $1.11 per ton, the 2015 SO_2 prices are little changed from the $0 AESC 2013 value. The 15-year levelized value of the embedded avoided cost of carbon compliance for AESC 2015 is 14 percent lower than AESC 2013 (2015$), i.e., $15.68/ton versus $20.42/ton. This decrease is primarily due to a slightly lower forecast of Regional Greenhouse Gas Initiative (RGGI) prices through 2020, reliance on year 2029 results from a regional CO_2 price forecast for 2021 onward based on a simulation of EPA’s proposed Clean Power Plan (CPP) and an assumed linear transition from the RGGI 2020 value to the 2029 CPP forecast value.

Exhibit 4-1. Emission Allowance Prices per Short Ton (Constant 2015$ and Nominal Dollars)

	NOx		SO2		CO2	
Year	2015$	Nominal	2015$	Nominal	2015$	Nominal
2015	10.00	10.00	1.11	1.11	6.28	6.28
2016	10.00	10.17	1.11	1.13	7.26	7.38
2017	10.00	10.16	1.11	1.15	7.87	8.15
2018	10.00	10.57	1.11	1.17	8.47	8.95
2019	10.00	10.78	1.11	1.19	9.32	10.05
2020	10.00	11.00	1.11	1.22	10.16	11.18
2021	10.00	11.22	1.11	1.24	12.54	14.07
2022	10.00	11.44	1.11	1.27	14.92	17.07
2023	10.00	11.67	1.11	1.29	17.30	20.18
2024	10.00	11.90	1.11	1.32	19.67	23.42
2025	10.00	12.13	1.11	1.34	22.05	26.74
2026	10.00	12.36	1.11	1.37	24.43	30.18
2027	10.00	12.59	1.11	1.39	26.80	33.74
2028	10.00	12.82	1.11	1.42	29.18	37.42
2029	10.00	13.07	1.11	1.45	31.56	41.23
2030	10.00	13.31	1.11	1.47	33.94	45.17

NO_x & SO_2 from SNL Financial. CO_2 (2015-2020) from RGGI Updated Model Rule Modeling. CO_2 (2029) from "Critical Mass: An SNL Energy Evaluation of Mass-based Compliance Under the EPA Clean Power Plan," SNL Energy. CO_2 (2021-2028): linear interpolation. CO_2 (2030): linear extrapolation.

NO_x and SO_2

The NO_x and SO_2 allowance prices are based on values provided by SNL Financial, which constitute the pCA default assumptions.[52] Since there is still considerable uncertainty about the longer term, we have kept NO_x and SO_2 prices level at constant 2015 dollar (2015$) values. For mercury, we assume no trading, and hence no allowance price.

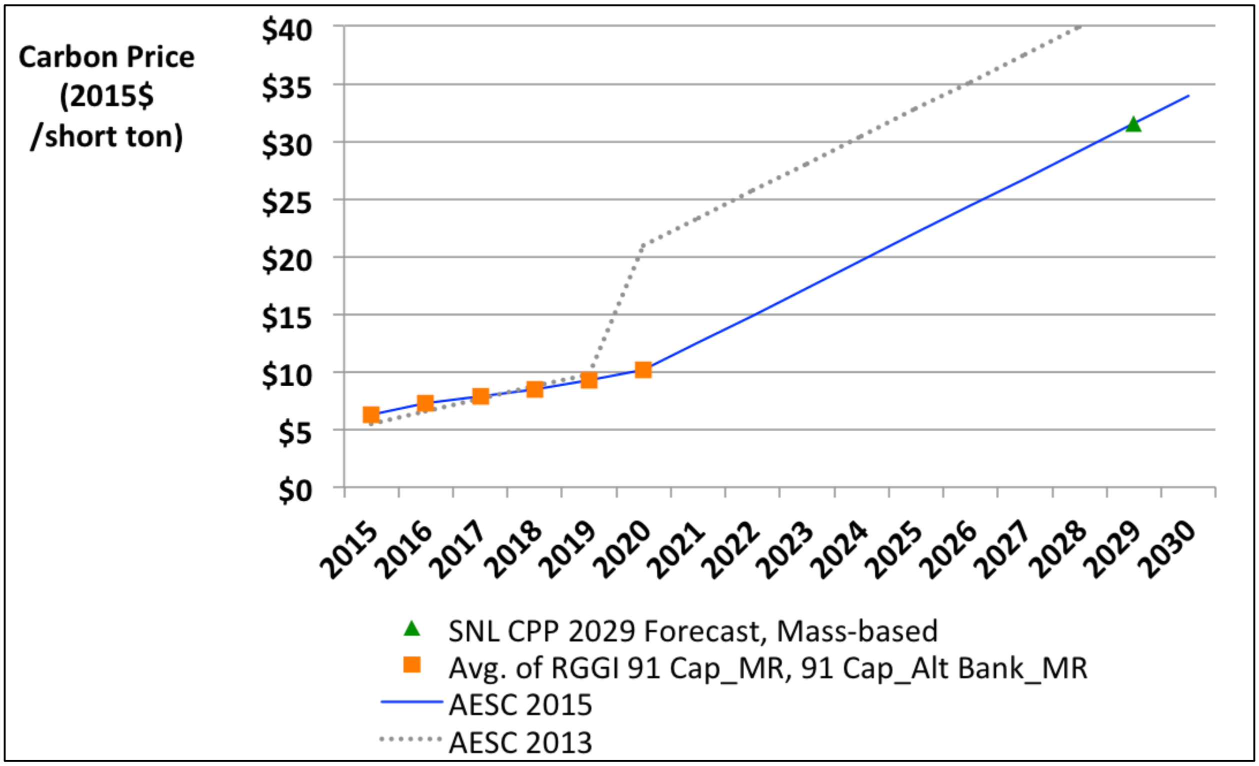
[52] The SNL values were found to be consistent with those in other sources, such as Megawatt Daily and Argus Air Daily.

CO_2

AESC 2015 assumes CO_2 regulation under the Regional Greenhouse Gas Initiative (RGGI) through 2020, and CO_2 regulation under EPA's proposed Clean Power Plan (CPP) between 2021 and 2030.

The AESC 2015 CO2 forecast is presented in Exhibit 4-2.

Exhibit 4-2 AESC 2015 Carbon Price Forecast



Our Base Case estimates of embedded CO_2 costs through 2020 are derived from RGGI allowance price forecasts through 2020. In February of 2012, the RGGI states agreed to reduce the 2014 CO_2 cap from 165 million to 91 million tons, a reduction of 45%. The cap would decline 2.5% each year from 2015 to 2020.[53] The RGGI states' analysis indicated that this would result in the allowance price rising to between approximately $4 and $6 per short ton (2010$) in 2014 and increasing to between approximately $8 and $10 per ton (2010$) in 2020, depending on the scenario. AESC 2015 uses annual prices that are the averages of those projected for the scenarios 91_Cap_Bank_MR and 91_Cap_AltBank_MR.[54]

[53] This annual reduction results in a 2020 cap value of 78.1 million short tons.

[54] RGGI IPM Analysis: Amended Model Rule, February 8, 2013, and associated IPM modeling results data. Available at: http://www.rggi.org/docs/ProgramReview/February11/. The average of the two scenarios modeled prices for 2014 (in current dollars) is very close to the RGGI December 3, 2014 auction price of $5.21.

Between 2020 and 2029, EPA has proposed that an interim standard would apply, which states or regions would be required to meet on average over the period.[55] Under the CPP as proposed, states or regions will have the option to comply with either an emissions rate-based standard, or its mass-based equivalent. Based on comments submitted by RGGI, and discussions with others following developments related to the regulations closely, we believe that compliance—at least in the RGGI states if not everywhere—is more likely to be implemented using mass-based standards, or mass-based equivalents of rate-based standards. SNL Energy has forecast allowance prices under CPP using AuroraXMP.[56] SNL modeled mass-based compliance under CPP for the RGGI region, without constraints representing the existing RGGI standards or potential extension of them. AESC uses SNL's 2029 (final CPP) value of $31 (2014$), with a linear interpolation between that and RGGI's 2020 value of $10.16 (2010$), extrapolating one year further to 2030.[57] The 2030 extrapolated value, incidentally, is approximately the same as the 2030 EPA modeled value under the rate-based standard.[58]

The sum of the CPP final (2029) goals for the RGGI states combined, in mass-equivalent terms, is 64 million short tons of CO2,[59] which is the level the RGGI cap would reach in 2028, were it to continue to decrease at the established 2014-2020 rate of 2.5% per year. Extending the 2.5% annual decrease in the RGGI cap results in a 2020-2029 average of 70 million short tons, as compared to a CPP interim standard for the RGGI states of 69 million short tons. Exhibit 4-3 shows a comparison of the RGGI cap and combined CPP goal.

[55] SNL does not present estimates for individual years during the interim period. As discussed below, it is expected that the EPA is likely to do away with or waive the interim goals.

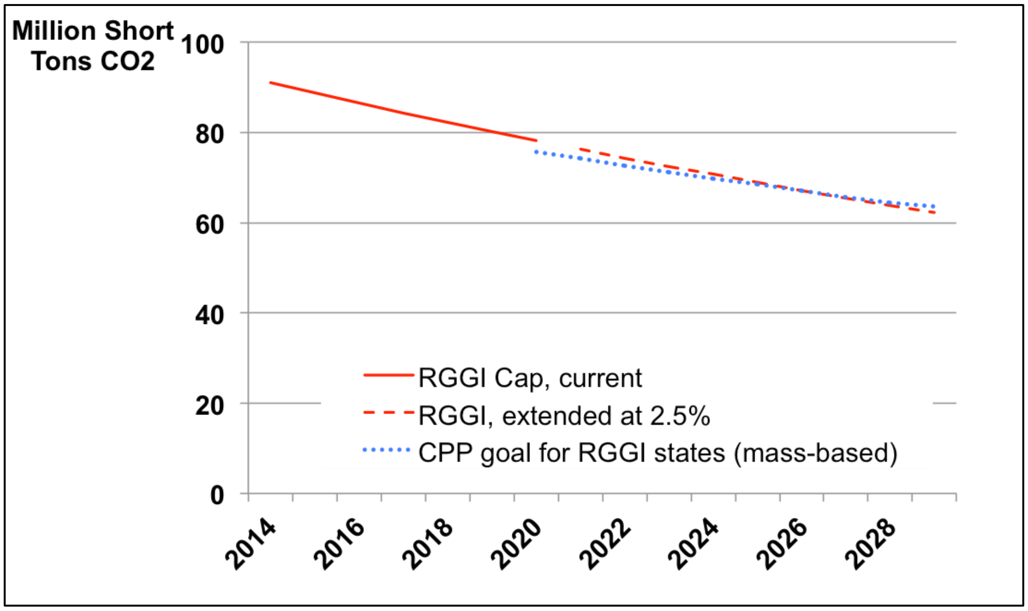
[56] "Critical Mass: An SNL Energy Evaluation of Mass-based Compliance under the EPA Clean Power Plan." A. Gelbaugh et. al, December 2014. http://www.slideshare.net/SNLFinancial/analysis-of-the-epas-clean-power-plan-on.

[57] EPA performed an analysis of example implementations of and compliance with CPP using the simulation tool IPM, developed by ICF, with five-year increments. The simulations were performed assuming compliance with the proposed state emissions rate standards, and assuming a given mix of compliance in each state using the four compliance "building blocks." Under mass-based standards, compliance costs are expected to be lower than under the equivalent rate-based standards.[57] For those reasons, and because we expect the RGGI states to elect to comply using a mass-based standard, we believe that EPA's modeled CO_2 shadow prices for a rate-based constraint are not appropriate for use as a CO_2 price trajectory in AESC.

[58] Based on EPA's IPM simulation results, CO2 shadow price for NPCC, Option 1, rate-based compliance ($34.27 in 2015$). Simulation results available at: http://www.epa.gov/airmarkets/powersectormodeling/docs/Option%201%20Regional.zip.

[59] Calculation based on data in the *Rate to Mass Translation Data File*. *See* U.S. Environmental Protection Agency website. Accessed December 2, 2014. Available at: http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule-technical-documents#rate-to-mass. In this report, we focus on the proposed final CO_2 emissions standards to be achieved by 2030 under compliance "Option 1." The EPA also proposed alternative "Option 2" goals, which reflect emissions reductions that are less stringent but must be met earlier, with an interim goal set for 2020–2024 and a final goal for 2025.

Exhibit 4-3. Current and Extended RGGI Cap Compared to Sum of CPP Goals for RGGI States



Source: Based on RGGI data and data in the U.S. EPA Clean Power Plan Rate to Mass Translation Data File (see text).

4.2.2 Existing and Expected Regulations

This section summarizes the existing and expected environmental regulations that are incorporated into AESC 2015, and which are reflected in Exhibit 4-1, above.

CO2 - Regional Greenhouse Gas Initiative

The Regional Greenhouse Gas Initiative is a cap and trade greenhouse gas program for power plants in the northeastern United States. Current participant states include Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. Pennsylvania, Québec, New Brunswick, and Ontario are official "observers" in the RGGI process. As of March 11, 2015, 27 RGGI auctions have occurred.

RGGI is designed to:

- Limit CO_2 emissions from power plants to 2009 levels for the period 2009 – 2013, followed by a 53 percent reduction below those levels by 2020.
- Allocate a minimum of 25 percent of allowances for consumer benefit and strategic energy purposes. Allowances allocated for consumer benefit will be auctioned and the proceeds of the auction used for consumer benefit and strategic energy purposes.

- Include certain offset provisions that increase flexibility to include opportunities outside the capped electricity generation sector.[60]

EPA Regulations—Greenhouse Gases

Greenhouse Gas Tailoring Rule

Under EPA's Greenhouse Gas Tailoring Rule, large sources of greenhouse gas emissions are subject to permitting requirements. For purposes of determining whether New Source Review applies, a "large source" is a new facility with emissions of at least 100,000 tons per year of carbon dioxide equivalent (CO_2e) or an existing facility that emits at least 100,000 tons per year CO_2e and is making modifications that would increase greenhouse gas emissions by at least 75,000 tons per year CO_2e. These sources are required to obtain permits under the New Source Review Prevention of Significant Deterioration program and therefore must install Best Available Control Technology (BACT) for greenhouse gases. In the case of a modification, to a facility that does not emit at least 100,000 tons per year CO_2e but will increase greenhouse gas emissions by 75,000 tons per year CO_2e, the BACT requirement only applies for GHG if the project triggers new source review for another criteria pollutant. Any new or existing source with emissions of 100,000 tons per year CO_2e or more must obtain a Title V operating permit.

On June 23, 2014, the U.S. Supreme Court confirmed the EPA's authority to regulate GHG emissions from new and modified stationary sources required to obtain pre-construction and operating permits for non-GHG air pollutants, but held that EPA may not require a source to obtain a pre-construction or operating permit solely on the basis of its potential GHG emissions. The decision upholds EPA's regulation of about 83 percent of stationary source GHG emissions under the PSD/Title V permitting process, because nearly all of these sources also emit significant amounts of criteria air pollutants.[61] In practice, this represents a modest change.

Greenhouse Gas New Source Performance Standards (GHG NSPS)

Under Section 111 of the Clean Air Act, EPA sets technology-based standards for new sources on a category-by-category basis. These standards are set based on the best demonstrated available technology (BDAT) and apply to all new sources built or modified following promulgation of the standard.

[60] *See* Regional Greenhouse Gas Initiative website. Accessed November 25, 2014. Available at: http://www.rggi.org/design/program-review. Our calculation of the 2020 reduction from the 165 million ton 2009 level is as follows: (165-91*(1-0.025)^6)/165 = 53%

[61] Jennings, et al., *Supreme Court rejects premise for GHG Tailoring Rule, but largely maintains EPA's authority to set GHG emission limits*, DLA Piper Climate Change Alert (June 26, 2014). Available at: https://www.dlapiper.com/en/us/insights/publications/2014/06/supreme-court-rejects-premise/

On March 27, 2012, EPA proposed[62] NSPS for greenhouse gas emissions from new electric generating units. The standard was set at 1,000 lb CO_2e/MWh, which is equivalent to the emission rate that a combined-cycle natural gas unit can achieve. The rule also allows a unit's emissions to be averaged over 30 years to achieve an annual average emission rate of 1,000 lb CO_2e/MWh. This option allows the phase-in of CCS within the first 10 years of operation. On January 8, 2014, EPA proposed to withdraw the 2012 proposed GHG NSPS, given that new proposed requirements based on different analyses from the original proposal would establish requirements that would differ significantly from the original proposal.[63]

In September 2013, EPA released a revised 111(b) rule, New Source Performance Standards for GHGs from new sources. The proposed standards for new power plants are the first uniform national limits on CO_2 emissions by new power plants. EPA is proposing separate standards for certain natural gas-fired stationary combustion turbines, fossil fuel-fired utility boilers, and integrated gasification combined cycle (IGCC) units. All standards are in pounds of CO_2 per megawatt-hour (lb CO_2/MWh gross).[64]

Fossil Fuel-Fired Utility Boilers and IGCC Units

EPA is proposing two limits for fossil fuel-fired utility boilers and IGCC units, depending on the compliance period that best suits the unit. These limits require capture of only a portion of the CO_2 from the new unit. These proposed limits are:

- 1,100 lb CO_2/MWh gross over a one-year period, or
- 1,000-1,050 lb CO_2/MWh gross over a seven-year period

Natural Gas-Fired Stationary Combustion Units

EPA is proposing two standards for natural gas-fired stationary combustion units, depending on size. The proposed limits are based on the performance of modern natural gas combined cycle (NGCC) units. These proposed limits are:

- 1,000 lb CO2/MWh gross for larger units (> 850 MMBtu/hr)
- 1,100 lb CO2/MWh gross for smaller units (≤ 850 MMBtu/hr)

[62] 77 Fed. Reg. 22392 (April 13, 2012).

[63] *See* U.S. Environmental Protection Agency website. Accessed December 2, 2014. Available at: http://www2.epa.gov/carbon-pollution-standards/2013-proposed-carbon-pollution-standard-new-power-plants

[64] *Ibid.*

On January 8, 2014, EPA issued a second NPRM on the proposal, and under an updated timeline announced late 2014, it intends to issue a final rule on Carbon Pollution Standards for New, Modified and Reconstructed Power Plants in summer of 2015.[65]

Almost no new coal plants are being proposed due to low gas prices, so the direct impact of Section 111(b) is currently modest. Nevertheless, the proposed rule is being litigated. It is thought that the principal purpose of challenges to Section 111(b) derives from the rule's role as a prerequisite for Section 111(d). Because Section 111(d) only applies to existing sources where there are standards of performance for new sources of the same type, invalidating Section 111(b) could also invalidate Section 111(d).[66]

Opponents question whether the proposed rule conforms to the Energy Policy Act of 2005 since the proposed rule relies on a "new technology," i.e., carbon capture and sequestration (CCS). It is unlikely for the current challenges to succeed, because the plaintiffs are seeking to stop the rulemaking while it is still underway. Future challenges are expected once the final rule is issued.

Clean Power Plan Proposed Rule

While New Source Performance Standards apply only to new facilities, Section 111(d) of the Clean Air Act requires states to develop plans for *existing* sources of any non-criteria pollutants (i.e., a pollutant for which there is no NAAQS) and non-hazardous air pollutant whenever EPA promulgates a standard for a new source. These plans are subject to EPA review and approval, similar to state implementation plans under the NAAQS program.

A draft 111(d) rule controlling GHGs from greenhouse gases existing sources was submitted on March 31, 2014, which laid out a timeline: EPA would propose standards in June 2014, EPA would finalize the standards in June 2015,[67] and states would submit SIPs to EPA in June 2016.[68]

On June 2, 2014, the EPA proposed the *Clean Power Plan* (CPP) to cut carbon emissions from existing power plants. The plan proposed to begin meaningful reductions in 2020, and to cut carbon emission from the power sector by 30 percent nationwide below 2005 levels by 2030, as well as cut particle pollution, nitrogen oxides, and sulfur dioxide by more than 25 percent as a co-benefit.[69] Under the plan,

[65] *See* U.S. Environmental Protection Agency website. Accessed January 27, 2015. Available at: http://www2.epa.gov/carbon-pollution-standards/fact-sheet-clean-power-plan-carbon-pollution-standards-key-dates

[66] "Legal Challenges to Obama Administration's Clean Power Plan," Michael B. Gerrard, New York Law Journal, September 11, 2014. Available at: http://www.arnoldporter.com/resources/documents/NYLJ_Legal Challenges to Obama Administration's Clean Power Plan_09112014.pdf

[67] John Podesta, former White House Chief of Staff, is said to believe that a final rule won't be issued until late summer 2015.

[68] *See* U.S. Environmental Protection Agency website. Accessed December 2, 2014. Available at: http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule

[69] President Obama and Chinese President Xi Jinping announced in November 2014 that the United States intends to set an economy-wide target of reducing CO_2 emissions by 26-28 percent below 2005 levels by 2025. This is roughly consistent with the 30% reduction from 2005 levels by 2030 proposed in the CPP.

each state has the flexibility to choose how to meet the goal using a combination of measures that reflect its particular circumstances and policy objectives. The basic formula for the state goal is a rate: CO_2 emissions from fossil fuel-fired power plants in pounds divided by state electricity generation from fossil-fuel fired power plants and certain low- or zero-emitting power sources in megawatt hours (MWh). EPA is proposing a two-part goal structure: an "interim goal" that a state must meet on average over the ten-year period from 2020-2029 and a "final goal" that a state must meet at the end of that period in 2030 and thereafter. As described above, the EPA also proposed alternative "Option 2" goals, which reflect emissions reductions that are less stringent but must be met earlier, with an interim goal set for 2020–2024 and a final goal for 2025.

Under CAA section 111(d), state plans must establish standards of performance that reflect the degree of emission limitation achievable through the application of the "best system of emission reduction" (BSER). The BSER proposed in the rule is based on a range of measures that fall into four main categories, or "building blocks," which comprise (1) improved generator operations, (2) dispatching lower-emitting generators and (3) zero-emitting energy sources and end-use energy efficiency. Only Building Block 1 is required; the others are optional. The proposed state-level goals reflect the level of reductions in CO^2 emissions and emission rates and the extent of the application of the building blocks that would be presumptively approvable in a state plan during the ramp-up to achieving the final goal.

EPA is also proposing to give states the option to convert the rate-based goal to a mass-based goal if they choose to in their state plans—something the RGGI states have heartily endorsed—and has published proposed conversion factors and methodology.[70] Adopting a mass-based goal would better allow a state or group of states to cap their CO_2 emissions and set up a trading program if they choose that option to meet the goals outlined in the proposal, and would make it easier to avoid double counting contributions of energy efficiency and renewable energy produced in one state and counted in another. EPA is only proposing goals for states with fossil fuel-fired power plants; Vermont and Washington, DC are excluded for that reason.

On October 28, 2014, EPA issued a supplemental proposal, which sets area-specific goals for Indian country and territories and provides options for meeting those goals in a flexible manner. Under a modified timeline announced in late 2014, EPA in summer 2015 would issue final rules on CPP and propose a federal plan for meeting CPP goals for public review and comment. By summer 2016, EPA will be in a position to issue a final federal plan for meeting Clean Power Plan goals in areas that do not submit plans.[71]

It is expected that the EPA is likely to do away with or waive the interim goals, not because of legal challenges, but because of significant push-back from the states. It is also possible that there will be

[70] *See* U.S. Environmental Protection Agency website. Accessed December 2, 2014. Available at: http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule-technical-documents-rate-to-mass

[71] *See* U.S. Environmental Protection Agency website. Accessed January 27, 2015. Available at: http://www2.epa.gov/carbon-pollution-standards/fact-sheet-clean-power-plan-carbon-pollution-standards-key-dates

some adjustment to the stringency of the prescribed state-specific emissions rates. One possibility is that the final overall rate will be the same as that in the proposed rule, but the individual rates will differ from those proposed. The latter is likely because of possible changes in the way Building Block 3 (renewable energy) amounts are calculated.

Although there are current legal challenges to the proposed rule, those are unlikely to succeed because the rulemaking is still in progress, and so are not likely to delay implementation of the rule. Although future lawsuits on the final rule may ultimately be successful, they are unlikely to cause delays in implementation, which would happen only in the rare event that a court issues a stay (as happened with CSAPR). A Supreme Court case on any of the challenges would likely be decided sometime between the spring 2017 and December 2019.

Carbon Pollution Standards for Modified and Reconstructed Power Plants

On June 2, 2014, EPA proposed standards to address carbon dioxide emissions from modified and reconstructed power plants. Like the proposed Carbon Pollution Standards for newly constructed power plants, the proposed Carbon Pollution Standards for modified and reconstructed power plants are also set under the authority of Clean Air Act Section 111(b). A modification, according to the rule, is "any physical or operational change to an existing source that increases the source's maximum achievable hourly rate of air pollutant emissions." A reconstructed source is "a unit that replaces components to such an extent that the capital cost of the new components exceeds 50 percent of the capital cost of an entirely new comparable facility."[72]

The fact that these provisions of Section 111(b) do not rely on new technology may be what ultimately enables the final rule to survive challenges aimed the new source provisions' reliance on CCS.

EPA Regulations—Other Emissions

National Ambient Air Quality Standards

National Ambient Air Quality Standards (NAAQS) set maximum air quality limitations that must be met at all locations across the nation. Compliance with the NAAQS can be determined through air quality monitoring stations, which are stationed in various cities throughout the United States, or through air quality dispersion modeling. States with areas found to be in "nonattainment" of a particular NAAQS are required to set enforceable requirements to reduce emissions from sources contributing to nonattainment such that the NAAQS are achieved and maintained. The U.S. Environmental Protection Agency (EPA) has established NAAQS for six pollutants: sulfur dioxide (SO_2), nitrogen dioxides (NO_2), carbon monoxide (CO), ozone, particulate matter—measured as particulate matter less than or equal to 10 micrometers in diameter (PM10) and particulate matter less than or equal to 2.5 micrometers in diameter (PM2.5)—and lead.

[72] *See* U.S. Environmental Protection Agency website. Accessed December 2, 2014. Available at: http://www2.epa.gov/carbon-pollution-standards/proposed-carbon-pollution-standards-modified-and-reconstructed-power

In nonattainment areas, pollutant sources must comply with emission reduction requirements known as "Reasonably Available Control Technology" (RACT) to bring the areas into attainment of the NAAQS. New major sources, including major modifications at existing sources, must comply with very strict emissions reductions consistent with "lowest achievable emissions reductions" (LAER) and obtain emission offsets.

EPA is currently in the process of drafting new, more stringent NAAQS for SO_2, PM2.5, and ozone.

- On June 22, 2010, EPA revised[73] the standard for SO_2 by establishing a new 1-hour standard at a level of 75 parts per billion (ppb) in place of the existing annual and 24-hour standards for SO_2. EPA on July 25, 2013 designated parts of 16 states as nonattainment for the 2010 SO_2 standard, and the designations were finalized in August 2013. For New England, parts of three counties in central New Hampshire were designated, and New Hampshire revised its state implementation plan (SIP) accordingly.[74] States have until October 2018 to attain the NAAQS.[75] On April 17, 2014, EPA issued a proposed rule that would allow state and local air agencies to use air quality monitoring or modeling to determine whether areas meet the 2010 air quality standards.[76]
- On December 14, 2012, EPA strengthened the annual PM2.5 standard from 15 µg/m3 to 12 µg/m3, and retained the current 24-hour standard at 35 µg/m3. On April 25, 2014, in response to a decision of the D.C. Circuit Court regarding implementation of the PM2.5 standard, EPA classified as "moderate" nonattainment areas for the 1997 and 2006 fine particle pollution standards and set December 31, 2014 as the deadline for states to submit remaining implementation plan requirements, outlining how they will reduce pollution to meet the standard by 2020.[77]
- In March 2008, EPA strengthened the 8-hour ozone standard from 84 ppb to 75 ppb. On September 16, 2009, EPA announced that because the 2008 standard was not as protective as recommended by EPA's panel of science advisors, it would reconsider the 75 ppb standard. In 2010, EPA proposed lowering the 8-hour ozone standard from 75 ppb to between 60 and 70 ppb, and on September

[73] 75 Fed. Reg. 35520 (June 22, 2010)

[74] *See* New Hampshire Department of Environmental Services website. Accessed December 2, 2014. Available at: http://des.nh.gov/organization/divisions/air/do/sip/sip-revisions.htm#so2

[75] *See* U.S. Environmental Protection Agency website. Accessed December 2, 2014. Available at: http://www.epa.gov/airquality/sulfurdioxide/implement.html

[76] *Ibid.*

[77] *See* U.S. Environmental Protection Agency website. Accessed December 2, 2014. Available at: http://www.epa.gov/pm/actions.html

2, 2011, the Administration announced that EPA would not finalize its proposed reconsideration of the 75 ppb standard ahead of the regular 5-year NAAQS review cycle. On November 25, 2014, the EPA proposed lowering the standard to within a range of 65 to 70 ppb. EPA projections show the vast majority of U.S. counties would meet the proposed standards by 2025 just with the rules and programs now in place or under way. States with nonattainment areas would have until 2020 to late 2037 to meet the proposed health standard. The agency will issue a final decision by Oct. 1, 2015.[78]

Cross State Air Pollution Rule

The Cross State Air Pollution Rule (CSAPR), which replaces the 2005 Clean Air Interstate Rule (CAIR), was finalized in 2011, establishing the obligations of each affected state to reduce emissions of NO_x and SO_2 that significantly contribute to another state's PM2.5 and ozone non-attainment problems. CSAPR requires a total of 28 states to reduce annual SO_2 emissions, annual NO_X emissions and/or ozone season NO_X emissions to assist in attaining the 1997 ozone and fine particle and 2006 fine particle NAAQS. The rule targets electric generating units, and uses a cap and-trade approach to limit each state to emissions below a level that significantly contributes to non-attainment in downwind states.

On August 21, 2012, the U.S. Court of Appeals for the District of Columbia vacated CSAPR by leaving the CAIR requirements in place. The EPA and various environmental groups petitioned the Supreme Court of the United States to review the D.C. Circuit Court's decision on CSAPR. On April 29, 2014, the U.S. Supreme Court issued an opinion reversing the D.C. Circuit decision. Following the remand of the case to the D.C. Circuit, EPA requested that the court lift the CSAPR stay and toll the CSAPR compliance deadlines by three years. On October 23, 2014, the D.C. Circuit granted EPA's request. Accordingly, CSAPR Phase 1 implementation is now scheduled for 2015, with Phase 2 beginning in 2017.[79] While CSAPR-related litigation remains pending, none is considered a threat to the rule.

None of the New England states have obligations under CSAPR, although a replacement or follow-up rule, expected to be developed during 2016-2017 for implementation in 2018-2019, could affect sources in Connecticut or Massachusetts.

Regional Haze Rules

One of the national goals set out in the Clean Air Act is reducing existing visibility impairment from human-made air pollution in all "Class I" areas (e.g., most national parks and wilderness areas).[80] EPA's

[78] *See* U.S. Environmental Protection Agency website. Accessed December 2, 2014. Available at: http://www.epa.gov/groundlevelozone/actions.html

[79] *See* U.S. Environmental Protection Agency website. Accessed December 2, 2014. Available at: http://www.epa.gov/airtransport/CSAPR/

[80] 42 U.S.C. § 7491(a)(1)

Regional Haze Rule—issued in 1999, and revised in 2005—requires states to create plans to significantly improve visibility conditions in Class I areas with the goal of achieving natural background visibility conditions by 2064. These requirements are implemented through state plans with enforceable reductions in haze-causing pollution from individual sources and with other measures to meet "reasonable further progress" milestones.[81] The first progress milestone is 2018.

A key component of this program is the imposition of air pollution controls on existing facilities that impact visibility in Class I areas. Specifically, the rules require installation of "best available retrofit technology" (BART) that is developed for such facilities on a case-by-case basis. In addition, EPA's BART determinations specify particular emission limits for each BART-eligible facility. EPA evaluates BART for the air pollutants that impact visibility in our national parks and wilderness areas—namely SO_2, PM, and NO_x. Under the Clean Air Act, states develop Regional Haze requirements, but EPA approves state plans for compliance. If EPA finds the plans are not consistent with the Clean Air Act, it adopts a federal plan with BART and reasonable progress requirements. Affected facilities must comply with the BART determinations as expeditiously as practicable but no later than five years from the date EPA approves the state plan or adopts a federal plan.[82]

Mercury and Air Toxics Standards (MATS)

In 2000, EPA determined it was appropriate and necessary to regulate toxic air emissions (or hazardous air pollutants) from steam electric generating units. As a result, EPA adopted strict emission limitations for hazardous air pollutants that are based on the emissions of the cleanest existing sources.[83] These emission limitations are known as Maximum Achievable Control Technology (MACT). The final MATS rule, approved in December 2011, sets strict stack emissions limits for mercury, other metal toxins, other organic and inorganic hazardous air pollutants, as well as acid gasses. Compliance with MATS is required by 2015, with a potential extension to 2016.

On March 28, 2013, the EPA finalized updates to certain emission limits for new power plants under MATS. This includes emission limits for mercury, PM, SO_2, acid gases and certain individual metals. On

[81] 40 C.F.R. §51.308-309

[82] EPA's regulations allow certain states in the "Grand Canyon Visibility Transport Region" to participate in an SO_2 trading program in lieu of adopting source-specific SO_2 BART requirements, if the trading program will result in greater reasonable progress toward attaining the national visibility goal than source-specific BART. Although nine states were originally eligible to participate, today only three states are opting to participate in this program – New Mexico, Utah, and Wyoming. These states agreed to a gradually declining cap on SO_2 emissions from all emission sources. If the declining caps are exceeded in any year, then even greater SO_2 emission reductions have to be achieved—although the reductions can be met through emissions trading, rather than imposition of specific emission limitations on any one facility. This program is called the Backstop Trading Program.

[83] Clean Air Act §112(d)

November 7, 2014, EPA finalized an action reconsidering the provisions applicable during periods of startup and shutdown under MATS and Utility New Source Performance Standards (Utility NSPS).[84]

According to ISO New England, approximately 7.9 GW of existing coal- and oil-fired capacity in the region are subject to MATS.[85] The ISO considers less than 1 GW of affected fossil capacity in New England to be at risk for retirement because of an inability to comply with MATS, because most remaining coal-fired generators already are retrofitted with needed controls to comply with state air toxics regulations, and most remaining larger oil-fired generators in New England are only subject to *de Minimis* work practice standards under MATS and not required to add any emission control devices.

MATS continues to face litigation, notably before the U.S. Supreme Court. The Court, on November 25, 2014, accepted three petitions, consolidated them and granted review: *Michigan v. EPA*, *Utility Air Regulatory Group v. EPA*, and *National Mining Association v. EPA*. The Court will consider "Whether the Environmental Protection Agency unreasonably refused to consider costs in determining whether it is appropriate to regulate hazardous air pollutants emitted by electric utilities." The implications of the case reach potentially beyond MATS.[86]

Coal Combustion Residuals Disposal Rule

Coal-fired power plants generate a tremendous amount of ash and other residual wastes, which are commonly placed in dry landfills or slurry impoundments. The risk associated with wet storage of coal combustion residuals (CCR) was dramatically revealed in the catastrophic failure of the ash slurry containment at the Kingston coal plant in Roane County, Tennessee in December 2008, releasing over a billion gallons of slurry and sending toxic sludge into tributaries of the Tennessee River.

On June 21, 2010, EPA proposed to regulate CCR for the first time either as a Subtitle C hazardous waste or Subtitle D solid waste under the Resource Conservation and Recovery Act. The current rulemaking is 30 years overdue. If the EPA classifies CCR as hazardous waste, a cradle-to-grave regulatory system would apply to CCR, requiring regulation of the entities that create, transport, and dispose of the waste. Under a Subtitle C designation, the EPA would regulate siting, liners, run-on and run-off controls, groundwater monitoring, fugitive dust controls, and any corrective actions required; in addition, the EPA would implement minimum requirements for dam safety at impoundments. For Subtitle C, requirements will go into effect in authorized states when the state adopts the rule. Timing will vary from state to state. Under a solid waste Subtitle D designation, the EPA would require minimum siting and construction standards for new coal ash ponds, compel existing unlined impoundments to install

[84] *See* U.S. Environmental Protection Agency website. Accessed December 2, 2014. Available at: http://www.epa.gov/airquality/powerplanttoxics/actions.html,

[85] ISO New England, *2014 Regional System Plan* (hereinafter "RSP2014"), November 6, 2014. Available at: http://www.iso-ne.com/static-assets/documents/2014/11/rsp14_110614_final_read_only.docx.

[86] Lyle Denniston, *Court to rule on disability rights, mercury pollution*, SCOTUSblog (Nov. 25, 2014, 1:39 PM), http://www.scotusblog.com/2014/11/court-to-rule-on-disabiity-rights-mercury-pollution/

liners, and require standards for long-term stability and closure care. For Subtitle D, the rule would be effective six months after promulgation.

The EPA is currently evaluating which regulatory pathway will be most effective in protecting human health and the environment. In 1999, EPA released a series of technical papers to Congress documenting cases in which damages are known to have occurred from leakages and spills from coal ash impoundments.[87] In the current proposed rule, the EPA recognizes a substantial increase in the types and quantities of potentially toxic CCR caused by air pollution control equipment.

Use of more advanced air pollution control technology reduces air emissions of metals and other pollutants in the flue gas of a coal-fired power plant by capturing and transferring the pollutants to the fly ash and other air pollution control residues. The impact of changes in air pollution control on the characteristics of CCRs and the leaching potential of metals is the focus of ongoing research by EPA's Office of Research and Development.[88] EPA has not yet set a date for issuance of a final rule.

Steam Electric Effluent Limitation Guidelines

Following a multi-year study of steam-generating units across the country, EPA found that coal-fired power plants are currently discharging a higher-than-expected level of toxic-weighted pollutants into waterways. Current effluent regulations were last updated in 1982 and do not reflect the changes that have occurred in the electric power industry over the last thirty years, and do not adequately manage the pollutants being discharged from coal-fired generating units. Coal ash ponds and flue gas desulfurization systems used by such power plants are the source of a large portion of these pollutants, and are likely to result in an increase in toxic effluents in the future as environmental regulations are promulgated and pollution controls are installed. On April 19, 2013, EPA signed a notice of proposed rulemaking that would strengthen existing controls on discharges, and a proposed rule was published on June 7, 2013. The public comment period closed on September 20, 2013. EPA is under a court order to issue a final action no later than September 30, 2015. New requirements will be phased in over 2017 to 2022.[89]

The proposal sets the first federal limits on the levels of toxic metals in wastewater that can be discharged from power plants. Under the most stringent preferred regulatory option, EPA's projects no plants will close and at most a few units will retire. Under the most stringent preferred regulatory

[87] EPA. March 15, 1999. Technical Background Document for the Report to Congress on Remaining Wastes from Fossil Fuel Combustion: Potential Damage Cases. http://www.epa.gov/osw/nonhaz/industrial/special/fossil/ffc2_397.pdf

[88] 75 Fed. Reg. 35139 (June 21, 2010).

[89] *See* U.S. Environmental Protection Agency website. Accessed December 2, 2014. Available at: http://water.epa.gov/scitech/wastetech/guide/steam-electric/proposed.cfm

option, EPA projects national average prices to increase minimally by only 0.025 cents/KW-hr, or 0.27 percent.[90]

Clean Water Act Cooling Water Intake Structure Rule

On March 28, 2011, the EPA proposed a long-expected rule implementing the requirements of Section 316(b) of the Clean Water Act at existing power plants.[91] Section 316(b) requires "that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact." Under this new rule, EPA set new standards reducing the impingement and entrainment of aquatic organisms from cooling water intake structures at new and existing electric generating facilities.

The rule provides that:

- Existing facilities that withdraw more than two million gallons per day are subject to an upper limit on fish mortality from impingement, and must implement technology to either reduce impingement or slow water intake velocities.
- Existing facilities that withdraw at least 125 million gallons per day are required to conduct an entrainment characterization study to establish a "best technology available" for the specific site.

EPA released a final rule for implementation of Section 316(b) of the Clean Water Act on May 19, 2014. The final rule became effective October 14, 2014, and requirements will be implemented in NPDES permits as they are renewed. The rule, including design enhancements and operational requirements to reduce impingement mortality and new requirements to protect threatened and endangered species and critical habitats federally listed and designated under the *US Endangered Species Act*, will be implemented by delegated states in New England, and EPA anticipates most retrofits occurring between 2018 and 2022.[92] According to ISO New England, as much as 12.1 GW of existing fossil fuel and nuclear capacity in New England may need cooling water intake structure modification, and 5.6 GW of facilities with larger water withdrawals of once-through cooling systems will need to prepare and submit entrainment characterization reports by 2018.[93]

As of October 2014, the rule is being litigated in the 4th Circuit Court of Appeals (consolidating six petitions from other circuits). Environmental advocates challenged provisions for control technology flexibility and discretion, while industry narrowly challenged the new unit criteria as contradictory.[94]

[90] *Ibid.*

[91] 33 U.S.C. § 1326.

[92] RSP2014.

[93] *Ibid.*

[94] *Cooling Water Intake Structure Coalition v. EPA*, Docket No. 14-1931.

4.2.3 Impact of Energy Efficiency Programs on CO_2 Emissions under a Cap and Trade Regulatory Framework

With CO_2 emissions regulated under a cap and trade system, as assumed in this market price analysis, it is conceivable that a load reduction from an energy efficiency program will not lead to a reduction in the amount of total system CO_2 emissions. The annual total system emissions for the affected facilities in the relevant region are, after all, capped. In the analysis documented in this report, the relevant cap and trade regulation is the RGGI for the period 2015 to 2020, and thereafter an assumed continuation of that regional cap and trade system (perhaps with other states joining), modified as needed to bring about CPP compliance in the member states. There are, however, a number of reasons why an energy efficiency program could nonetheless result in CO_2 emission reductions. Specifically:

- A reduction in load that reduces the cost (marginal or total cost) of achieving an emissions cap can result in a decision to tighten the cap. This is a complex interaction between the energy system and political and economic systems, and is difficult or impossible to model, but it's reasonable to assume the dynamic exists.
- Specific provisions in RGGI provide for a tightening or loosening of the cap (via adjustments to the reserve provisions that are triggered at different price levels). It is plausible that those provisions can be modified as needed to ensure compliance with the CPP as proposed.
- It is also possible that energy efficiency efforts will be accompanied by specific retirements or allocations of allowances that would cause them to have an impact on the overall system level of emissions (effectively tightening the cap).
- To the extent that the cap and trade system "leaks" outside of its geographic boundaries, one would expect the benefits of a carbon emissions reduction resulting from an energy efficiency program to similarly "leak." That is, a load reduction in New York could cause reductions in generation (and emissions) at power plants in New York, Pennsylvania, and elsewhere. Because New York is in the RGGI cap and trade system, the emissions reductions realized at New York generating units may accrue as a result of increased sales of allowances from New York to other RGGI states. Since Pennsylvania is not in the RGGI system, however, the emissions reductions at Pennsylvania generating units would be true reductions attributable to the energy efficiency program.

The first three of these points, above, would also apply to a future CO_2 cap and trade program which expands the RGGI footprint and is designed to comply with the CPP. The fourth point, regarding leakage and boundaries, would apply as well in an expanded cap and trade footprint, but to a lesser extent the larger the footprint is.

4.3 Non-Embedded Environmental Costs

Non-embedded costs are impacts from the production of a good or service that are not reflected in price of that good or service, and are not considered in the decision to provide that good or service.[95] Air pollution generated in the production of electricity is a classic example of a non-embedded cost: pollutants released from a power plant impose health impacts on a population, cause damage to the environment, or both. In this example, health impacts and ecosystem damages not reflected in the price of electricity and not considered in the power plant owner's decision of how much electricity to provide are "non-embedded," whereas adverse impacts that are reflected in the market price of electricity (e.g., through regulation) and are considered in decisions regarding production are "embedded."

For AESC 2015, the non-embedded carbon cost continues to be the dominant non-embedded environmental cost associated with marginal electricity generation in New England. This is the case for two main reasons. First, regulations to address the greenhouse gas emissions responsible for global climate change have yet to be implemented with sufficient stringency to reduce carbon emissions, particularly in the United States.[96] The damages from the EPA's criteria air pollutants are relatively bounded, and to a great extent embedded, as a result of existing regulations. In contrast, global climate change is a problem on an unprecedented scale with far-reaching and potentially catastrophic implications.

Second, New England avoided electric energy costs over the study period are dominated by natural gas-fired generation, which has minimal SO_2, mercury, and particulate emissions, as well as relatively low NO_x emissions.

4.3.1 History of Non-Embedded Environmental Cost Policies in New England

In the 1980s and 1990s, several New England states had proceedings dealing with non-embedded costs that influence current utility planning and decision-making.[97] In Massachusetts, dockets DPU 89-239 and 91-131 served as models for other states. Docket DPU 89-239 was opened to develop "Rules to Implement Integrated Resource Planning" and included the determination and application of non-embedded environmental cost values. This docket adopted a set of dollar values for air emissions, including a CO_2 value of $38 per ton of CO_2 (in 2015 dollars).[98] Docket DPU 91-131 examined

[95] In economics, a non-embedded impact can be positive (a non-embedded benefit) or negative (a non-embedded cost); in this discussion we are focusing on negative impacts (non-embedded costs).

[96] On April 17, 2009; EPA issued a proposed finding that concluded that greenhouse gases posed an endangerment to public health and welfare under the Clean Air Act ("Proposed Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act" 74 Fed. Register 78: 18886–18910). This proposed finding initiates the process of potentially regulating greenhouse gases as an air pollutant. http://epa.gov/climatechange/endangerment.html

[97] A more detailed description of the history of electricity generation environmental externalities and policies in New England may be found in AESC 2007 (p. 7-6–7-8).

[98] Exhibit DOER-3, Exhibit. BB-2, p. 26. $22 in 1989 dollars.

environmental costs to develop recommendations of various approaches for quantifying the non-embedded CO_2 value. The Department of Public Utilities' (DPU) Order in Docket DPU 91-131 was noteworthy for its foresight regarding climate change, albeit optimistic about the timing of the adoption of climate change regulations in the U.S.[99] Based on information in the record, the Department reaffirmed the CO_2 value it had adopted in the previous case, $38 per ton (in 2015 dollars).

In May 2014, the Department of Environmental Protection (DEP) and the Department of Energy Resources (DOER) filed a joint petition with the Massachusetts DPU requesting the DPU to commence a proceeding to determine whether the existing method of calculating the costs (associated with GHG emissions) to comply with the Global Warming Solutions Act (GWSA), should be replaced by the marginal abatement cost curve method.[100] The matter, discussed further below in Section 4.6, is still pending before the DPU.

4.3.2 Estimating Non-Embedded CO_2 Costs

Setting a Threshold for Global CO_2 Emissions

The level of global CO_2 emissions thought to be consistent with avoiding the most serious forms of climate damage is essentially unchanged since AESC 2011.[101] Sustainability targets for CO_2 equivalent concentrations in the atmosphere are roughly 350 to 450 ppm,[102] consistent with an approximately 50 percent chance of limiting the change in the average global temperature to 2°C above pre-industrial levels.[103] The Copenhagen Agreement, drafted at the 15th session of the Conference of the Parties to the United Nations Framework Convention on Climate Change in 2009, recognizes the scientific view that in order to prevent the more drastic effects of climate change, the increase in global temperature should be limited to no more than 2°C.[104]

The Intergovernmental Panel on Climate Change (IPCC 2014, Table SPM.1) indicates that reaching concentrations of 430 to 480 ppm CO_2 equivalent, in order to limit temperature change to between 1.5 °C to 1.7 °C above pre-industrial levels by the end of the century will require a reduction in 2050 global

[99] AESC 2009 provides more detail about the Massachusetts DPU Order in Docket DPU 91-131.

[100] Massachusetts Department of Public Utilities, Docket No. 14-86, May 16, 2014.

[101] AESC 2011 Section 6.6.4.1 page 6-97.

[102] According to IPCC, "Only a limited number of individual model studies have explored levels below 430 ppm CO_2eq… Assessing this goal is currently difficult because no multi-model studies have explored these scenarios." *See* IPCC, 2014: Summary for Policymakers, In: Climate Change 2014, Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. (Hereinafter, "IPCC 2014"). The information and analysis presented here therefore focuses on the 450 ppm target.

[103] Ackerman and Stanton (2013) *Climate Economics: The State of the Art*. Routledge: NY.

[104] IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

CO_2 emissions of 41 to 72 percent below 2010 emissions levels. To accomplish such stabilization, the U.S. and other industrialized countries would have to reduce greenhouse gas emissions on the order of 80 to 90 percent below 1990 levels, and developing countries would have to achieve reductions from the baseline increase in emissions caused by improvements in the standard of living as soon as possible (den Elzen and Meinshausen, 2006).

In the U.S., several states have adopted state greenhouse gas abatement targets of 50 percent or more reduction from a baseline of 1990 levels or then-current levels by 2050 (Arizona, California, Connecticut, Florida, Illinois, Maine, Massachusetts, Minnesota, New Hampshire, New Jersey, New Mexico, Oregon, Vermont, and Washington).[105] In Massachusetts, the GWSA, signed into law by Governor Patrick in August 2008, calls for initial reductions in greenhouse gas emissions of between 10 percent and 25 percent below 1990 levels by 2020.[106] The *Massachusetts Clean Energy and Climate Plan for 2020* (CECP), released on December 29, 2010 by the Massachusetts Executive Office of Energy and Environmental Affairs, sets out policies, with associated emissions reductions, necessary to meet the 2020 target of 25 percent below 1990 levels.[107] In early January 2015, the Massachusetts Department of Environmental Protection ("Mass DEP") published a proposed "Clean Energy Standard" (CES) regulation for public comment. A Massachusetts CES would implement one of the strategies in the CECP, and providing a long-term incentive to ensure ongoing progress toward reducing greenhouse gas emissions by 80 percent by 2050.[108]

Methods to Monetize Non-Embedded CO_2

Several different methods are available to monetize environmental costs. These include "damage cost" approaches that seek to assign a value to damages associated with a particular pollutant, and "control cost" approaches that seek to quantify the marginal cost of controlling a particular pollutant. For the same reasons outlined in AESC 2013, AESC 2015 recommends using the control cost approach to estimate non-embedded CO_2 costs for the study period.

Damage Cost Approach: The Social Cost of Carbon

Damage cost methods generally rely on travel costs, hedonic pricing, or contingent valuation to assign values in the absence—by definition—of market prices for non-embedded impacts. These are forms of "implied valuation," asking complex and hypothetical survey questions, or extrapolating from observed behavior, to impute a price to something that is never bought or sold in a market. For example, data on how much people will spend on travel, subsistence, and equipment on fishing can be used to measure

[105] Center for Climate and Energy Solutions, "A Look at Emissions Targets," http://www.c2es.org/what_s_being_done/targets

[106] Massachusetts G.L. c. 21N

[107] http://www.mass.gov/eea/docs/eea/energy/2020-clean-energy-plan.pdf

[108] "Summary of Proposed MassDEP Regulation: Clean Energy Standard (310 CMR 7.75)," Available at: http://www.mass.gov/eea/docs/dep/air/climate/ces-fs.pdf. Additional information available at http://www.mass.gov/eea/agencies/massdep/climate-energy/climate/ghg/ces.html.

the value of those fish, and the value of *not* killing fish with waterborne pollution. Even human lives sometimes have been valued based on wage differentials for jobs that expose workers to different risks of mortality. Comparing the difference in wages between two jobs—one with higher hourly pay rate and higher risk than the other—can serve as a measure of the compensation that someone is "willing to accept" in order to be exposed to a life-threatening risk and, by analogy, as a controversial estimate of the value of life itself.

Valuation of the societal damages caused by the emission of an additional ton of CO_2—a measure often called the "social cost of carbon"—typically combines cost estimates, using a variety of implied valuation techniques, for numerous damages from climate change that are expected around the world. In 2010, the U.S. government began to include a social cost of carbon in the valuation of federal rulemakings with the goal of accounting for the damages resulting from climate change, defined as "an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year."[109] A range of four social cost of carbon values was initially calculated by the Interagency Working Group on the Social Cost of Carbon (the "Working Group"), a group composed of members of the Department of Agriculture, Department of Commerce, Department of Energy, Environmental Protection Agency, and Department of Transportation, among others.

The Working Group's estimates, presented in Exhibit 4-4, seek to represent the range of social cost of carbon values for three discount rates as well as the high-cost tail-end of the uncertain distribution of impacts in 2015 dollars per short ton CO_2.[110] It is important to note that social cost of carbon values represent the damages associated with an incremental increase in CO_2 emissions *in a given year*; for this reason, they are time-dependent and are expected to increase in future years as atmospheric concentrations of CO_2 increase. As of May 2012, these estimates had been used in more than 20 federal government rulemakings, for policies including fuel economy standards, industrial equipment efficiency, lighting standards, and air quality rules.[111] In May 2013 and again in November 2013, the Working Group released technical updates that revised its estimate of the Social Cost of Carbon.[112]

[109] Interagency Working Group on the Social Cost of Carbon, U. S. G. (2010). Appendix 15a. Social cost of carbon for regulatory impact analysis under Executive Order 12866. In Final Rule Technical Support Document (TSD): Energy Efficiency Program for Commercial and Industrial Equipment: Small Electric Motors. U.S. Department of Energy. URL http://go.usa.gov/3fH.

[110] The Working Group's 2010 social cost of carbon values are commonly reported in 2007 dollars of $5, $21, $35, and $65 per metric tonne CO_2. In Exhibit 4-4, these values are converted to 2015 dollars and short tons.

[111] Robert E. Kopp and Bryan K. Mignone (2012). The U.S. Government's Social Cost of Carbon Estimates after Their First Two Years: Pathways for Improvement. Economics: The Open-Access, Open-Assessment E-Journal, Vol. 6, 2012-15. http://dx.doi.org/10.5018/economics-ejournal.ja.2012-15

[112] Interagency Working Group on the Social Cost of Carbon, U. S. G. (2013). Technical Support Document:- Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis- Under Executive Order 12866. URL http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf; http://www.whitehouse.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf. The values presented here have been converted from the published values in 2007$/metric ton to 2015$ per short ton.

Exhibit 4-4. U.S. Interagency Working Group Social Cost of Carbon (2015 dollars per short ton CO_2)

Statistic	Average	Average	Average	95th Percentile
Discount Rate	**5%**	**3%**	**2.5%**	**3%**
2015	$11	$38	$59	$112
2020	$12	$44	$66	$132
2025	$14	$48	$71	$147
2030	$16	$54	$77	$164
2035	$20	$58	$82	$180
2040	$22	$63	$89	$197
2045	$25	$68	$95	$212
2050	$27	$73	$100	$227

Source: US EPA, Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866 - Interagency Working Group on the Social Cost of Carbon, United States Government, November 2013 (original values in 2007$ per metric ton). http://www.whitehouse.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf

These social cost of carbon values are the result of the Working Group's reanalysis using the DICE, PAGE, and FUND integrated assessment models, which simplify the relationships among complex climate and economic systems with the goal of providing information useful in making climate policy decisions.[113] The social cost of carbon values are calculated as the net present value of the discounted path of hundreds of years of future damages computed by each of the three models resulting from the addition of a ton of CO_2 emissions in a given year.

The Working Group based its common sets of assumptions regarding emissions, population, and gross domestic product (GDP), used for all three models, on four business-as-usual scenarios from an Energy Modeling Forum (EMF) model comparison exercise and an average of 550 ppm CO_2e scenarios from the same four EMF models.[114] The process-based integrated assessment models used in the EMF survey contain substantially more detailed representations of the climate and energy systems than the DICE, PAGE, and FUND models, but only provide results out to 2100. The Working Group analysis extrapolates these trends out to 2300 based upon assumptions regarding changes in fertility rates, GDP per capita, and carbon intensities.

DICE, PAGE, and FUND all employ simplified climate modules to convert emissions into atmospheric concentrations, and then use a climate sensitivity parameter to convert concentrations into temperature increases. To address the substantial uncertainty in this climate sensitivity parameter, the Working Group conducted a Monte Carlo analysis that averages results from a distribution of likely

[113] The DICE model was further simplified by the Working Group for use in its analysis, see Interagency Working Group 2010.

[114] Clarke, L. (2009). Overview of EMF 22 international scenarios. Available at: https://emf.stanford.edu/projects/emf-22-climate-change-control-scenarios

sensitivities. Three of the four social cost of carbon values are based on the average of this distribution, with the fourth based on the high-cost tail-end 95th percentile.

The DICE, PAGE, and FUND integrated assessment models rely on implied valuations of future climate damages to calibrate their "damage functions," which translate temperature changes into changes in GDP. Climate damage valuation is hampered by significant uncertainty in the climate system itself, long time intervals separating cause and effect, and practical difficulties in assigning monetary values to projected damages that fall outside of the range of past experience. A common practice used in these and other climate-economics models is to set a point estimate for the expected cost of near-term, low-level climate damages and then to extrapolate the costs as rising with the square of temperature change.[115] The climate damage values used in the Working Group analysis represent the most likely level of damage given these estimation techniques, ignoring any uncertainty in the range of damages expected to occur from a given rise in temperature. The EPA notes,

> However, given current modeling and data limitations, [Social Cost of Carbon] does not include all important damages. As noted by the IPCC Fourth Assessment Report, it is "very likely that [SCC] underestimates" the damages. The models used to develop SCC estimates, known as integrated assessment models, do not currently include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature because of a lack of precise information on the nature of damages and because the science incorporated into these models naturally lags behind the most recent research.

AESC 2013 discussed various flaws of the overall methodology and application of the Working Group's Social Cost of Carbon estimates, and presented alternate estimates of the Working Group's Social Cost of Carbon estimates by various researchers, produced by varying several of the analyses' assumptions. The alternate estimates were up to more than an order of magnitude larger than the Working Group's. While beyond the scope of AESC 2015, it is worth mentioning that ongoing research and analysis continues to quantify the degree to which the Working Group's estimates are significantly too low because they fail to account for what are potentially first order effects, effects supported by mounting empirical evidence.[116]

As noted previously, in May and then again in November 2013, the Working Group released a technical update to its Social Cost of Carbon that used the same methodology as 2010, but used updated versions of the DICE, FUND, and PAGE models. The revised modeling exercise resulted in change in the working Group's average, 3-percent-discount-rate social cost of carbon—for 2015, $25 to $38 per short ton in 2015 dollars.

[115] Stanton, Ackerman and Kartha (2009) "Inside the Integrated Assessment Models: Four Issues in Climate Economics." Climate and Development 1:2(166-184). DOI 10.3763/cdev.2009.0015

[116] For example, see Moore, F. and Diaz, D., "Temperature impacts on economic growth warrant stringent mitigation policy," *Nature Climate Change* 5, 127–131 (2015). The analysis addresses the impact of climate change on GDP growth, which the Working Group's models consider to be exogenous.

For the purposes of AESC 2015, the Working Group's revised $38/t may be viewed as an extreme lower bound to possible non-embedded CO_2 values in 2015.

Control Cost Approach

The Marginal Cost of Stabilizing CO_2 Emissions

Control cost methods generally look at the marginal cost of abating CO_2 emissions—that is, the last (or most expensive) unit of emissions reduction required to comply with regulations. The cost of control approach is often based on regulators' revealed preferences. For example, if air quality regulators require a particular technology that costs $X for each ton of emissions that it achieves, then this can be taken as an indication that regulators value emission reductions at or above $X/t. For CO_2 emissions, however, regulators' preferences are not as yet fully revealed.

A marginal cost of abatement can also be based on a sustainability target of staying at or below the highest level of damage or risk that is considered to be acceptable. In this case, the marginal cost of abatement is the cost per ton of the most expensive technology needed to achieve the sustainability target. A sustainability target for CO_2 emissions relies on the assumption—well established in documents related to international climate policy negotiations—that there is a threshold beyond which the nations of the world deem climatic changes and their associated damages to be unacceptable.

A wealth of well documented, compelling research exists both on setting an acceptable threshold for CO_2 emissions and on current and projected costs of CO_2 emissions abatement technologies. Here, we review several recent analyses of strategies and technologies that would contribute to emission reductions consistent with an increase in average temperature of no more than 2°C above preindustrial levels or atmospheric concentrations no greater than 450 ppm CO_2 equivalent.

The 350 ppm target has been identified and is viewed as a more current target to maintain the global temperature increase above pre-industrial levels at no more than 2°C. According to one source, "The measured energy imbalance [of +0.5 W/m^2] indicates that an initial CO_2 target '<350 ppm' would be appropriate, if the aim is to stabilize climate without further global warming."[117] While there is a lack of abatement cost estimates associated with a 350 ppm target, given the factors described in the following text it is reasonable to conclude that such an abatement cost would be equal or more than the abatement cost associated with a 450 ppm target, and could potentially be considerably higher.[118] The information and analysis presented here focuses on the 450 ppm target, entirely because the available

[117] Hansen J, et al. (2013) "Assessing 'Dangerous Climate Change': Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature. *See also* Hansen J, et al. (2008) "Target Atmospheric CO2: Where Should Humanity Aim?" The Open Atmospheric Science Journal, 2: 217-231.

[118] If the more ambitious target could be achieved using more of the same abatement resource, the marginal cost would be the same. If a different (and therefore more expensive) resource were needed to achieve the target, the cost would be higher.

studies used the 450 ppm level in their analyses. The associated cost estimate can therefore be considered to be a conservative choice.

McKinsey & Company examined abatement technologies in a 2010 report entitled *Impact of the Financial Crisis on Carbon Economics: Version 2.1 of the Global Greenhouse Gas Abatement Cost Curve*. The CO_2 mitigation options identified by McKinsey and the costs of those options are reproduced in Exhibit 4-3. The figure represents a marginal abatement cost curve, where the per-ton cost of abatement is shown on the vertical axis and cumulative metric tons of CO_2 equivalent reductions are shown on the horizontal axis. Global CO_2 mitigation technologies are ordered from least to most expensive with the width of each bar representing each technology's expected total emission reduction. If technologies are assumed to be implemented in order of their costs, beginning with the cheapest abatement options, the marginal cost of maintaining the sustainability threshold is the cost per ton of the most expensive technology needed to provide the appropriate reduction (here, 38 metric gigatons CO_2 equivalent in 2030).

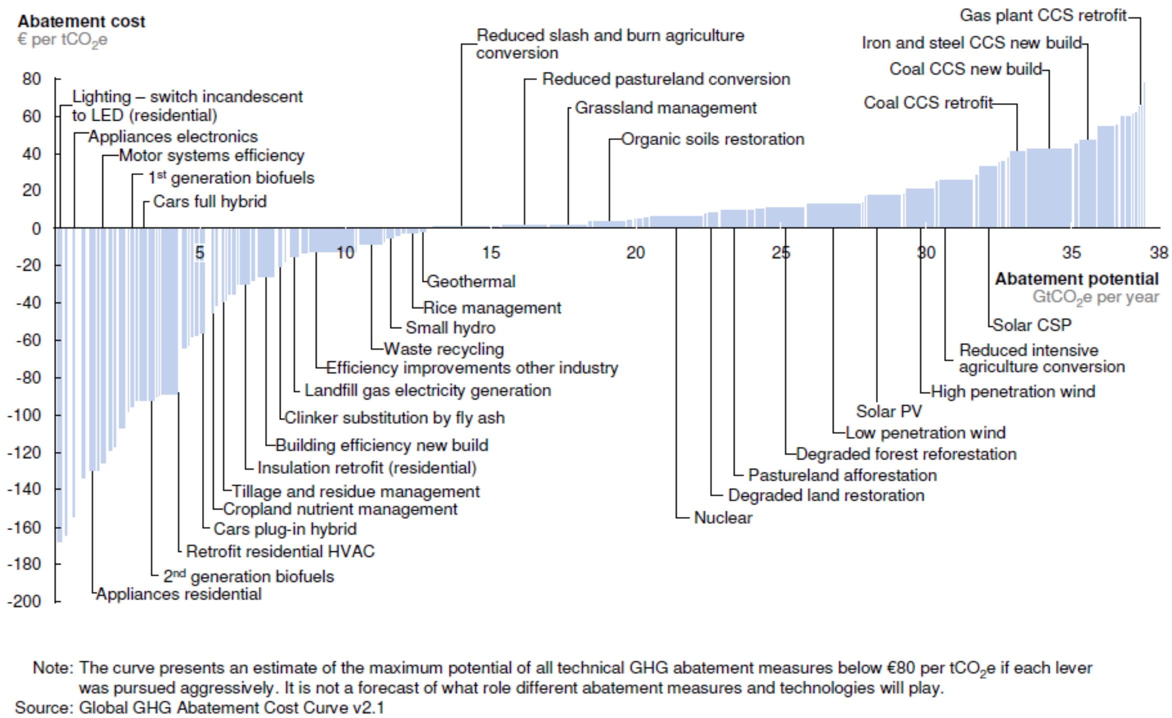
As shown in Exhibit 4-3, the marginal technology for the year 2030 is a gas plant carbon capture and storage (CCS) retrofit costing $120 per short ton in 2015 dollars.[119] This figure also shows a variety of technologies for carbon mitigation that are available to the electric sector, including those related to energy efficiency, nuclear power, renewable energy, and CCS for fossil-fired generating resources.

In *Energy Technology Perspectives 2014* (ETP 2014), the IEA has modeled the implications of several emissions scenarios, and presents marginal CO_2 abatement costs for each. Its 2DS Scenario, an emissions trajectory with at least a 50% chance of limiting average global temperature increase to 2°C, is broadly consistent with IEA's World Energy Outlook (WEO) 450 Scenario, which stabilizes CO_2 levels at 450 ppm.[120] IEA projects global marginal cost of abatements under this and other scenarios for 2020, 2030, 2040, and 2050, with the cost for each year generally spanning a $20 range. The averages of the cost ranges for the 2DS Scenario increase over time from $42 to $163 in 2015 dollars.

[119] 2005 Euro to Dollar conversion factor, 1.25, http://www.oanda.com/convert/fxhistory accessed 4/28/09

[120] IEA (2014). *Energy Technology Perspectives 2014* ("ETP 2014"). Available at: http://www.iea.org/w/bookshop/472-Energy_Technology_Perspectives_2014

Exhibit 4-5. Marginal Abatement Technologies and Associated Costs for the Year 2030



Source: McKinsey & Company. Impact of the Financial Crisis on Carbon Economics: Version 2.1 of the Global Greenhouse Gas Abatement Cost Curve. 2010. Page 8.

In *ETP 2014*, the IEA examines two additional scenarios. Its 4DS scenario, broadly consistent with the WEO New Policies Scenario, projects a long-term temperature rise of 4°C. The WEO New Policies Scenario stabilizes CO_2 levels at 660 ppm.[121] The 6DS scenario, which projects a long-term temperature rise of 6°C, is largely an extension of current trends, and is broadly consistent with the WEO Current Policy Scenario, which stabilizes CO_2 levels at 950 ppm.[122] The 2050 costs for the 4DS and 6DS Scenarios are $53/t and $63/t respectively, in 2015 dollars per short ton.

The global marginal costs of abatement for all of these scenarios are roughly the same as those presented for equivalent scenarios in *WEO 2012* and *ETP 2012*, cited in AESC 2013, whereas those costs represented a decrease on the order of $20/t from the earlier *Energy Technology Perspectives 2010*, primarily as a result of higher projected prices for fossil fuels and more optimistic forecasts for low-carbon technologies.

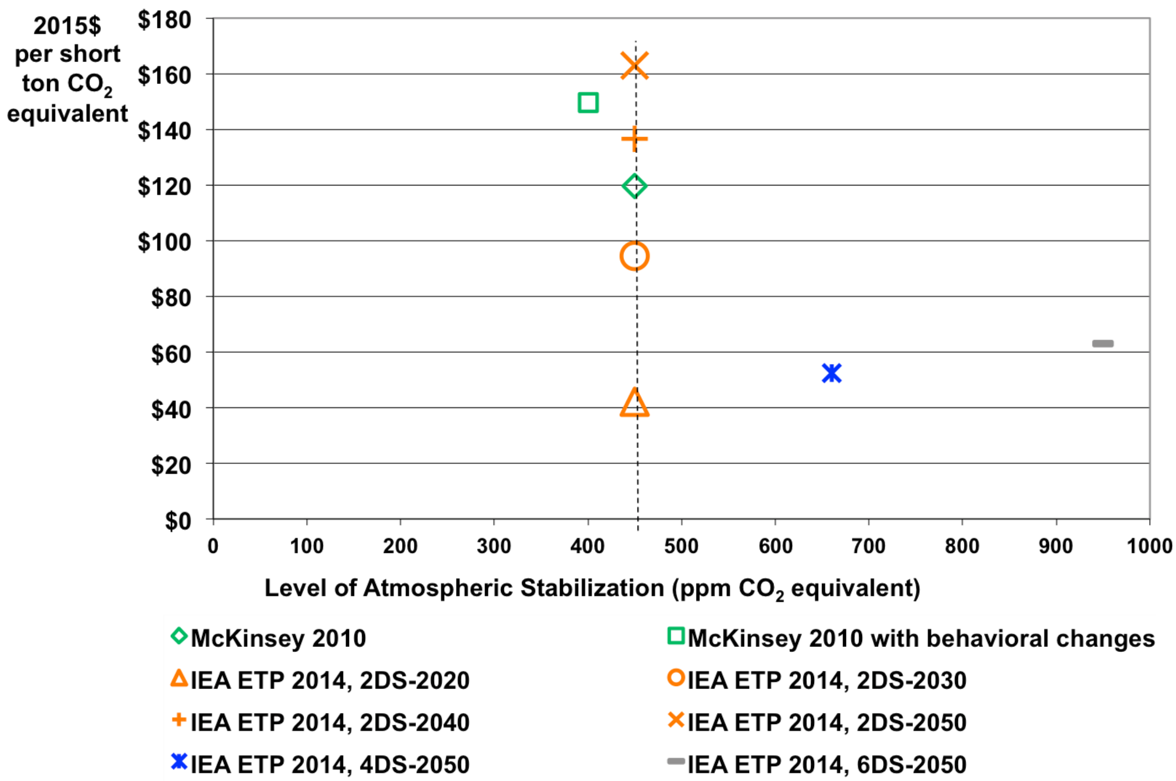
The results of these studies are summarized in Exhibit 4-4. The dotted line is drawn at the value of atmospheric stabilization of 450 ppm CO_2 equivalent, which corresponds to a good chance of limiting

[121] IEA (2012). *World Energy Outlook 2012*. Available at: http://www.worldenergyoutlook.org/publications/weo-2012/

[122] *Ibid.*

global temperature increase to 2°C above pre-industrial levels. Based on this analysis—as well as the CCS costs presented in the section below, and our own judgment and experience—we recommend an AESC 2015 abatement cost of $100 per short ton (in 2015 dollars). This value is unchanged in nominal terms from that of AESC 2013.

Exhibit 4-6. Summary Chart of Marginal Abatement Cost Studies



Source: See text.

CCS Technology Costs

CCS for electricity generation is often at or near the margin for targets of limiting temperature rise to 2°C above pre-industrial levels. For this reason, we expect that CCS costs may be viewed as providing an alternate, first-order approximation of the marginal cost of abating CO_2 emissions. Due to the relatively nascent state of the technology and few projects that are either operating or at advanced stages of development,[123] projected technology costs vary widely, with gas CCS typically more expensive than

[123] As of November 2014, only two of the 40 large-scale CCS projects in the "operate," "execute" or "define" stages as defined by the Global CCS Institute (GCCSI) were on gas-fired generation: the Peterhead CCS Project in Scotland (340 MW, 1 $MtCO_2$ per year integrated CCS), and Sargas Texas Point Comfort Project (250 MW, 0.8 MtCO2 /year), both in the "define" stage. *See* GCCSI (2014), Status of CCS Project Database. Available at: http://www.globalccsinstitute.com/content/ccs-around-world

coal on a per ton of avoided emissions basis. As presented in AESC 2013, mature CCS deployment estimates are commonly in the range of $60 to $100 per short ton of CO_2 avoided. According to IEA, carbon prices need to approach $84 per short ton (2015 dollars) to drive adoption of CCS—prices above which a CCGT with CCS will have a lower LCOE than either a CCGT or supercritical pulverized coal plant.[124]

Substantial uncertainty still exists in the long-term costs of CCS deployment. CCS costs can provide an important cross-check of long-term forecasts of mitigation costs, but should be coupled with other metrics such as complete marginal cost of abatement curves constructed from energy system modeling results.

CO_2 Abatement Cost in AESC 2015

Based on our review of the most current research on marginal abatement and CCS costs, and our experience and judgment on the topic, we believe that it is reasonable to use a CO_2 marginal abatement cost of $100 per short ton in 2015 dollars. This value is the same in nominal terms as the AESC 2013 value. Because the AESC 2015 embedded CO_2 cost is lower than that of AESC 2013, the non-embedded component is correspondingly higher.

A value of $100/short ton is a practical and reasonable measure of the total societal cost of carbon dioxide emissions. This CO_2 marginal abatement cost can be applied to the emissions reductions that result from lower electricity generation as a result of energy efficiency, in order to quantify these reductions' full value to society. A portion of this CO_2 marginal abatement cost will be reflected in the allowance price for emissions, and thus embedded in the avoided costs; the balance may be referred to as a non-embedded cost.

States that have established targets for climate mitigation comparable to the targets discussed in section 4.3.1, or that are contemplating such action, could view the $100/t CO_2 marginal abatement cost as a reasonable estimate of the societal cost of carbon emissions, and hence as the long-term value of the cost of reductions in carbon emissions required to achieve those targets.

Like any long-run projections, this estimate of the marginal abatement cost includes important uncertainties in underlying assumptions regarding the extent of technological innovation, the selected emission reduction targets, the technical potential of key technologies, and the evolution of international and national policy initiatives, along with a variety of other influencing factors. It will be necessary to review available information and reassess what value is reasonable given the best state of knowledge at the time of future reviews.

[124] ETP 2014, converted from $80/metric ton in 2012 dollars. This calculation assumes gas prices of $4/MMBtu.

Estimating Non-Embedded CO_2 Costs for New England

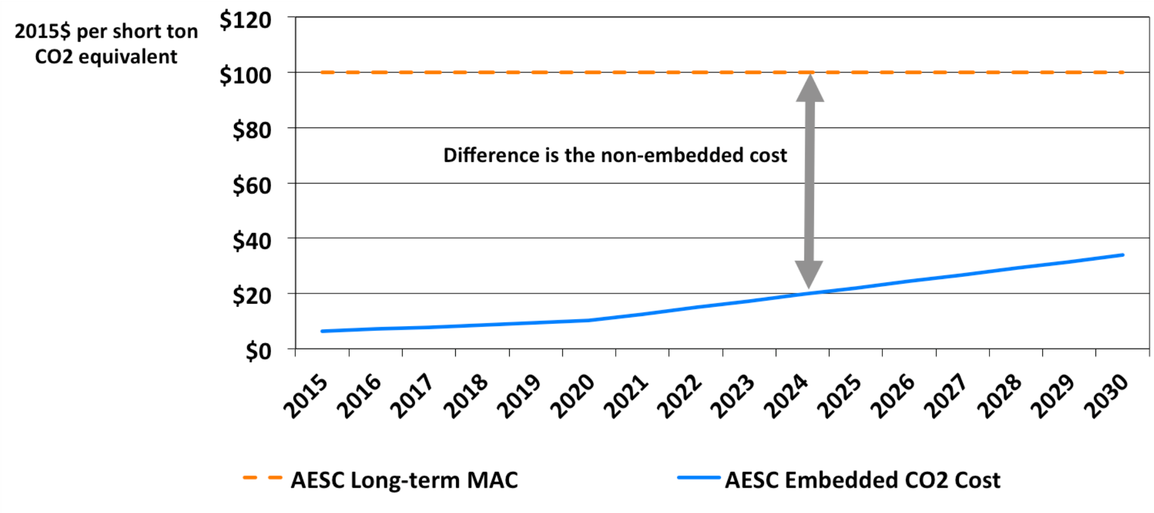
The non-embedded value for New England's CO_2 emissions in each year was calculated as the estimated marginal abatement cost of $100 per short ton in 2015 dollars less the annual allowance values embedded in the projected electric energy market prices. These values are summarized in Exhibit 4-5.

Exhibit 4-7. AESC 2015 Non-Embedded CO_2 Costs (2015 dollars per short ton CO_2)

	Marginal Abatement Cost	Allowance Price	Externality
	a	b	c = a - b
2015	$100	$6.28	$93.72
2016	$100	$7.26	$92.74
2017	$100	$7.87	$92.13
2018	$100	$8.47	$91.53
2019	$100	$9.32	$90.68
2020	$100	$10.16	$89.84
2021	$100	$12.54	$87.46
2022	$100	$14.92	$85.08
2023	$100	$17.30	$82.70
2024	$100	$19.67	$80.33
2025	$100	$22.05	$77.95
2026	$100	$24.43	$75.57
2027	$100	$26.80	$73.20
2028	$100	$29.18	$70.82
2029	$100	$31.56	$68.44
2030	$100	$33.94	$66.06

The annual allowance values embedded in the projected electric energy market prices are shown in column b. These carbon prices were included in the generators' bids in the dispatch model runs and therefore are embedded in the AESC 2015 avoided electricity costs. The non-embedded value in each year is the difference between the marginal abatement cost ($100/t) and the value of the embedded carbon price shown in column c. Exhibit 4-6 illustrates the relationship between the embedded and non-embedded CO_2 cost.

Exhibit 4-8. Non-Embedded Cost of CO_2 Emissions (2015$/short ton of CO_2 equivalent)



Comparison to AESC 2013

The AESC 2015 value for the CO_2 marginal abatement cost of $100/ton is the same in nominal terms as the AESC 2013 value. Because the AESC 2015 embedded CO_2 cost is lower than that of AESC 2013, the non-embedded cost is correspondingly higher.

Applying Non-Embedded CO_2 Costs in Evaluating Energy Efficiency Programs

The non-embedded values from Exhibit 4-5 are incorporated as a separate value in the avoided electricity cost workbooks and expressed as dollars per kWh based upon our analysis of the CO_2 emissions of the marginal generating units summarized below. We recommend that program administrators include these values in their analyses of energy efficiency programs unless specifically prohibited from doing so by state or local regulations. At a minimum, program administrators should calculate the costs and benefits of energy efficiency programs with and without these values in order to assess their incremental impact on the cost-effectiveness of programs.

4.4 Value of Mitigating Significant Pollutants

4.4.1 Electricity Generation

Pollutants and Their Significance

Impacts associated with electricity production and uses include a wide variety of air pollutants, water pollutants, and land use impacts. These include the following:

- Air emissions (including SO_2, NO_x and ozone, particulates, mercury, lead, other toxins, and greenhouse gases) and the associated health and ecological damages

- Fuel cycle impacts associated with "front end" activities such as mining and transportation, and waste disposal
- Water use and pollution
- Land use
- Aesthetic impacts of power plants and related facilities
- Radiological exposures related to nuclear power plant fuel supply and operation (routine and accident scenarios)
- Other non-embedded impacts, such as economic impacts (generally focused on employment), energy security, and others

Over time, regulations limiting emission levels have forced suppliers and buyers to consider at least a portion of these costs in their production and use decisions, thereby embedding a portion of these costs in electricity prices. We anticipate that the non-embedded carbon cost will continue to be the dominant non-embedded environmental cost associated with marginal electricity generation in New England.

For AESC 2015, our approach to quantifying the reduction in physical emissions due to energy efficiency is as follows:

- Identify the marginal unit in each hour in each transmission area from our energy model;
- Draw the heat rates, fuel sources, and emission rates for NO_x and CO_2, of those marginal units from the database of input assumptions used in our pCA simulation; and
- Calculate the physical environmental benefits from energy efficiency and demand reductions by calculating the emissions of each of those marginal units in terms of lbs/MWh. We do this by multiplying the quantity of fuel burned by each marginal unit by the corresponding emission rate for each pollutant for that type of unit and fuel.

The calculations for each pollutant in each hour are as follows:

$$\text{Marginal Emissions} = [\text{Fuel Burned}_{MU}\ (\text{MMBtu}) \times \text{Emission Rate}_{MU}\ (\text{lbs/MMBtu}) \times 1\ \text{ton}/2000\ \text{lbs}]/\text{Generation}_{MU}\ (\text{MWh})$$

Where:

Fuel Burned$_{MU}$	=	the fuel burned by the marginal unit in the hour in which that unit is on the margin,
Emission Rate$_{MU}$	=	the emission rate for the marginal unit, and
Generation$_{MU}$	=	generation by the marginal unit in the hour in which that unit is on the margin.

Value of Mitigating Significant Pollutants

The scope of work for AESC 2015 asks for the heat rates, fuel sources, and emissions of NO_x, and CO_2 of the marginal units during each of the energy and capacity costing periods in the 2015 base year. It also asks for the quantity of environmental benefits that would correspond to energy efficiency and demand reductions, in pounds per MWh, respectively, during each costing period.

Exhibit 4-9 summarizes the marginal heat rate and marginal fuel characteristics from the model results. The results are based on the marginal unit in each hour in each transmission area, as reported by the model. Once the marginal units are identified, we extracted the heat rates, fuel sources, and emission rates for the key pollutants from the database of input assumptions used in our pCA simulation of the New England wholesale electricity market.

Exhibit 4-9. 2015 New England Marginal Heat Rate by Pricing Period

	Summer		Winter		Grand Total
	Off Peak	On Peak	Off Peak	On Peak	
Marginal Heat Rate (BTU/kWh)	8,261	9,551	8,236	8,866	8,495

Exhibit 4-10. 2015 New England Marginal Fuel by Percentage

Marginal Fuel Type	Summer		Winter		Grand Total
	Off Peak	On Peak	Off Peak	On Peak	
Natural gas	85%	85%	85%	83%	85%
Oil	1%	3%	11%	16%	9%
Coal	9%	12%	4%	1%	5%
Nuclear	0%	0%	0%	0%	0%
Other	4%	0%	1%	0%	1%
Renewable	0%	0%	0%	0%	0%
Grand Total	100%	100%	100%	100%	100%

The avoided emissions values shown in the exhibits below represent the averages for each pollutant over each costing period for all of New England in pounds per MWh. The emission rates are presented by modeling zone; however, differences between zones tend to be relatively minor.

Exhibit 4-11. 2015 New England Avoided CO_2 and NO_x Emissions by Pricing Period

Marginal Emission Type	Summer		Winter		Grand Total
	Off Peak	On Peak	Off Peak	On Peak	
CO_2 Rate (lbs/MWh)	1,040	1,086	1,007	1,019	1,029
NO_x Rate (lbs/MWh)	0.446	0.412	0.405	0.480	0.437

Our recommended dollar values to use for relevant "embedded" avoided pollutant emissions are summarized in Exhibit 4-1. Our recommended dollar value to use for non-embedded carbon costs is provided in Exhibit 4-7.

4.4.2 End-Use Natural Gas

We estimate the environmental benefit from reduced combustion of end-use natural gas due to energy efficiency programs with the following analyses:

- Identifying the various pollutants created by the combustion, and assessing which of them are significant and how, if at all, the impact of those pollutants is currently embedded in the cost of natural gas.
- Finding the value associated with mitigation of each significant pollutant and the portion that should be treated as a non-embedded cost.

Natural gas consists of methane (generally above 85 percent) and varying amounts of ethane, propane, butane, and inert gases (typically nitrogen, carbon dioxide, and helium) (EPA 1999).

In general, the combustion in boilers and furnaces generate the following pollutants (EPA 1999, 1.4-2–5):

- Oxides of nitrogen (NO_x)
- Sulfur oxides (SO_x) (trace levels),[125]
- CO_2 and other greenhouse gases
- Particulates (trace levels)
- Volatile organic compounds
- Carbon monoxide

Pollutants and their Significance

To estimate the absolute quantities of each pollutant from the combustion of natural gas relative to the absolute quantity of each from all sources, we began by estimating the quantity of each that is emitted per MMBtu of fuel consumed. Exhibit 4-12 provides emissions factors for NO_x and CO_2 for three generalized boiler type categories.

[125] Sulfur is generally added as an odorant to natural gas, which generates trace quantities of sulfur oxides when combusted.

Exhibit 4-12. Emission Rates of Significant Pollutants

Boiler Type	NO_x (lbs/MMBtu)	CO_2 (lbs/MMBtu)
Residential boiler	0.092	118
Commercial boiler	0.098	118
Industrial boilers	0.137	118

Notes:

NO_x emissions from industrial boilers without low NO_x burners would be 0.274 lb/MMBtu. We assumed these boilers were controlled in order to be conservative.

NO_x and CO_2 emissions factors for all boilers utilized conversion rate of 1,020 Btu/scf.

Source:

Environmental Protection Agency, AP-42, Volume I, Fifth Edition, January 1995, Chapter 1, External Combustion Sources. http://www.epa.gov/ttnchie1/ap42/

We apply the pollutant emission rates for these sectors to the quantity of natural gas consumed by each in New England in 2013. The resulting estimated annual quantities of NO_x and CO_2, along with those for electric generation, are presented in Exhibit 4-13.

Exhibit 4-13. 2013 Pollutant Emissions in New England from Natural Gas

Sector	NO_x (tons)	CO_2 (tons)
Residential	9,766	12,466,973
Commercial	8,150	9,780,545
Industrial	8,675	7,435,983
R, C & I Total [a]	**26,592**	**29,683,501**
Electric Generation [b]	3,582	22,521,319

Sources:

[a] Based on gas volumes from Energy Information Administration, http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_a_EPG0_vrs_mmcf_a.htm

[b] Electric generation emissions from Environmental Protection Agency AMPD Database, http://ampd.epa.gov/ampd/?bookmark=5342

Exhibit 4-13 illustrates that combustion of natural gas is a source of both NO_x and CO_2 emissions. Moreover, these emissions are not currently subject to regulation, as explained below.

- **CO_2:** RGGI applies to electric generating units larger than 25 MW. New England CO_2 emissions for 2013 were 22.5 million tons. The total CO_2 emissions from the end-use sectors above would represent about 57 percent of the total CO_2 emissions, if such emissions were included.
- **NO_x:** The Clean Air Interstate Rule applied only to Massachusetts and Connecticut during the ozone season, as its successor is likely to. New England NO_x emissions for 2013 were

approximately 3,600 tons for just the electric generating sector.[126] The total NO_x emissions from the end-use sectors above would represent about 88 percent of the total NO_x budget if such emissions were included.

Value of Mitigating Significant Pollutants

We estimate the value associated with mitigation of NO_x and CO_2 as the product of the emissions allowance prices presented in Exhibit 4-1 and emission rates in Exhibit 4-12.[127] In addition, for states with aggressive carbon mitigation targets, we provide a value of reducing CO_2 based upon the $100/ton long-term marginal abatement cost of carbon dioxide reduction. The values by end-use sector are summarized below in Exhibit 4-14.

As noted previously, natural-gas combustion is not a significant source of SO_2 emissions. Consequently, we have not included an emission value for SO_2.

[126] A few large sources in the industrial sector are included in CAIR. These include municipal waste combustors, steel and cement plants, and large industrial boilers (such as those located at Pfizer in New London, CT and General Electric in Lynn, MA). However, the number of NO_x allowances used, sold, and traded for the industrial sector is very small. A few allowances in each state are allocated to non-electric generating units compared to thousands of allowances used, sold and traded for electric generating units.

[127] The full non-embedded value associated with NO_x emissions is probably not captured in the allowance price from electricity generation; however, determining that non-embedded value is beyond the scope of this project.

Exhibit 4-14. Annual Pollutant Emission Values by Sector (2015$/MMBtu)

	Residential			Commercial			Industrial		
	NO_x	CO_2	CO_2 at $100/ton	NO_x	CO_2	CO_2 at $100/ton	NO_x	CO_2	CO_2 at $100/ton
2015	$0.000	$0.37	$5.88	$0.000	$0.37	$5.88	$0.001	$0.37	$5.88
2016	$0.000	$0.43	$5.88	$0.000	$0.43	$5.88	$0.001	$0.43	$5.88
2017	$0.000	$0.48	$5.88	$0.001	$0.48	$5.88	$0.001	$0.48	$5.88
2018	$0.000	$0.53	$5.88	$0.001	$0.53	$5.88	$0.001	$0.53	$5.88
2019	$0.000	$0.59	$5.88	$0.001	$0.59	$5.88	$0.001	$0.59	$5.88
2020	$0.001	$0.66	$5.88	$0.001	$0.66	$5.88	$0.001	$0.66	$5.88
2021	$0.001	$0.83	$5.88	$0.001	$0.83	$5.88	$0.001	$0.83	$5.88
2022	$0.001	$1.00	$5.88	$0.001	$1.00	$5.88	$0.001	$1.00	$5.88
2023	$0.001	$1.19	$5.88	$0.001	$1.19	$5.88	$0.001	$1.19	$5.88
2024	$0.001	$1.38	$5.88	$0.001	$1.38	$5.88	$0.001	$1.38	$5.88
2025	$0.001	$1.57	$5.88	$0.001	$1.57	$5.88	$0.001	$1.57	$5.88
2026	$0.001	$1.78	$5.88	$0.001	$1.78	$5.88	$0.001	$1.78	$5.88
2027	$0.001	$1.98	$5.88	$0.001	$1.98	$5.88	$0.001	$1.98	$5.88
2028	$0.001	$2.20	$5.88	$0.001	$2.20	$5.88	$0.001	$2.20	$5.88
2029	$0.001	$2.43	$5.88	$0.001	$2.43	$5.88	$0.001	$2.43	$5.88
2030	$0.001	$2.66	$5.88	$0.001	$2.66	$5.88	$0.001	$2.66	$5.88
Levelized (2015$/MMBtu)									
5 year (2016-20)	$0.000	$0.54	$5.88	$0.001	$0.54	$5.88	$0.001	$0.54	$5.88
10 year (2016-25)	$0.001	$0.84	$5.88	$0.001	$084	$5.88	$0.001	$084	$5.88
15 year (2016-30)	$0.001	$1.24	$5.88	$0.001	$1.24	$5.88	$0.001	$1.24	$5.88

Notes:
Based on Emission Rates of Significant Pollutants for Natural Gas in Exhibit 4-12.
Pollutant values based on emission allowance prices detailed in Exhibit 4-1 and $100/short ton long-term marginal abatement cost for CO_2.

The entire amount of each value is a non-embedded cost. With the exception of those industrial sources subject to the EPA NO_x budget programs, which represent a small fraction of the total emissions, none of these emissions are currently subject to environmental requirements. Therefore, none of these values are embedded in their market prices.

4.4.3 End-Use Fuel Oil and Other Fuels

We estimate the environmental benefit from reduced combustion of fuel oil and other fuels due to energy efficiency programs with the following analyses:

- Identifying the various pollutants created by the combustion, and assessing which of them are significant and how, if at all, the impact of those pollutants is currently embedded in the cost of the studied fuels.
- Finding the value associated with mitigation of each significant pollutant and the portion that should be treated as a non-embedded cost.

The pollutant emissions associated with the combustion of fuel oil are dependent on the fuel grade and composition, boiler characteristics and size, combustion process and sequence, and equipment maintenance (EPA 1999 1.3-2). [128]

In general, the combustion in boilers and furnaces generate the following pollutants (EPA 1999, 1.4-2–5):

- Oxides of nitrogen (NO_x)
- Sulfur oxides (SO_x)
- CO_2 and other greenhouse gases
- Particulates
- Volatile organic compounds
- Carbon monoxide
- Trace elements
- Organic compounds

Pollutants and Their Significance

Like the combustion of natural gas, NO_x, SO_x, and CO_2 are potentially the most significant pollutants.[129] NO_x is a precursor to the unhealthy concentrations of ozone that areas in New England continue to experience. The region is also required to reduce NO_x and SO_x emissions by EPA programs, implement state low sulfur fuel requirements, and participate in the RGGI program to reduce CO_2 from the power sector, as described in Section 4.2.2.

For the electric generation sector, the forecast of emissions allowance prices value of mitigating emissions of from the combustion of NO_x, SO_x, and CO_2 is shown in Exhibit 4-1.

In order to estimate the absolute quantities of each pollutant from the combustion of fuels by sector, we began by estimating the quantity of each pollutant that is emitted per MMBtu of fuel consumed.[130] The pollutant emissions associated with the combustion of wood are dependent on the species of wood, moisture content, appliance used for its combustion, combustion process, and sequence and equipment

[128] EPA, 1999. "Stationary Point and Area Sources" v. 1 of Compilation of Air Pollutant Emission Factors 5th Ed. AP-42. Triangle Park, N.C.: U.S. Environmental Protection Agency. (Section 1.3-2)

[129] Wood combustion may contribute to an accumulation of unhealthy concentrations of fine particulate matter ($PM_{2.5}$). This is especially true in many valleys, where pollutants accumulate during stagnant meteorological conditions. The regulation of $PM_{2.5}$ from wood combustion is a state by state process. No comparable regionally consistent or market-based program of allowances have been established for $PM_{2.5}$, like those described above for SO_x, NO_x, and CO_2.

[130] Number-6 fuel oil has about the same rate of SO_2 emissions as distillate, about twice the rate of NO_x emissions and about seven percent higher rate of CO_2 emissions.

maintenance. The pollutant emissions associated with the combustion of kerosene are similar to those associated with the combustion of distillate oil, and depend upon boiler characteristics and size, combustion process and sequence, and equipment maintenance (EPA 1999, 1.3-2).

Exhibit 4-15 provides emissions factors for each fuel based on predominant sector-specific characteristics.

Exhibit 4-15. Emission Rates of Significant Pollutants from Fuel Oil

Sector and Fuel	SO_2 (lbs/MMBtu)	NO_x (lbs/MMBtu)	CO_2 (lbs/MMBtu)
#2 Fuel Oil [a,b]			
Residential, #2 oil	0.002	0.129	163
Commercial, #2 oil	0.002	0.171	163
Industrial, #2 oil	0.002	0.171	163
Kerosene—Residential heating [c]	0.152	0.129	173
Wood—Residential heating [d]	0.020	0.341	N/A

Notes:
For fuel oil, assumed sulfur content of 15 ppm.
Sources:
[a] Environmental Protection Agency, AP-42, Volume I, Fifth Edition, January 1995, Chapter 1, External Combustion Sources. *http://www.epa.gov/ttnchie1/ap42/* (for SO_2 and NO_x)
[b] Based on "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012," Table A-11: 2012 Energy Consumption Data and CO_2 Emissions from Fossil Fuel Combustion by Fuel Type, US EPA, 2013. http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html (for CO_2)
[c] AESC 2013.
[d] James Houck and Brian Eagle, OMNI Environmental Services, Inc., Control Analysis and Document for Residential Wood Combustion in the MANE-VU Region, December 19, 2006. http://www.marama.org/publications_folder/ResWoodCombustion/RWC_FinalReport_121906.pdf

Next, we applied those pollutant emission rates to the quantity of each fuel consumed by sector in New England in 2012 (Exhibit 4-16), with one exception: EIA supply data for 2012 indicated a supply mix of approximately 20% low sulfur distillate and 80% ULSD. For this reason, we assumed a weighted average sulfur content of 112 ppm rather than 15 ppm. The results are shown in Exhibit 4-17.

Exhibit 4-16. New England Distillate Consumption, 2012

	Residential	Commercial	Industrial
Distillate Consumption, 2012 (Trillion BTU)	217	60	24

Note:
Includes entire state of Maine.

Source:
Distillate Fuel Oil Consumption Estimates, US EIA, 2012.
http://www.eia.gov/state/seds/data.cfm?incfile=/state/seds/sep_fuel/html/fuel_use_df.html&sid=US

Exhibit 4-17. Pollutant Emissions in New England for Selected Sources

Sector	SO_2 (tons)	NO_x (tons)	CO_2 (tons)	
Emissions from Electric Generation	35,762	43,017	38,242,782	**A**
R, C & I Natural Gas Combustion		23,029	25,541,693	**B**
R, C & I #2 Fuel Oil Combustion				
Residential	1,061	12,009	15,247,491	i
Commercial	250	3,771	3,586,600	Ii
Industrial	105	1,577	1,500,491	Iii
R, C & I Total	1,415	17,357	20,334,583	**C** = i + ii + iii
Residential Combustion of Kerosene	127	108	144,194	**D**
Residential Combustion of Wood	341	5,862	0	**E**
Total	37,645	89,373	84,263,251	**F** = A+B+C+D+E
Natural gas as percent of total	**0%**	**26%**	**30%**	B/F
Other fuel as percent of total	**5%**	**26%**	**24%**	(C+D+E)/F
Non-electric as percent of total	**5%**	**52%**	**55%**	(B+C+D+E)/F

Notes:

All figures are for 2012. Natural gas values equivalent to those in Exhibit 4-13, but for 2012.
SO_2 emissions for #2 fuel oil based on weighted average fuel sulfur content of 112 ppm for low sulfur heating oil.
Includes entire state of Maine, not just portion within ISO-NE.

Value of Mitigating Significant Pollutants

Emissions of NO_x, SO_x, and CO_2 from the combustion of these fuels are not currently subject to regulation, as explained below.

All of these values are non-embedded values.

- SO_2 and CO_2: The acid rain program and RGGI apply to electric generating units larger than 25 MW. New England SO_x emissions from electric generating units for 2012 were approximately 35,800 tons. The total SO_x emissions from the end-use sectors above would represent approximately 5 percent of the total SO_x emissions, if such emissions were included.[131] New England electric generation CO_2 emissions for 2012 were approximately 38.2 million tons. The calculated CO_2 emissions from the non-electric end-use sectors above would represent approximately 55 percent of the total CO_2

[131] Northeastern states began in 2012 to phase in requirements for ultra-low sulfur distillate (ULSD, 15 ppm sulfur). With the exception of New Hampshire, the transition to new requirements will be complete by mid-2018. In conjunction with this transition, the Northeast Home Heating Oil Reserve converted to ULSD in 2011, and in 2013, NYMEX switched its specification for the heating oil futures contract to the ULSD specification. As a result, approximately 80% of the supply (as indicated by 2012 EIA data) had shifted to the new specification by 2012. Taking the lower sulfur content into account in our analysis of 2012 resulted in a significant decrease in the estimate for fuel oil SO_2 emissions, relative to the AESC 2013 estimate for 2011.

emissions shown here, with natural gas accounting for 30 percent and other fuels accounting for 24 percent.

- NO_x: The Ozone Transport Commission–EPA NO_x budget program applies to electric generating units larger than 15 MW and to industrial boilers with a heat input larger than 100 MMBtu per hour. New England NO_x emissions for 2012 were approximately 43,000 tons for just the electric generating sector.[132] The calculated NO_x emissions from the non-electric end-use sectors above would represent approximately 52 percent of the total NO_x emissions shown here, split evenly between natural gas and other fuels.

The allowance prices associated with electricity generation for NO_x and SO_x represent the value associated with mitigating these emissions on the 2015 NO_x and SO_2 emissions allowance prices per short ton in Exhibit 4-1, the value AESC 2015 has internalized in its forecast consistently across fuels as noted elsewhere in this chapter.[133] Those values, per MMBtu of fuel, are presented in Exhibit 4-18.

Because we have estimated the full cost of CO_2 mitigation, and because none of that cost is embedded in the prices of non-electricity fuel use, the value of CO_2 shown in Exhibit 4-18 is the long-term marginal abatement cost of $100/ton, presented here per MMBtu of fuel.

Exhibit 4-18. Value of Pollutant Emissions from Fuel Oil in 2015 (2015$/MMBtu)

Sector	SO_2	NO_x	CO_2
Residential	$0.0000	$0.0001	$8.16
Commercial	$0.0000	$0.0001	$8.15
Industrial	$0.0000	$0.0001	$8.15

With the exception of those industrial sources subject to the EPA NO_x budget program, which represent a small fraction of the total emissions, none of the non-electric emissions shown in Exhibit 4-17 are currently subject to environmental requirements.[134] None of the values shown in Exhibit 4-18, therefore, are internalized in the relevant fuels' market prices.

The values by year for fuel oil over the study period are presented in Appendix E.

[132] A few large sources in the industrial sector are included in the NO_x budget program. These include municipal waste combustors, steel and cement plants and large industrial boilers (such as those located at Pfizer in New London, Connecticut, and General Electric in Lynn, Massachusetts). However, the number of NO_x allowances used, sold and traded for the industrial sector is very small. A few allowances in each state are allocated to non-electric generating units compared to thousands of allowances used, sold, and traded for electric generating units.

[133] The full externality value associated with SO_x and NO_x emissions is probably not captured in the allowance price from electricity generation associated with these two pollutants; however, determining that externality value is beyond the scope of this project.

[134] EPA. Factsheet: EPA's Final Air Toxics Standard Major and Area Source Boilers and Certain Incinerators Overview of Rules and Impacts. Available at http://www.epa.gov/airquality/combustion/docs/overviewfsfinal.pdf. Accessed January 30, 2015.

4.5 Discussion of Non-Embedded NO_x Costs

This section addresses the request in the AESC 2015 scope of work to provide a discussion of non-embedded NO_x costs. We are not recommending an additional non-embedded NO_x value additive to the embedded allowance prices based on the analysis discussed in this section; rather, we recommend an approach consistent with AESC 2013, and detailed below.

4.5.1 Health Impacts and Damages

NO_x emitted from the combustion of coal and natural gas reacts with compounds in the air ("precursors") to produce ozone, particulate matter ("PM2.5"), and acid rain. Both PM2.5 and ozone are EPA criteria pollutants that have been shown to have harmful effects on human health, and are regulated under the Clean Air Act. Quantifying the value associated with damages from NO_x emissions is a particularly complicated process. Most studies look at incidence rates of premature death and chronic respiratory diseases such as bronchitis, emphysema, and asthma in order to evaluate health impacts. The reaction of NO_x with precursors to form PM2.5 and ozone is highly dependent on atmospheric conditions and local emissions of other precursors. Fowlie and Muller use a stochastic model to estimate damages and quantify health impacts for 565 coal plants, with average impacts on human health to be valued at $1,795/ton NOx. The intra-source variation in damage estimates they found was considerable; their damage estimate for a representative source in Ohio was $1,549/ton NO_x, with a standard deviation of $1,859/ton (2015 dollars).[135] Mauzerall et al. found a similar level of uncertainty in an earlier study, citing one location where the health impact of emissions nearly doubled within a short span of time as the temperature changed. [136] EPA has used the BenMAP tool to calculate benefits of NO_x reduction based on reduced mortality from particulate matter, and calculates 2015 national benefits of approximately $20,000/ton for electricity generation and $13,000/ton for non-electricity sources (2015 dollars), with considerable variation in benefit levels among the nine metropolitan areas examined.[137]

The analyses above do not include valuation of the impacts of environmental effects resulting from nitrogen deposition, or visibility impairment from increased haze.

[135] Fowlie, M. N. Muller (2013) "Market-Based Emissions Regulation When Damages Vary Across Sources: What Are the Gains from Differentiation?" (With appendices). National Bureau of Economic Research. NBER Working Paper No. 18801. $1,734, $1,496, and $1,976 in 2013 dollars, respectively. http://nature.berkeley.edu/~fowlie/papers.html

[136] Mauzerall, D.L., B. Sultan, N. Kim, and D.F. Bradford. 2005. "NO_x emissions from large point sources: Variability in ozone production, resulting health damages and economic costs." Atmos. Environ. 39(16):2851-2866

[137] EPA (2015). "RSM-based Benefit per Ton Estimates." Values in 2006$: $17,000 and $11,000. Accessed January 30, 2015. Available at: http://www.epa.gov/oaqps001/benmap/bpt.html

4.5.2 Abatement Costs

In New England, significant progress on NO_x abatement has already been made, marked by rapid reductions over the past decade (see Exhibit 4-19).

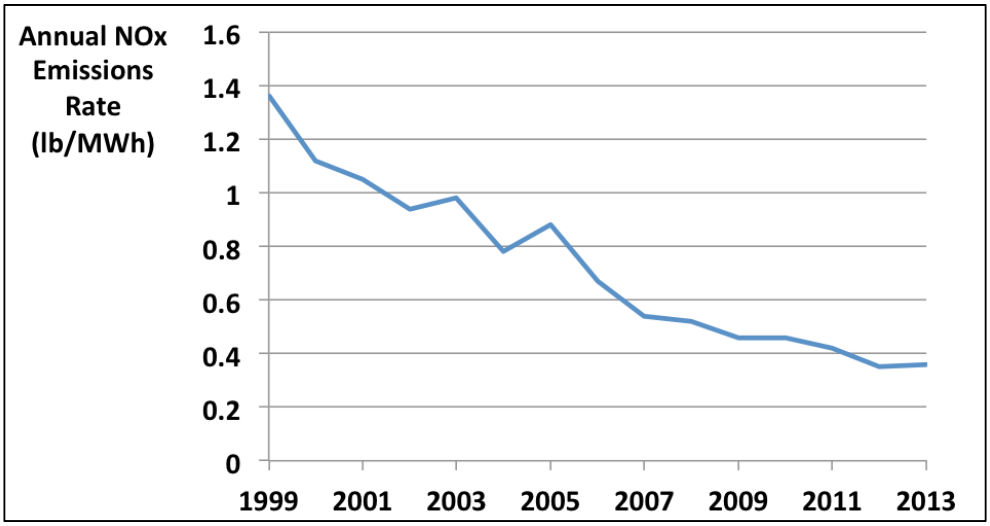
Market prices for NO_x emissions fall far below the estimated costs of health impacts. AESC 2013 embedded NO_x prices were approximately $28 per ton; by the end of 2014, values for costs of NO_x mitigation under CAIR had fallen substantially from those cited in AESC 2013 to levels in the $10/ton range. With the replacement of CAIR by CSAPR, NO_x mitigation costs in New England are currently uncertain.[138]

Connecticut and Massachusetts had been included in the ozone-season CAIR program, but not in CSAPR because air quality modeling shows they no longer contribute significantly to nonattainment of the 1997 ozone or 1997 and 2006 PM NAAQS in other states.[139] Nevertheless, the two states had relied on CAIR reductions to comply with air quality obligations under Regional Haze and ozone NAAQS. Options to maintain the reductions include intrastate NO_x trading programs, and enforceable ozone season emission limits on CAIR units; a number of SIPs in the two states will likely need amending in order to meet remaining obligations. Once more information is available about a potential Federal CAIR replacement for New England, and amended SIPs are in place, the impact on future compliance costs should become more apparent.

[138] With the restarting of CSAPR in January 2015, CSAPR NO_x allowance prices traded in the $250/ton range, although those prices are irrelevant to generators in the New England states, which are not subject to the rule.

[139] US EPA presentation, "CSAPR Stay Lifted – Implications for Connecticut Sources," David B. Conroy, CT SIPRAC, November 13, 2014. Available at: http://www.ct.gov/deep/lib/deep/air/siprac/2014/conroy_ctsiprac11132014.pdf

Exhibit 4-19. Annual NO_x Emissions Rate in New England (lb/MWh)



Source: 2013 ISO New England Electric Generator Air Emissions Report. December 2014. http://www.iso-ne.com/static-assets/documents/2014/12/2013_emissions_report_final.pdf

4.6 Compliance with State-Specific Climate Plans

The AESC 2015 scope of work required the project team to determine if there was some component of compliance with state-specific regulations or climate plans that would directly impact generators and that the project team could quantify and credibly support. The scope of work further required the project team, if it made such a determination, to include their estimate of that compliance cost in one of the three categories of costs related to emissions control reflected in the AESC 2015 avoided energy cost forecast. (Those three categories of emissions control costs are "currently enforced," "enacted, but not yet in effect," and "reasonably expected to be enacted.") This is because, due to the nature of the regional market, the costs of complying with one state's law may also affect avoided costs in other states in the New England market. The scope notes that AESC 2015 was not to determine the value of full compliance with these plans, laws, or regulations or the impact of energy efficiency on other sectors that may also be covered by them, such as transportation or industry, in achieving the overall objectives of the plan, law or regulation.

The project team is not aware of any instances of state-specific climate plans that will *directly* affect generators, other than those already discussed and accounted for in the analysis of embedded environmental costs associated with state compliance with regional or Federal standards and costs associated with renewable portfolio standards.

As described above, there is one proceeding that could impact the estimate of non-embedded costs in Massachusetts, i.e., DPU Docket No. 14-86. In that proceeding the Massachusetts DEP and DOER filed a joint petition requesting the DPU to determine whether the existing method of calculating the costs of reducing GHG emissions to comply with the Global Warming Solutions Act (GWSA) should be replaced by a marginal abatement cost curve approach, and that Program Administrators incorporate estimates of avoided GWSA compliance costs in energy efficiency cost-effectiveness analyses. The petitioners have filed estimates of GWSA compliance costs and have asked the DPU to order that these values be used.[140] The proceeding is still underway as of this writing, and the DPU has not yet made a determination. It should be noted that the marginal abatement cost for Massachusetts to achieve compliance with the GWSA are not comparable with the global marginal abatement costs to achieve specific atmospheric CO_2 concentrations, discussed above.

Additionally as described above, Mass DEP in early January 2015, published a proposed "Clean Energy Standard" regulation for public comment. A Massachusetts CES would implement one of the strategies in the CECP, and providing a long-term incentive to ensure ongoing progress toward reducing greenhouse gas emissions by 80 percent by 2050. The proposed regulation would qualify clean energy generators based on a generic 50 percent-below-natural-gas threshold, and would count RPS compliance toward CES compliance, with CES targets exceeding RPS targets. Resources outside ISO-NE such as Canadian hydro would be required to use transmission that commenced operation after 2010.[141] Public comment on the proposed regulations is being accepted through April 27, 2015.

[140] For the proposed values and a description of the proposed approach, see "Amended Direct Testimony of Elizabeth A. Stanton On Behalf of the Department of Energy Resources and the Department of Environmental Protection Regarding the Cost of Compliance with the Global Warming Solutions Act," September 16, 2014, filed in MA D.P.U. No. 14-86.

[141] "Summary of Proposed MassDEP Regulation: Clean Energy Standard (310 CMR 7.75)," Available at: http://www.mass.gov/eea/docs/dep/air/climate/ces-fs.pdf. Additional information available at http://www.mass.gov/eea/agencies/massdep/climate-energy/climate/ghg/ces.html.

Chapter 5: Avoided Electric Energy and Capacity Costs

This chapter provides projections of avoided electric energy and capacity market prices, as well as Renewable Portfolio Standard (RPS) compliance costs that are not embedded in those market prices. We present the projections of electric energy and capacity market prices in the same chapter because these projections are directly interrelated, capacity prices in the long-term affect energy prices in the long-term and vice versa.

The chapter presents projections of avoided electric energy and capacity market prices for two cases, a Base Case and a BAU Case. The Base Case assumes no reductions from new ratepayer funded energy efficiency programs approved from January 2015 onward except for the reductions which have been bid into the Forward Capacity Auctions for power years through May 2018. The BAU Case assumes a continuation of reductions from ratepayer funded energy efficiency at the levels reflected in ISO-NE forecasts.

This chapter is organized as follows:

- Section 5.1S provides an overview of wholesale energy and capacity markets in New England.
- Section 5.2 describes the model AESC 2015 used to simulate the operation of those two markets.
- Section 5.3 describes the common assumptions AESC 2015 used to simulate the operation of those two markets.
- Section 5.4 describes the assumptions AESC 2015 used solely to simulate the operation of the capacity market;
- Section 5.5 presents the Base Case projections and compares those results to AESC 2013. Appendix B provides detailed results for each year of the study period, by zone by season, by period (i.e. on-peak, off-peak);
- Section 5.6 presents the projections of RPS compliance costs. Appendix F provides detailed renewable energy certificate (REC) price forecasts and avoided RPS costs by state for each year of the study period; and
- Section 5.7 presents an assessment of alternative electric energy costing periods.

5.1 New England Wholesale Energy and Capacity Markets

5.1.1 Wholesale Energy Markets

ISO New England (ISO-NE) manages two primary wholesale energy markets, Day-Ahead and Real-Time, with the objective of:

> The primary objective of the electricity markets operated by ISO New England is to ensure a reliable and economic supply of electricity to the high-voltage power grid. The markets include a Day-Ahead Energy Market and a Real-Time Energy Market. In what is termed a multi-settlement system, each of these markets produces a separate but related financial settlement.142

Most transactions are scheduled in the Day-Ahead Market, with transactions in the Real-Time Market limited to balancing actual supplies with actual demands in real time. On average energy prices in the markets are very close, although real-time market prices exhibit greater volatility.

The Day-Ahead Energy Market produces financially binding schedules for the sale and purchase of electricity one day before the operating day. However, supply or demand for the operating day can change for a variety of reasons, including forecast error for load and for variable resources such as wind and solar, generator reoffers of their supply into the market, real-time hourly self-schedules (i.e., generators choosing to be on line and operating at a fixed level of output regardless of the price of electric energy), self-curtailments, transmission or generation outages, and unexpected real-time system conditions.

Physically, real-time operations balance instantaneous changes in supply and demand and ensure that adequate reserves are available to operate the transmission system within its limits. Financially, the Real-Time Energy Market settles the differences between the day-ahead scheduled amounts of load and generation and the actual real-time load and generation. Participants in this market either pay, or are paid, the real-time locational marginal price (LMP) (see below) for the amount of load or generation in megawatt-hours (MWh) that deviates from their day-ahead schedule.

Unit Commitment

In a power system the supply curve in a given hour is defined by the set of generating units committed to run in that hour. The process through which the system operator, in New England it is ISO NE, schedules individual generating units to be run in a given hour of a given day, or not run in that hour of that day, is referred to as "unit commitment". [143]

[142] ISO-New England 2010 Annual Market Report (2011, 29–30)

[143] Lelic, Lzudin. Unit Commitment & Dispatch, Introduction to Wholesale Electricity Markets (WEM 101), ISO NE, September 15-19, 2014

Unit commitment is related to, but different from, economic dispatch. The goal of the unit commitment decision is find the least-cost mix of units to supply energy for the 24 hours period for which the decision is being made, plus at least another 24 hours of the look-ahead time to correctly assess the future implications of decisions made for the first 24 hours. Thus, ISO NE is making unit commitment decisions for a 24 hour period, not a 1 hour period. ISO NE makes unit commitment decisions for each unit based on the unit's operational constraints in addition to the load to be served and the economics of the unit. The operational constraints include minimum up- and down-times, minimum operating limits, and start-up costs

ISO New England makes its initial unit commitment decision prior to the power day, and then makes additional decisions during the day. For a given day, ISO New England makes its first (and financially binding) unit commitment decision by 13:30 on a preceding day – Day-ahead market clearing and formation of day-ahead LMPs. After that ISO-NE immediately opens re-offer period and by 17:00 of the preceding day produces an update to the unit commitment decision through the process known as Resource Adequacy Assessment (RAA)/security constrained reliability assessment (SCRA). During the operating day, ISO NE continues to perform SCRA for that day. At each unit commitment decision ISO NE effectively modifies the set of committed generating resources influencing price formation. One of the most critical inputs into the unit commitment process is the level of demand anticipated to be served during the entire optimization horizon of the unit commitment process. In the day ahead market, the demand is determined through demand bids, decrement bids and export external transactions. In the RAA/SCRA, ISO New England augments bid information with current demand forecasts.

ISO NE produces unit commitment decisions by solving advanced algorithms of the mixed integer linear programming problem. In formulating and solving this problem, ISO NE considers not only fuel and variable O&M costs submitted by generation owners though supply offers, but also start-up costs and opportunity costs associated with running energy limited resources such as hydro and pumped storage resources. This problem is essentially a dynamic optimization problem with economic and operational considerations spanning over 24 hours of the day for which the problem is being solved plus at least another 24 hours of the look-ahead time to correctly assess the future implications of decisions made for the first 24 hours. The solution to this problem is sensitive to the level of load that the power system is projected to serve.

Locational Marginal Prices

Wholesale electric energy prices are set at various pricing points or "nodes" throughout New England referred to as "pnodes". These prices, referred to as "locational marginal prices" (LMP), reflect the value of electric energy at those specific locations by accounting for the patterns of load, generation, and the physical limits of the transmission system at those locations. New England wholesale electricity prices are identified at 900 pnodes on the bulk power grid. If the system were entirely unconstrained and had no losses, all LMPs would be the same, reflecting only the cost of serving the next increment of load. This incremental megawatt of load would be served by the generator with the lowest-cost energy offer available to serve that load, and electric energy from that generator would be able to flow to any node on the transmission system. LMPs differ among locations during time periods when transmission and reserve constraints prevent the next-cheapest megawatt (MW) of electric energy from reaching all locations of the grid. In addition, even during periods when the cheapest megawatt can reach all locations, the marginal cost of physical losses will result in different LMPs across the system.

New England has five types of pnodes, with "hub" nodes representing load-weighted prices for uncongested areas, or load zones. New England currently has eight load zones: Maine (ME), New Hampshire (NH), Vermont (VT), Rhode Island (RI), Connecticut (CT), Western/Central Massachusetts (WCMA), Northeast Massachusetts and Boston (NEMA), and Southeast Massachusetts (SEMA). Generators are paid the day-ahead and real-time LMP for electric energy at their respective nodes, and participants serving demand pay the price at their respective load zones.

Import-constrained load zones are areas within New England that must use more expensive generators than the rest of the system because local, inexpensive generation or transmission-import capability is insufficient to meet both local demand and reserve requirements. Export-constrained load zones are areas within New England where the available resources, after serving local load, exceed the areas' transmission capability to export excess electric energy.

5.1.2 Wholesale Capacity Markets

ISO New England describes this market as follows:

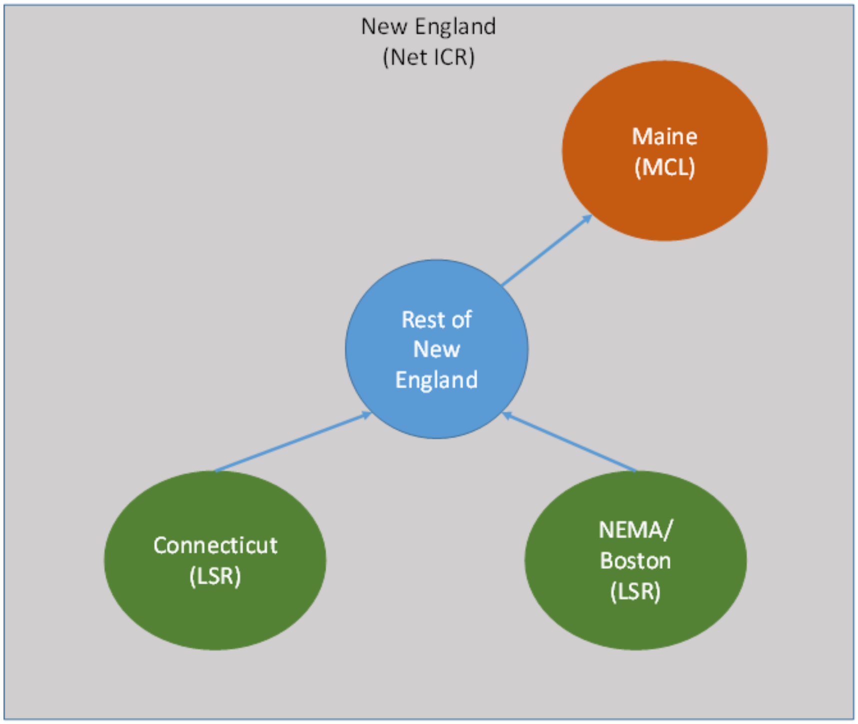
> [t]he Forward Capacity Market is a long-term wholesale market that assures resource adequacy, locally and system wide. The market is designed to promote economic investment in supply and demand resources where they are needed most. Capacity resources may be new or existing resources and include supply from power plants, import capacity, or the decreased use of electricity through demand resources. To purchase enough qualified resources to satisfy the region's future needs and allow enough time to construct new capacity resources, Forward Capacity Auctions (FCAs) are held each year approximately three years in advance of when the capacity resources must provide service. Capacity resources compete in the annual FCA to obtain a commitment to supply capacity in exchange for a market-priced capacity payment.[144]

ISO NE uses FCAs to ensure a sufficient quantity of capacity is available to serve the region in each power year, i.e., June 1 to May 31. This quantity, the "installed capacity requirement' or ICR, is equal to the projected peak for the year plus a reserve margin. The ICR defined for the entire system does not reflect locational capacity requirements due to transmission constraints preventing ISO NE from using every MW of installed capacity to meet demand at any location on the system. Unlike energy market, in which transmission constraints are represented explicitly, in the FCA design transmission limitations are implicit in the determination of locational requirements for installed capacity. To determine these locational requirements, ISO New England uses a sophisticated probabilistic modeling of the electrical

[144] "Introduction to New England's Forward Capacity Market. ISO 101," ISO New England.

grid. This modeling is conducted annually and employs General Electric Multi Area Reliability Simulator (GE MARS). The most recent study published by ISO New England is for the 2017-2018 commitment period.[145] Exhibit 5-1 depicts the schematics of locational installed capacity requirements in New England.

Exhibit 5-1. Schematics of FCA Capacity Requirements[146]



As shown in this figure, installed capacity requirements in New England are set as follows:

- System-wide Installed Capacity Requirement (ICR). For the purpose of the study, AESC 2015 used ICRs that are net of capacity supply provided by imports from Hydro Quebec across HVDC interties (Net ICR represented by the gray rectangle).
- Local Sourcing Requirements (LSRs) for import constraint zones – Connecticut and NEMA/Boston represented by green ovals. Local sourcing requirements specify the minimum level of capacity that must be procured from resources electrically located in import-constrained zones.

[145] ISO New England Installed Capacity Requirement, Local Sourcing Requirements, and Maximum Capacity Limit for the 2017/18 Capacity Commitment Period.

[146] This schematics does not show SEMA as another import constrained zone. At the time when TCR was preparing this analyses, it had no sufficient information to explicitly model SEMA as a capacity zone.

- Maximum Capacity Limit (MCL) for export constrained zone – Maine represented by the orange oval. MCL is the maximum capacity that can be procured in the export constrained zone.
- The diagram in Exhibit 5-1 also depicts a notional Rest of New England Zone (blue circle) for which no requirements are specified. The arrows between constrained zones and the Rest of New England simply reflect the directions in which excess capacity can be sold. Thus, capacity in an excess constrained zones that is in the excess of LSR in that zone can be sold to meet system-wide ICR. However, as the direction of the arrow indicates, the reverse is not true, capacity not located in the import-constrained zone cannot be sold to meet LSR in that zone. In contrast, for the export constrained zone, capacity located elsewhere can be used to meet MCL in that zone. However, no capacity in Maine in excess of MCL can be sold to meet system-wide requirements.

During the auction, suppliers submit offers to meet installed capacity requirements: MW quantities of generation and/or demand resources and offered prices. In addition, suppliers may submit delist bids indicating that certain capacity will not be available to meet the demand. The auctioneer ultimately selects a set of offers which are sufficient to meet capacity requirements while minimizing the total costs (as offered) of meeting those requirements. The outcome of the auction is the set of resources selected to meet ICAP requirement and capacity prices. Each FCA is held to acquire capacity commitments for that power year.

5.2 Market Simulation using *pCloudAnalytics* (*pCA*)

AESC 2015 developed projections of electric energy and electric capacity prices by simulating the operation of the ISO New England markets for energy and ancillary services (E&AS) and for capacity, i.e., the Forward Capacity Market (FCM) interactively using pCloudAnalytics (pCA).

pCA utilizes the Power System Optimizer Model ("PSO") developed by Polaris Systems Optimizations, Inc. ("Polaris")[147] to perform the production cost modeling of the ISO New England power system. PSO is a detailed, MIP based, unit commitment and economic dispatch model that simulates the operation of the electric power system. PSO determines the security-constrained commitment and dispatch of each modeled generating unit, the loading of each element of the transmission system, and the locational marginal price (LMP) for each generator and load area. PSO support both hourly and sub hourly timescales. The analytical structure of PSO is graphically presented in Exhibit 5-2 which distinguishes four important components of PSO: Inputs, Models, Algorithms and Outputs. This document primarily focuses on data sources and analytical steps used by NEG to develop Inputs to the PSO. Where relevant,

[147] http://www.psopt.com

this assumptions document describes how PSO Models are configured to provide adequate representation of the ISOE New England's energy market.

pCA is a cloud based power market simulation environment implemented on Amazon EC2 commercial cloud and organized as Software as a Service (SaaS). TCR licenses this service from Newton Energy Group, pCA developer and vendor. Exhibit 5-3 provides a graphical representation of *pCA* architecture. *pCA* manages formation of data inputs for PSO organized into distinct simulation scenarios, partitions each scenario into concurrently simulated segments, provides virtual machines on the cloud to process segments through PSO, collects and reassembles simulations results into scenario specific outputs and loads them into the Power Explorer (pEx), multi-dimensional data structure accessible through Microsoft Excel via pivot tables. The user prepares input data and accesses modeling results in MS Excel. The user communicates with cloud resources through pLINC, a special software tool linking user's local environment with the cloud environment in Amazon EC2.

Exhibit 5-2. Analytical Structure of PSO

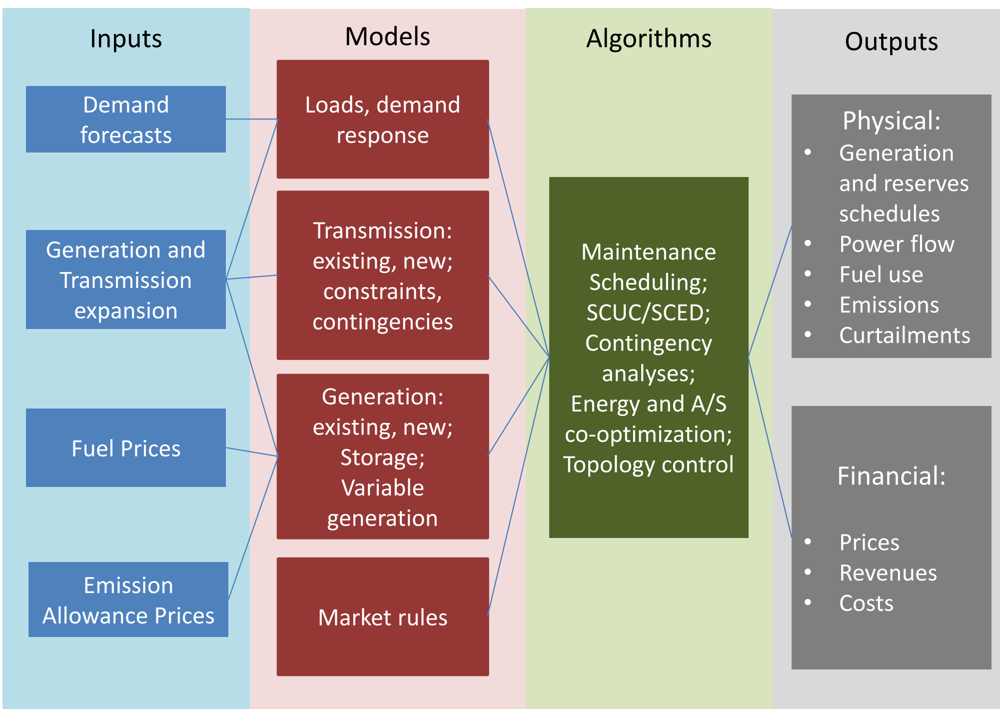
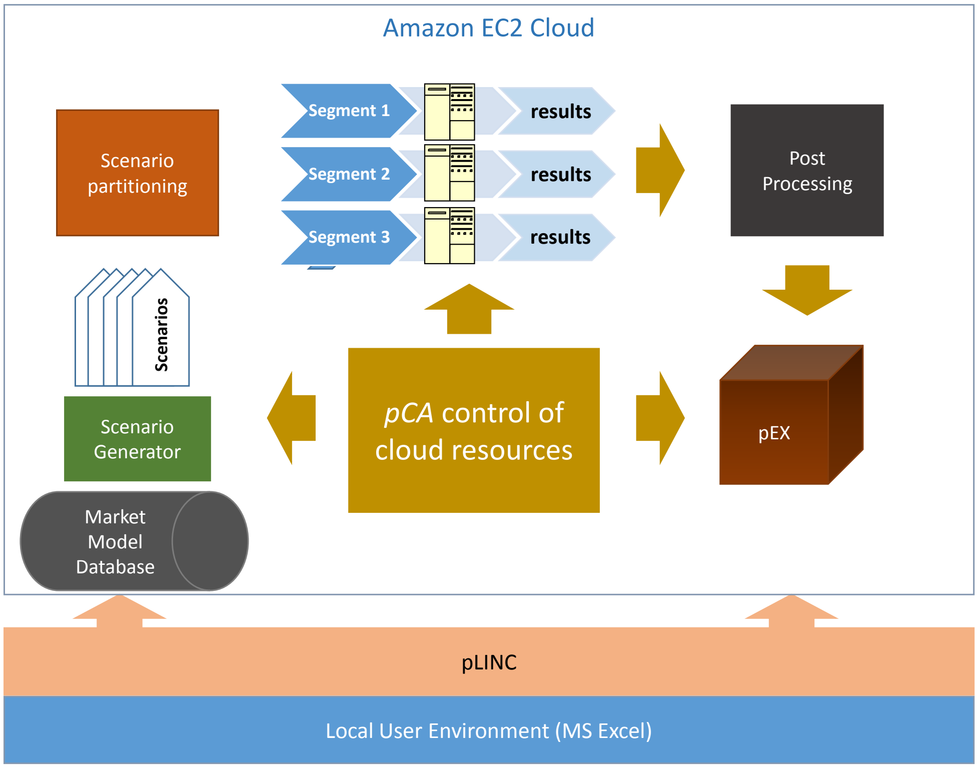


Exhibit 5-3. Architecture of *pCloudAnalytics*



In the PSO modeling used for this project, there is a commitment (next-day) step and a dispatch (real-time) step. In the commitment process, generating units in a region are turned on or kept on in order for the system to have enough generating capacity available to meet the expected peak load and required operating reserves in the region for the next day. PSO then uses the set of committed units to dispatch the system on an hourly real-time basis, whereby committed units throughout the modeled footprint are operated between their minimum and maximum operating points to minimize total production costs. The unit commitment in PSO is formulated as a mixed integer linear programming optimization problem which is solved to the true optima using the commercial Gurobi solver.

5.2.1 Configuration of pCloudAnalytics for AESC 2015

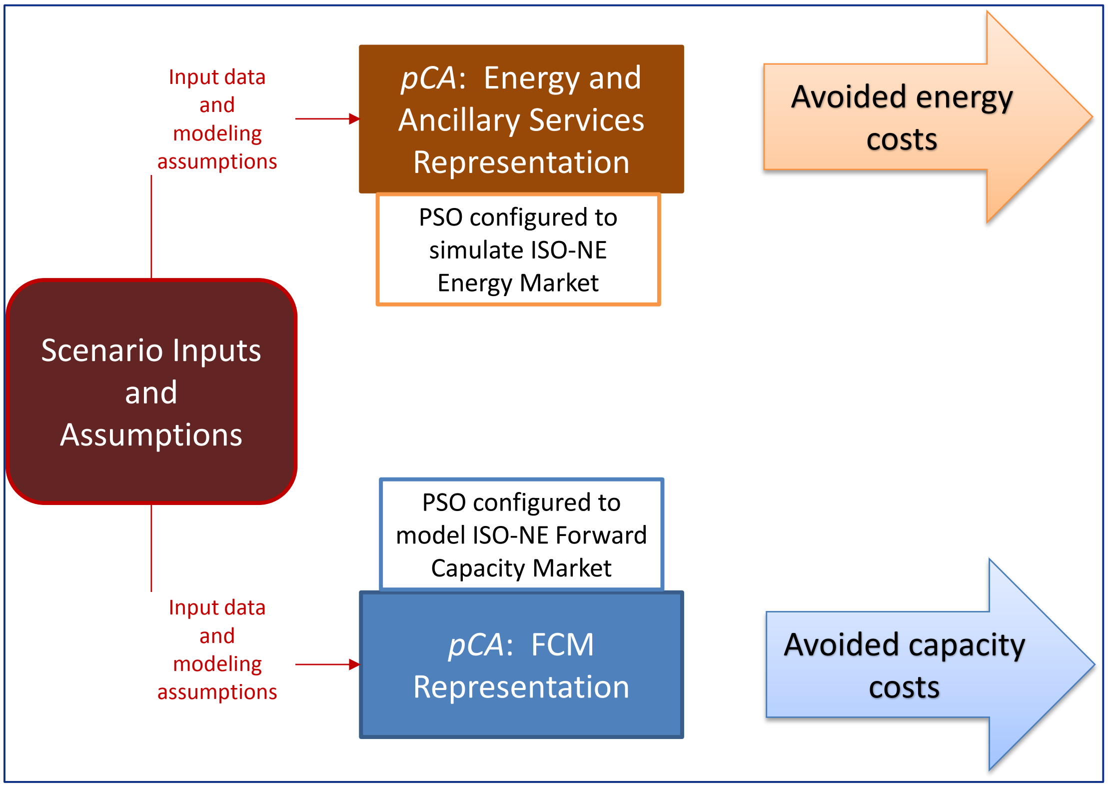
TCR configured *pCloudAnalytics* (pCA) to iteratively model two distinct ISO New England markets: market for energy and ancillary services (E&AS) and the Forward Capacity Market (FCM). As shown in Exhibit 5-4, the E&AS configuration of pCA produces the projection of energy prices while the FCM configuration produces the projection of capacity prices.

The critical element of this analysis is development of input assumptions which are consistent between the two market configurations. To achieve this consistency, two conditions must hold:

- The set of generating units included in the E&AS model should be sufficient to meet system-wide and local resource adequacy requirements. Otherwise, E&AS simulation will yield avoided energy costs that are too high.

- On the other hand, the generating resources modeled in the E&AS configuration should include only those resources that clear in the market in the FCM configuration. Otherwise, E&AS simulations will yield energy costs that are too low.

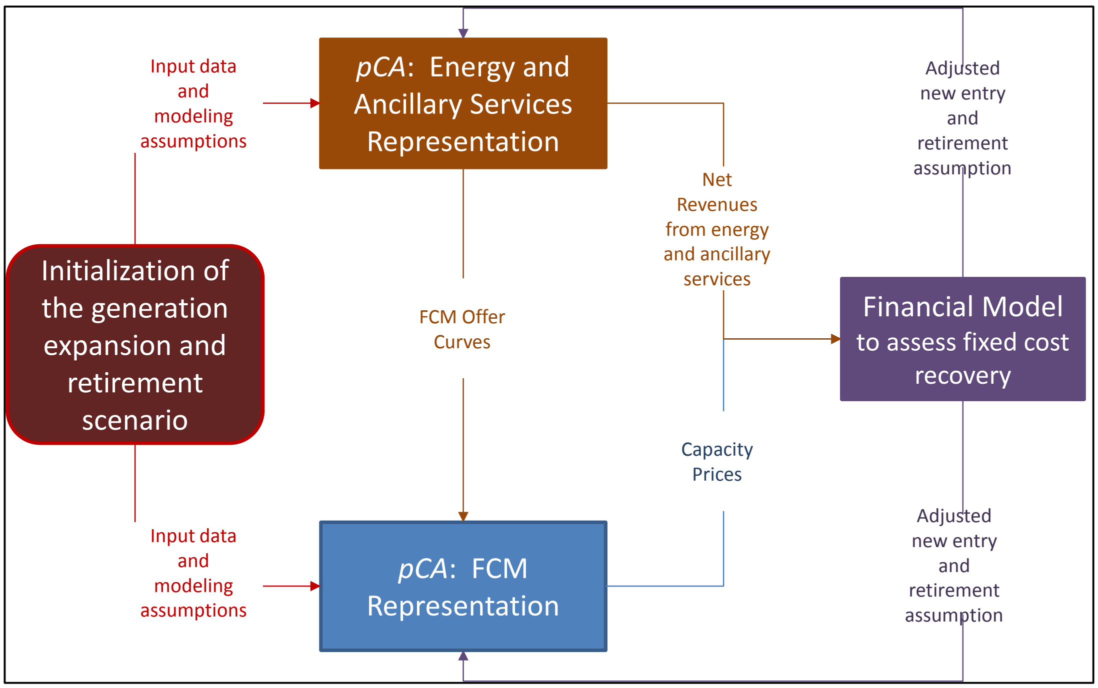
Exhibit 5-4. Use of pCloudAnalytics in AESC 2015



5.2.2 Iterative Use of pCA to develop a Consistent Set of Generating Resources

To develop a consistent set of resources across two markets, TCR ran E&AS and FCM iteratively as shown in Exhibit 5-5.

Exhibit 5-5. Iterative Use of pCA



In the initial iteration, TCR developed a forward-looking capacity balance to make sure that system wide and local resource adequacy requirements are met.

Next, TCR ran its E&AS simulations. TCR used the results of these simulations to project the energy market revenues capacity resources would receive each year. Based on those projected energy revenues, and our projection of the total cost a generating unit would need to recover each year to earn its threshold level of earnings, TCR projected the bids that new units would submit in the FCAs. TCR represents these projected bids as "offer curves" in the FCM model to simulate the outcome of the FCAs. (TCR made this interactive analysis using the results of the E&AS and FCM simulations as inputs to a financial model which it ran for each potential capacity resource addition. The financial model computed the net cash flow of each resource over the modeling horizon.)

- For existing resources the key question is whether the resource can consistently recover its fixed O&M costs given E&AS and FCM revenues. AESC 2015 assumes that if a resource cannot recover its fixed O&M costs for 2-3 subsequent years, it will be removed from the dataset as if retired while a generic new resource will be added to the dataset to maintain capacity balance.

- For potential new resources the key question is whether the resource recovers its fixed O&M and capital cost given E&AS and FCM revenues during the commitment period when the resource first enters the market. If the resource does not recover these costs for a given assumed generating technology and/or load zone, TCR would consider whether the new resource should be placed in a different location or should be of different technology.

After reviewing these changes to the assumed generation mix, TCR did another run of the E&AS model and the FCM model. TCR continued this iterative process until the results met the two consistency conditions described above.

5.3 Input Assumptions Common to E&AS and FCM Modes

This section describes assumptions that are used to simulate the operation of the E&AS market and the Forward Capacity Market (FCM).

5.3.1 Load Forecasts

AESC 2015 ran market simulations for two different load forecasts, a Base Case and a BAU Case. It developed the load forecasts for both Cases through 2023 from ISO New England (ISO NE) forecasts presented in the 2014 Regional System Plan (2014 RSP). The forecasts for 2024 through 2030 are extrapolations using the Compound Aggregation Growth Rates (CAGRs) for 2018 through 2023.

ISO NE presents several load-related forecasts in its 2014 RSP. First, ISO-NE provides an econometric forecast through 2023 of the hypothetical level of electricity consumption that would occur had no energy efficiency measures been installed in the past and if no new energy efficiency measures are installed in the future. energy and peak load by area.

Exhibit 5-6 and Exhibit 5-7 summarize this high or "gross" forecast of annual energy and peak load by area.

Exhibit 5-6: Gross Annual Energy Forecast summary by ISO-NE area

Load Zone	2015 (GWH)	2016 (GWH)	2017 (GWH)	2018 (GWH)	2019 (GWH)	2020 (GWH)	2021 (GWH)	2022 (GWH)	2023 (GWH)	CAGR
CT	34,825	35,250	35,635	35,980	36,290	36,585	36,885	37,185	37,495	0.83%
ME	12,475	12,625	12,730	12,810	12,875	12,945	13,020	13,100	13,175	0.56%
NH	12,575	12,765	12,935	13,085	13,210	13,335	13,455	13,575	13,700	0.92%
NMABO	28,440	28,880	29,265	29,580	29,865	30,145	30,430	30,715	31,000	0.94%
RI	8,850	8,960	9,060	9,150	9,220	9,280	9,340	9,400	9,455	0.66%
SEMA	17,470	17,760	18,005	18,220	18,410	18,595	18,785	18,975	19,170	1.02%
VT	6,790	6,840	6,890	6,935	6,975	7,025	7,070	7,125	7,175	0.68%
WCMA	19,000	19,250	19,465	19,635	19,780	19,925	20,070	20,215	20,360	0.73%
Total	140,425	142,330	143,985	145,395	146,625	147,835	149,055	150,290	151,530	0.83%

Exhibit 5-7: Gross Coincident Summer Peak Load Forecast Summary by ISO-NE area.

Load Zone	2015	2016	2017	2018	2019	2020	2021	2022	2023	CAGR
CT	7510	7630	7740	7830	7900	7970	8035	8105	8165	0.84%
ME	2145	2175	2200	2220	2240	2255	2275	2295	2315	0.84%
NH	2605	2655	2700	2740	2780	2820	2860	2900	2940	1.42%
NMABO	5820	5940	6055	6150	6225	6305	6380	6455	6525	1.19%
RI	1950	1980	2015	2040	2065	2085	2110	2130	2150	1.06%
SEMA	3655	3735	3810	3870	3920	3975	4020	4075	4120	1.26%
VT	1110	1125	1135	1145	1150	1160	1170	1180	1190	0.77%
WCMA	3820	3890	3955	4010	4055	4095	4135	4175	4215	1.00%
Total	28615	29130	29610	30005	30335	30665	30985	31315	31620	1.05%

Source: ISO New England 2014 RSP Forecast

Second, ISO-NE provides a forecast of passive demand resources (PDR) that have cleared in FCAs for power years through May 2018. PDR reduces the level of electric energy consumption that would otherwise have to be supplied from generation resources. PDR includes such resources as energy efficiency and “behind-the meter” distributed generation (DG) used on site at locations that have net metering, which allows power customers who generate their own electricity to feed their excess back into the grid. PDR resources participate in the energy market under normal conditions, and should therefore be accounted for in modeling energy and capacity markets.

Exhibit 5-8. ISO NE Projected Peak Reduction Due to PDR

Load Zone	2014 (MW)	2015 (MW)	2016 (MW)	2017 (MW)
CT	431	420	450	421
ME	145	157	171	184
NH	78	84	86	97
NMBAO	295	343	368	497
RI	92	139	153	179
SEMA	165	190	209	259
VT	110	124	136	132
WCMA	191	227	264	321
Total	**1507**	**1685**	**1839**	**2089**

Exhibit 5-9. ISO NE Projected Annual Energy Use Reduction Due to PDR

Load Zone	2014 (GWH)	2015 (GWH)	2016 (GWH)	2017 (GWH)
CT	2575	2554	2568	2335
ME	871	1013	1104	1180
NH	467	506	523	543
NMBAO	1730	1996	2215	2701
RI	537	717	890	1010
SEMA	909	1074	1201	1395
VT	698	791	878	896
WCMA	1061	1305	1530	1801
Total	**8848**	**9955**	**10909**	**11862**

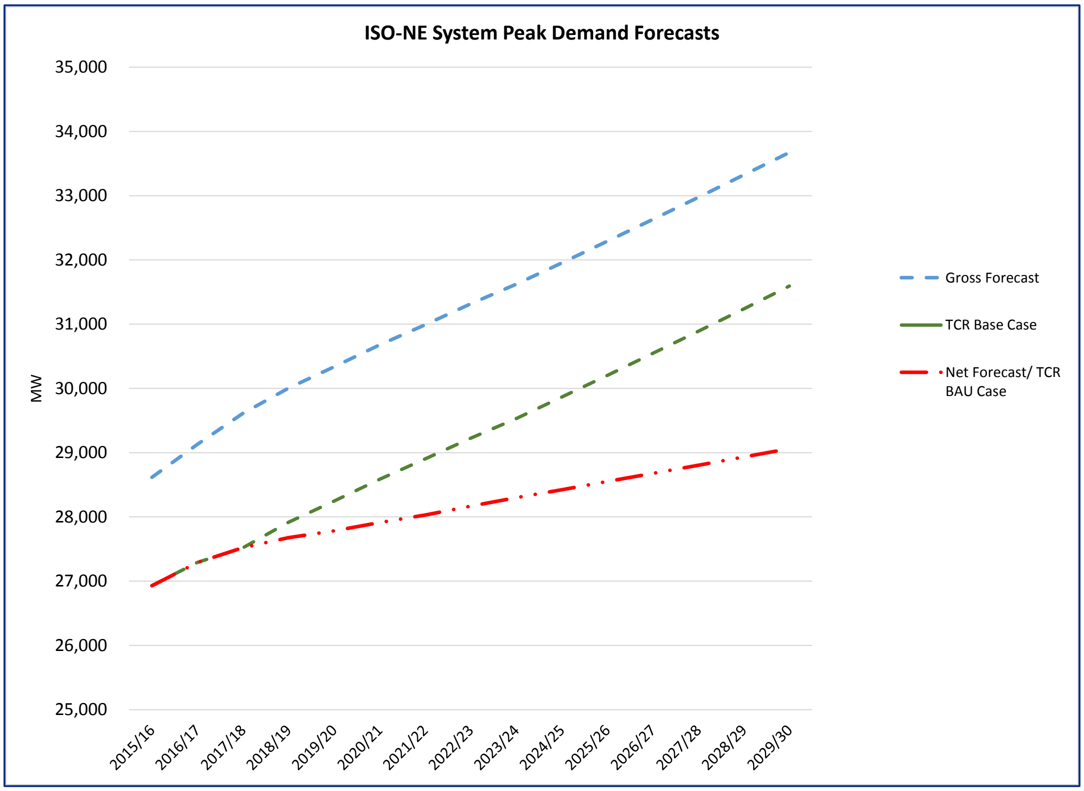
Third, ISO-NE provides a forecast of the level of electricity consumption that it expects to occur through 2023. This lower, or "net", forecast is equal to the gross load forecast minus the PDR through May 2018 and its projection of additional reductions from new ratepayer funded energy efficiency measures implemented from 2018 through 2023. (ISO NE develops its energy-efficiency forecast based on data that each state provides on actual funding and actual reductions.[148] (ISO-NE does not adjust the data it receives from each state. As a result the ISO NE projected reductions for state "A" are consistent with the energy efficiency accounting and cost recovery policies of state A. However, the composition of the projected reductions for state A may differ from those projected for state B due to differences in energy efficiency policies between state A and state B.)

5.3.2 Development of AESC 2015 Load Forecasts

Exhibit 5-10 presents the ISO NE gross forecast of system peak demand, the AESC 2015 Base Case forecast and the ASEC 29015 BAU Case forecast.

[148] ____, ISO New England Energy Efficiency Forecast Report for 2018 to 2023. June 3, 2014.

Exhibit 5-10 ISO New England System Peak Forecasts



The AESC 2015 Base Case forecast through May 2018 is equal to the ISO-NE gross load forecast minus the PDR that have cleared in the FCA through that period. From June 2018 through December 2023 the Base Case forecast is equal to the ISO-NE gross load forecast minus the PDR that cleared in the FCA for 2017/2018. This adjustment is consistent with an assumption of no new EE or DR from 2015 onward. The forecast through this period is consistent with an assumption of no new ratepayer funded EE or DR from 2015 onward, except PDR for which program administrators are financially committed, and with the fact that the measures causing the 2017/18 PDR reductions will continue to have an impact for several more years. From 2024 to 2030 the Base Case load is an extrapolation based on the 2018-2023 CAGR of that forecast. The resulting energy and peak projections are presented in Exhibit 5-11 and Exhibit 5-12.

Exhibit 5-11. AESC 2015 Base Case Annual Energy Forecast

Load Zone	2015 (GWH)	2016 (GWH)	2017 (GWH)	2018 (GWH)	2019 (GWH)	2020 (GWH)	2021 (GWH)	2022 (GWH)	2023 (GWH)	CAGR
CT	32,271	32,682	33,300	33,244	33,554	33,849	34,149	34,449	34,759	0.90%
ME	11,462	11,521	11,550	11,488	11,553	11,623	11,698	11,778	11,853	0.63%
NH	12,069	12,242	12,392	12,466	12,591	12,716	12,836	12,956	13,081	0.97%
NMABO	26,444	26,665	26,564	26,476	26,761	27,041	27,326	27,611	27,896	1.05%
RI	8,133	8,070	8,050	7,999	8,069	8,129	8,189	8,249	8,304	0.75%
SEMA	16,396	16,559	16,610	16,616	16,806	16,991	17,181	17,371	17,566	1.12%

VT	5,999	5,962	5,994	5,914	5,954	6,004	6,049	6,104	6,154	0.80%
WCMA	17,695	17,720	17,664	17,566	17,711	17,856	18,001	18,146	18,291	0.81%
Total	130,469	131,421	132,124	131,769	132,999	134,209	135,429	136,664	137,904	0.91%

Exhibit 5-12. AESC 2015 Base Case Coincident Summer Peak Forecast

Load Zone	2015	2016	2017	2018	2019	2020	2021	2022	2023	CAGR
CT	7090	7180	7319	7409	7479	7549	7614	7684	7744	0.89%
ME	1988	2004	2016	2036	2056	2071	2091	2111	2131	0.92%
NH	2521	2569	2603	2643	2683	2723	2763	2803	2843	1.47%
NMABO	5477	5572	5558	5653	5728	5808	5883	5958	6028	1.29%
RI	1811	1827	1836	1861	1886	1906	1931	1951	1971	1.16%
SEMA	3465	3526	3551	3611	3661	3716	3761	3816	3861	1.35%
VT	986	990	1003	1013	1018	1028	1038	1048	1058	0.87%
WCMA	3593	3626	3634	3689	3734	3774	3814	3854	3894	1.09%
Total	26931	27294	27520	27915	28245	28575	28895	29225	29530	1.13%

The BAU Case forecast is the ISO NE net forecast through 2023 (It is identical to the Base Case through 2018). It reflects the impact of PDR and future energy efficiency. From 2024 to 2030 the BAU Case load is an extrapolation based on the 2018-2023 CAGR of that forecast.

Exhibit 5-13. Net Annual Energy Forecast summary by ISO-NE area. AESC 2015 BAU Case Forecast.

Load Zone	2015 (GWH)	2016 (GWH)	2017 (GWH)	2018 (GWH)	2019 (GWH)	2020 (GWH)	2021 (GWH)	2022 (GWH)	2023 (GWH)	CAGR
CT	32,271	32,682	33,300	33,244	33,174	33,111	33,073	33,054	33,064	-0.11%
ME	11,462	11,521	11,550	11,488	11,421	11,369	11,330	11,304	11,280	-0.36%
NH	12,069	12,242	12,392	12,466	12,518	12,574	12,627	12,684	12,749	0.45%
NMABO	26,444	26,665	26,564	26,476	26,384	26,312	26,267	26,244	26,241	-0.18%
RI	8,133	8,070	8,050	7,999	7,937	7,875	7,820	7,774	7,730	-0.68%
SEMA	16,396	16,559	16,610	16,616	16,612	16,615	16,635	16,666	16,712	0.12%
VT	5,999	5,962	5,994	5,914	5,834	5,767	5,702	5,650	5,599	-1.09%
WCMA	17,695	17,720	17,664	17,566	17,459	17,369	17,295	17,235	17,188	-0.43%
Total	130,469	131,421	132,124	131,769	131,339	130,992	130,749	130,611	130,563	-0.18%

Exhibit 5-14. Net Coincident Summer Peak Load Forecast summary by ISO-NE area. AESC 2015 BAU Case Forecast.

Load Zone	2015	2016	2017	2018	2019	2020	2021	2022	2023	CAGR
CT	7,090	7,180	7,319	7,360	7,384	7,411	7,435	7,466	7,489	0.35%
ME	1,988	2,004	2,016	2,016	2,017	2,015	2,019	2,024	2,030	0.14%
NH	2,521	2,569	2,603	2,631	2,659	2,688	2,717	2,747	2,777	1.09%
NMABO	5,477	5,572	5,558	5,598	5,622	5,654	5,685	5,718	5,749	0.53%
RI	1,811	1,827	1,836	1,839	1,844	1,845	1,852	1,856	1,860	0.23%
SEMA	3,465	3,526	3,551	3,582	3,606	3,636	3,657	3,691	3,715	0.73%
VT	986	990	1,003	996	984	977	972	967	962	-0.69%
WCMA	3,593	3,626	3,634	3,654	3,666	3,675	3,686	3,699	3714	0.33%
Total	26,931	27,294	27,520	27,676	27,782	27,901	28,023	28,168	28296	0.44%

5.3.3 Development of Hourly Load Shapes for AESC 2015 Load Forecasts

RSP 2014 provides projections of summer and winter peak, and annual energy, by load zone. However, to simulate the ISO New England market on an hourly basis, PSO requires an hourly load shape for each simulated time frame and area modeled. AESC 2015 constructed load shapes for each area from the following data:

- Template hourly load profiles
- Annual energy and summer/winter peak forecasts for the study period

AESC 2015 uses 2006 historical load shapes by zone as a template for load profiles. AESC 2015 selected 2006 to ensure the load profiles were synchronized with the most recent modeling of wind generation patterns in New England available from the National Renewable Energy Laboratory (NREL), which is 2006. To develop hourly load forecast for future years, pCA load algorithms first calendar shifts the template load profile to align days of the week and NERC holidays between 2006 and the forecast year. pCA algorithms then modify calendar shifted template profiles in such a manner that the resulting load shape exhibits the hourly pattern close to that of the template profile while the total energy for the year match the energy forecast and summer and winter peaks match the summer and winter peak forecast.

5.3.4 Interchange Data

pCA models New England interchanges with neighboring regions, i.e., the Canadian provinces of New Brunswick and Quebec and the New York ISO, using ISO-NE reported historical hourly interchange schedules for calendar year 2006. Similarly to load profiles, interchange flow data are calendar shifted for each forecast year and therefore remain synchronized with load pattern in ISO New England. Explicitly distinguished interchange schedules include:

- New Brunswick Interface at Keswig external node

- Phases I and II Interface with Hydro Quebec via HVDC
- Highgate interface with Hydro Quebec via HVDC
- Cross Sound Cable HVDC interconnection with NYSIO
- Roseton AC interface with NYSIO

These interfaces are mapped to electrical points of interconnection with the ISO New England in the power flow model used for pCA simulations.

5.3.5 Transmission

The geographic footprint PSO modeled encompasses the six New England states: Maine, Massachusetts, New Hampshire, Vermont, Rhode Island, and Connecticut, whose electricity movement and wholesale markets are coordinated by ISO-NE.

The physical location of all network resources is organized using substation and node mapping. The transmission topology is modeled based on the 2011 FERC 715 power flow fillings for summer peak 2016. NEG verified the power flow model against the ISO-NE queue to make sure that essential transmission projects are represented in the power flow case. Generators are mapped to bus bars/electrical nodes (eNodes). Bus bars are mapped to substations and substations are in turn mapped to ISO New England SMD Zones. The mapping of bus bars to zones allows PSO to allocate hourly area load forecasts to load busses in proportion to the initial state from the power flow.

In determining a representative list of transmission constraints to monitor, NEG includes all major ISO-NE interfaces and frequently binding constraints, as reported by ISO-NE. Key interface limits are specified in Exhibit 5-15. For certain interfaces, limits obtained from the ISO New England's FERC Form 715 filing represent Critical Energy Infrastructure Information (CEII) and are not shown in that table. All single line normal and emergency ratings are taken directly from the power flow.

Exhibit 5-15: Interface Limits

Interface	Max MW	Min MW
New England – Boston*	4850	No Limit
Connecticut Import *	3050/2950 [a]	No Limit
Maine - New Hampshire *	1600 /1900 [b]	No Limit
New England East – West *	2800/ 3500 [a]	-1000/ -2200 [a]
Newington Area Generation **	CEII Protected	No Limit
New Hampshire-Maine **	CEII Protected	No Limit
Northern Vermont Import **	CEII Protected	No Limit
Orrington – South *	1200/1325 [b]	No Limit
Rhode Island Import **	CEII Protected	No Limit
Surowiec – South *	1150/ 1500 [b]	No Limit
Western Connecticut Import **	CEII Protected	No Limit
North – South *	2700	No Limit
Sandy Pond – South **	CEII Protected	No Limit
New England - Southwest Connecticut *	3200	No Limit
New England - Norwalk Stamford **	CEII Protected	No Limit
Northern New England Scobie 345kV - Scobie + 394 **	CEII Protected	No Limit

Notes:
[a] New limit effective 2017
[b] New limit effective 2015

Sources:
*ISO New England, Transmission Interface Transfer Capabilities: 2014 Regional System Plan Assumptions, Part 3, March 17, 2014. Available online at http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/pac/mtrls/2014/mar172014/a8_rsp14_transmission_interface_transfer_capabilities.pdf

The 2014 RSP describes a considerable number of "Elective Transmission Upgrades" that are currently under review by ISO New England. These include a number of major proposed AC and HVDC projects to increase transfer capabilities between New England and the Canadian provinces of Quebec and New Brunswick, as well as between the Maine Zone and major load centers in New England. One of the Elective Transmission Upgrades is Northern Pass Transmission (NPT), which received Proposed Plan Application approval from ISO New England on December 31, 2013.

Based upon its review, AESC 2015 did not assume any of these proposed projects in its Base or BAU Cases because of the high degree of uncertainty regarding the key assumptions require to model any of them. Those key assumptions include whether the project will receive approval at the Federal and state levels, when it might come into service, the location of its ultimate interconnection points within New England and the technical and economic characteristics of the electric energy the project would deliver into the New England market.

5.3.6 Generating Unit Retirements and Additions

Exhibit 5-16 summarizes the generation retirements approved by ISO-NE and assumed in our simulations.

Exhibit 5-16: Approved retirements in ISO-NE

Full Name	Retire Date	Area	Capacity (MW)
Mt. Tom	6/2/2014	WCMA	145
Salem Harbor 3	6/1/2014	NEMA	150
Salem Harbor 4	6/1/2014	NEMA	437
VT Yankee Nuclear	12/31/2014	VT	620
Brayton Point 1-4	6/1/2017	SEMA	1,534
Total			**2,886**

Over the AESC 2015 time horizon, new generation resources will be needed to satisfy renewable portfolio standards and resource adequacy requirements. Since pCA is not a capacity expansion model, these additions are exogenous. Section 5.6 provides the AESC 2015 assumptions for renewable resource additions to comply Renewable Portfolio Standard (RPS) requirements. Exhibit 5-17 summarizes known near-term new generation additions included in the pCA database. These are projects listed in ISO-NE's interconnection queue which are either under construction or which have major interconnection studies completed.

Exhibit 5-17. New Generation Additions

Name	Unit	Fuel	SumMW	OpDate	Zone	ST
Cape Wind Turbine Generators	WT	WND	462	12/31/2016	SEMA	MA
Brockton Combined Cycle	CC	NG DFO	332	4/19/2017	SEMA	MA
Oakfield II Wind - Keene Road	WT	WND	147.6	12/31/2015	ME	ME
Palmer Renewable Energy	ST	WDS	36.7	7/15/2017	WCMA	MA
Saddleback Ridge Wind Project	WT	WND	33	12/2/2014	ME	ME
Canton Mountain Winds	WT	WND	19.25	11/1/2016	ME	ME
Fair Haven Biomass	ST	WDS	33	3/30/2016	VT	VT
Kendall #3 Back Pressure Steam Turbine	ST	NG DFO	28.5	12/31/2015	NMABO	MA
Pisgah Mountain	WT	WND	9	11/1/2015	ME	ME
CPV Towantic Energy Center	CC	NG DFO	745	6/1/2018	CT	CT
Weston Station Uprate U4	HD	WAT	14.81	11/25/2015	ME	ME
Weston Station AVR Replacement U2-4	HD	WAT	14.81	10/3/2015	ME	ME
Berkshire Wind Increase	WT	WND	19.8	1/1/2017	WCMA	MA
MATEP -3rd CTG	CT	DFO NG	100	6/1/2017	NMABO	MA
Jericho Wind	WT	WND	8.55	6/30/2015	NH	NH
Footprint Combined Cycle Unit	CC	NG	715.6	3/1/2017	NMABO	MA
Northfield Mt Upgrade #1	PS	WAT	295	6/1/2016	WCMA	MA

5.3.7 Generating Unit Operational Characteristics

Thermal Units

Thermal generation characteristics are generally determined by unit type. These include: heat rate curve shape, non-fuel operation and maintenance costs, startup costs, forced and planned outage rates, minimum up and down times, and quick start, regulation and spinning reserve capabilities.

Capacity ratings were obtained from SNL Financial. Fully Loaded Heat Rates (FLHRs), forced outage rates and planned outage rates were not available from ISO-NE. Instead, NEG used information by similar unit type as obtained from both the North American Electric Reliability Corporation (NERC) Generating Availability Report and power industry data provided by SNL Financial. Similarly, given the lack of information from ISO-NE on Variable O&M costs, NEG used its assumptions by unit type for existing and planned units that are consistent with modeling these units in other markets.

Due to the large number of small generating units, NEG aggregates all units below 20 MWs by type and size into a smaller set of units. Full load heat rates for the aggregates are calculated as the average of the individual units and all other parameters are inherited from the unit type.

Heat rate curves are modeled as a function of full load heat rate ("FLHR") by unit type:

- CT: Single block at 100% capacity at 100% of FLHR.
- CC: 4 blocks: 50% capacity at 113% of FLHR, 67% capacity at 75% of FLHR, 83% capacity at 86% of FLHR, and 100% capacity at 100% of FLHR. As an example, for a 500 MW CC with a 7000 Btu/KWh FLHR, the minimum load block would be 250 MW at a heat rate of 7910, the 2nd step would be 85 MW at a heat rate of 5250, the 3rd step would be 80 MW at a heat rate of 6020, and the 4th step would be 85 MW at a heat rate of 7000.
- Steam Coal for all MW: 4 blocks: 50% capacity at 106% of FLHR, 65% capacity at 90%, 95% capacity at 95% FLHR, and 100% capacity at 100% FLHR.
- Steam Gas for all MW: 4 blocks: 25% capacity at 118% of FLHR, 50% capacity at 90%, 80% capacity at 95% FLHR, and 100% capacity at 100% FLHR.

Exhibit 5-18 below shows other assumptions by type for thermal plants. The abbreviations in the Unit Type column are structured as follows: First 2-3 characters identify the technology type, the next 1-2 characters identify the fuel used (**g**as, **o**il, **c**oal, **r**efuse) and the numbers identify the size of generating units mapped to that type.

Exhibit 5-18. Thermal Unit Assumptions by Type and Size

Unit Type	Min Up Time (h)	Min Down Time (h)	EFORd	VOM ($/MWh)	Startup Cost ($/MW-start)	Startup Failure Rate
CCg100	6	8	4.35	2.5	35	0.01
CTb50 (1-19MW)	1	1	19.73	0	35	0.06
CTb50 (20-49MW)	1	1	10.56	0	35	0.03
CTg50 (1-19MW)	1	1	19.73	10	0	0.06
CTg50 (20-49MW)	1	1	10.56	10	0	0.03
CTg50+	1	1	7.25	10	0	0.02
ICr50 (0-50MW)	10	8	19.73	2	40	0.06
NUC-PWR (400-799MW)	164	164	2.58	0	35	0
NUC-BWR (400-799MW)	164	164	3.24	0	35	0.02
NUC-PWR (800-999MW)	164	164	4.34	0	35	0.01
NUC-BWR (800-999MW)	164	164	1.8	0	35	0.05
NUC-PWR (1000+MW)	164	164	2.88	0	35	0.004
NUC-BWR (1000+MW)	164	164	2.82	0	35	0.025
STc100 (0-100MW)	24	12	10.64	5	45	0.02
STc200 (100-199MW)	24	12	6.3	4	45	0.03
STc300 (200-299MW)	24	12	7.1	4	45	0.03
STc400 (300-399MW)	24	12	6.85	3	45	0.04
STc600 (400-599MW)	24	12	7.82	3	45	0.06
STc800 (600-799MW)	24	12	6.71	2	45	0.03
STc1000 (800-999MW)	24	12	4.65	2	45	0.04
STc1000+ (1000+MW)	24	12	8.62	2	45	0.06
STg100 (0-100MW)	10	8	12.55	6	40	0.009
STg200+ (100-200MW)	10	8	7.28	5	40	0.01
STgo300 (200-299MW)	10	8	6.67	4	40	0.02
STgo400 (300-399MW)	10	8	5.41	4	40	0.02
STgo500 (400-599MW)	10	8	9.06	4	40	0.03
STgo600 (600-799MW)	10	8	9.48	3	40	0.05
STgo600+	10	8	1.93	3	40	0.02
STo100 (1-99MW)	10	8	3.54	6	40	0.006
STo200 (0-200MW)	10	8	5.6	5	40	0.02
STo600 (200-299MW)	10	8	10.59	4	40	0.02
STo600 (300-399MW)	10	8	4.53	4	40	0.02
STo600 (400-599MW)	10	8	4.45	4	40	0.01
STo600+ (600-799MW)	10	8	41.26	3	40	0.03
STo600+ (800-999MW)	10	8	14.36	3	40	0.09
STr	10	8	10.26	2	40	0.02

Source: NEG Analysis

Nuclear Units

Nuclear plants are assumed to run when available, and have minimum up and down times of approximately one week (164 hours). Capacity ratings, planned outage rates and forced outage rates are the same as those obtained from the NERC Generating Availability Report. The values represent a normalized annual rate that does not directly capture the timing of refueling outages. In general, nuclear facilities are treated as must run units. Production costs were modeled using NEG input assumptions for fuel and variable O&M.

Hydro and Pumped Storage

Hydro units are specified as a daily pattern of water flow, i.e. the minimum and maximum generating capability and the total energy for each plant. Of those, NEG assumed that hydro plants use 40% of the daily energy at the same level in each hour of the day. The remaining 60% of the daily energy is optimally scheduled by PSO to minimize system-wide production costs. Daily energy was estimated using plant specific capacity factors under the assumption that hydro conditions do not vary significantly across seasons.

PSO fully optimizes pumped storage operation schedules.

Renewable Energy Resources

We model wind, solar, and biomass generating capacity.[149] Technology-specific assumptions for each are described below.

Wind

Onshore and offshore wind generation is represented in the model using hourly generation profiles developed using the 10-minute wind power output profiles, averaged hourly, which are obtained from the National Renewable Energy Laboratory (NREL).[150] The pCA database stores wind generation profiles provided by NREL based on 2006 weather data, so as to be consistent with the 2006 load profiles used in the analysis. Each wind site in ISO-NE is mapped to the nearest NREL wind site to obtain the appropriate hourly schedule. The resulting schedule is scaled to the installed capacity of the corresponding wind site and then calendar-shifted for each forecast year making it synchronized with load profiles and interchange schedules.

Solar Photovoltaics

PV generation is represented in the model using hourly generation profiles for three system sizes in each of the six states (for a total of 18 profiles). The profiles were developed using the NREL SAM PV Watts

[149] The modeling of hydro resources is discussed in the previous section.

[150] National Renewable Energy Laboratory (US), "Wind Systems Integration - Eastern Wind Integration and Transmission Study," nrel.gov, 2010. [Online]. Available at: http://www.nrel.gov/electricity/transmission/eastern_wind_methodology.html

module, with 2006 weather data files obtained from NREL. The array types (fixed open rack or roof mount) and tilt were selected based on the system size and location to conform to typical practice in New England. The hourly profiles were adjusted so that the capacity factors matched those used by ISO New England in its PV forecast,[151] listed below in Exhibit 5-19.

Exhibit 5-19. PV Capacity Factor Assumptions

	CT	MA	ME	NH	RI	VT
Capacity Factor (AC)	16.0%	15.4%	15.4%	15.1%	15.5%	14.0%

Biomass is modeled as dispatchable generation subject to generation technology parameters and fuel prices.

5.3.8 Operating Reserves

AESC 2015 modelled four types of Ancillary Services: Regulation, Ten-Minute Spinning Reserve, Ten-Minute Non-Spinning Reserve and Thirty-Minute Operating Reserve. Reserves are cascading – excess regulation counts toward spinning reserves. Excess spinning reserves counts toward Non-spinning. Spinning reserve requirements are considered bi-directional. Non-Spinning reserves can be provided by offline peaking capacity and can handle upward ramping only.

- Regulation must be provided by online resources at the level of ramp rate (in MW/min) limited by a 5 minute activation time.
- Ten-Minute Spinning Reserve (TMSR) must be provided by online resources at the level of ramp rate (MW/min) limited by a 10 minute activation time. Hydro can provide Synchronized reserve up to 50% of its dispatch range.
- Ten-Minute Non-Spinning Reserve (TMSNR) is provided by offline resources capable of supplying energy within 10 minutes of notices. TMSNR can only be provided by quick start capable CTs and Internal Combustion (IC) units.
- Thirty-Minute Operating Reserve (TMOR) can be provided by either on-line or off-line resources with less than 30 minutes activation time.

Hydro generators are assumed to provide regulation and reserves for up to 50% of available dispatch range. Nuclear and wind provide no ancillary services.

[151] ISO New England PV Energy Forecast Update, available at: http://www.iso-ne.com/static-assets/documents/2014/09/pv_energy_frcst_update_09152014.pdf.

Exhibit 5-200 below summarizes reserve requirements in ISO-NE.

Exhibit 5-20 ISO-NE Regulation and Reserve Requirements

Reserve Type	Requirement (MW)
Regulation	Hourly schedule per ISO-NE requirements
Ten min spinning reserves	820
Ten min non-spinning reserves	820
Thirty min operating reserves	750

5.3.9 Emission Rates and Allowances

Emission rates for most plants were obtained from historical SNL emission rate data. For plants for which there were no emission rates (i.e., those under construction) generic EIA emission data were used.

Emission allowance price assumptions are presented in Chapter 4.

5.4 Capacity Market-Specific Modeling Assumptions

5.4.1 Projection of System-Wide Installed Capacity Requirements

Exhibit 5-21 below summarizes actual ICR through 2017/18 (FCA 8) and the AESC 2015 projections.

Exhibit 5-21. Base Case Projection of System-Wide ICRs

	ISO New England Data[152]				Projection					
Period	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
FCA	5	6	7	8	9	10	11	12	13	14
Gross 50/50 Peak (MW)	29,025	29,380	29,400	29,790	30,005	30,335	30,675	30,990	31,315	31,620
ICR (MW)	34,154	34,498	34,023	34,922	35,109	35,495	35,893	36,262	36,642	36,999
Margin	17.67%	17.42%	15.72%	17.23%	17.01%	17.01%	17.01%	17.01%	17.01%	17.01%
HQ ICC (MW)	954	1,042	1,055	1,068	1,068	1,068	1,068	1,068	1,068	1,068
Net ICR (MW)	33,200	33,456	32,968	33,854	34,041	34,427	34,825	35,194	35,574	35,931

152 ISO New England Installed Capacity Requirement, Local Sourcing Requirements, and Maximum Capacity Limit studies for 2014/15, 2015/16, 2016/17 and 2017/18 capability periods

Starting with the data provided in the four most recent ICR studies, we estimated implied reserve margin requirements – a difference between ICR and projected summer peak demand divided by the peak demand. A simple average of these margins is 17.01%. AESC 2015 assumed ISO NE would continue to require this level of reserve margin. AESC 2015 also assumes import capacity from Hydro Quebec will remain at the level of 1068 MW and computed the resulting net ICRs.

5.4.2 Projection of Local Sourcing Requirements (LSRs) for NEMA /Boston and Connecticut Import Constrained Zones

Local Sourcing Requirements are minimum levels of installed capacity that must be procured within an import-constrained zone. There are two currently recognized import-constrained zones in New England – NEMA/Boston and Connecticut. Exhibit 5-22 summarizes the AESC 2015 projection of Local Sourcing Requirements for import-constrained zones.

Exhibit 5-22 Projection of LSRs for Import Constrained Zones

	ISO NE Data			Projection					
Period	**2015/16**	**2016/17**	**2017/18**	**2018/19**	**2019/20**	**2020/21**	**2021/22**	**2022/23**	**2023/24**
NEMA/Boston									
90/10 Peak	6,530	6,520	6,745	6,615	6,700	6,785	6,865	6,950	7,025
N-1 Import Limit	4,850	4,850	4,850	4,850	4,850	4,850	4,850	4,850	4,850
LSR	3,288	3,209	3,427	3,329	3,434	3,540	3,638	3,744	3,836
Margin	24.6%	23.6%	22.7%	23.6%	23.6%	23.6%	23.6%	23.6%	23.6%
Connecticut									
90/10 Peak	8,250	8,201	8,330	8,530	8,605	8,680	8,750	8,825	8,890
N-1 Import Limit	2,600	2,600	2,800	2,950	2,950	2,950	2,950	2,950	2,950
LSR	7,542	7,603	7,319	7,537	7,629	7,721	7,807	7,900	7,979
Margin	22.9%	24.4%	21.5%	22.9%	22.9%	22.9%	22.9%	22.9%	22.9%

Starting with the data provided in the three most recent ICR studies[153], we estimated implied reserve margin requirements for import-constrained zones. For each zone, the implied reserve margin was computed as a difference between the sum of LSR and N-1 contingency import limit into the zone and the 90/10 peak demand in that zone divided by the 90/10 peak demand. 90/10 peak demand is the ISO New England estimated summer peak which is likely to occur under the 1 in 10 years most critical weather conditions. For each zone, AESC 2015 computed a simple average of that zone's margin (23.6%

[153] ICR study for 2014/15 did not contain sufficient details for this analysis and was not used.

for NEMA Boston and 22.9% for Connecticut) and assumed that this margin will persist in the future. Using this assumption, AESC 2015 projected future LSR values for import constraint zones.

5.4.3 Projection of Maximum Capacity Limit (MCL) for Maine

A Maximum Capacity Limit is the maximum level of installed capacity that can be procured within the export constrained zone. Main is the only export constrained zone in New England. Exhibit 5-233 below summarizes the AESC 2015 projection of the Maximum Capacity Limit for the Maine export constrained zone. Starting with the data provided in the four most recent ICR studies, we estimated ratio of the MCL determined by ISO New England in that period over the sum of the peak demand in Maine and Maine export Limit. AESC 2015 computed the average ratio for this four-year period, 94.4% and assumed that that ratio would persist in the future. Based on that assumption and using ISO New England's forecast of summer peak demand for the Maine zone, AESC 2015 developed projections for the MCL value.

Exhibit 5-23. Projection of MCL for the Maine Zone

	ISO NE Data				**Projection**					
Period	**2014/15**	**2015/16**	**2016/17**	**2017/18**	**2018/19**	**2019/20**	**2020/21**	**2021/22**	**2022/23**	**2023/24**
Peak	2,050	2,150	2,160	2,200	2,220	2,240	2,255	2,275	2,295	2,315
Export Limit	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900
MCL	3,702	3,888	3,709	3,960	3,890	3,909	3,923	3,942	3,961	3,980
Ratio	93.7%	96.0%	91.4%	96.6%	94.4%	94.4%	94.4%	94.4%	94.4%	94.4%

5.4.4 PDR Levels

PDR levels used in the Base Case and BAU Cases are summarized in Exhibit 5-24 below.

Exhibit 5-24. PDR levels used in modeling FCA

BAU	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
ISO-NE	2328	2553	2764	2962	3148	3322
CT	470	516	559	600	639	676
NMABO	552	603	651	695	737	776
ME	204	223	240	256	271	285
Base	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
ISO-NE	2089	2089	2089	2089	2089	2089
CT	421	421	421	421	421	421
NMABO	497	497	497	497	497	497
ME	184	184	184	184	184	184

Demand Curve Assumptions

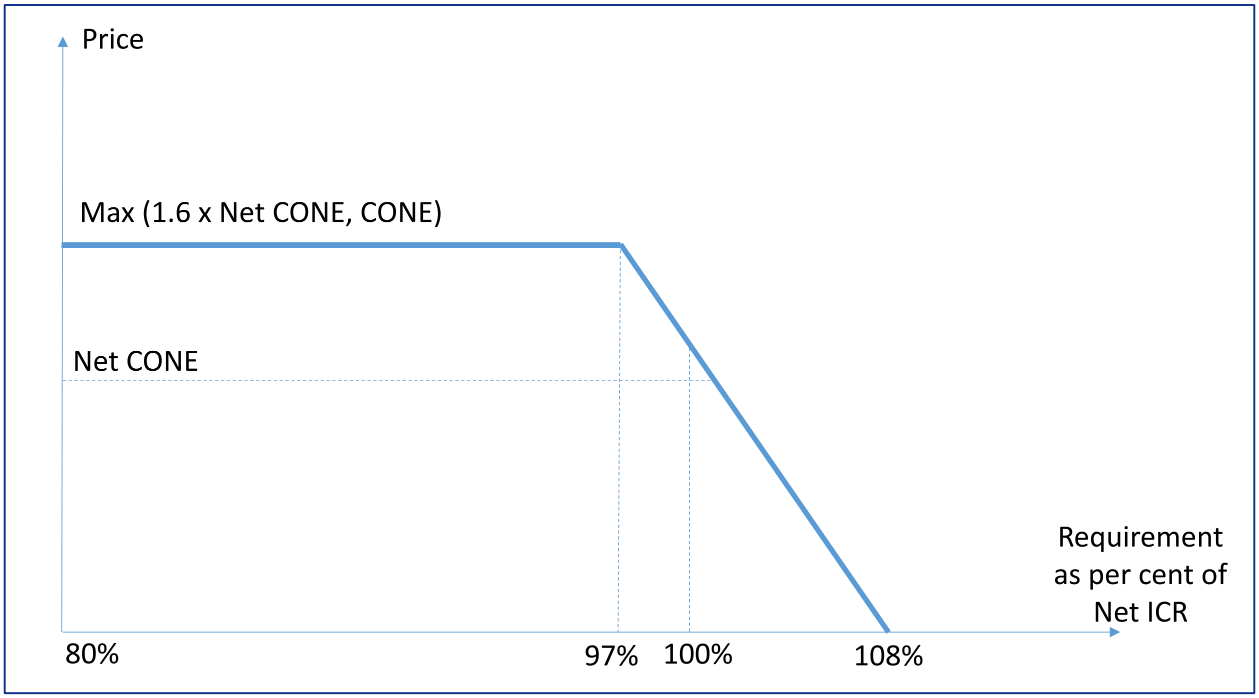
Starting with FCA9 (2018/19 Commitment Period) ISO New England plans to incorporate sloped demand curves into the FCM market design. Introduction of sloped demand curves will significantly impact the capacity price formation mechanism by making capacity prices less volatile in response to changes in reserve margins.

The introduction of demand curves will be implemented in two phases. First, starting with FCA9 (2018/19 commitment period auctioned in 2015) ISO New England will implement only a system-wide demand curve. Second, starting with FCA10, sloped demand curves will be introduced for constrained capacity zones. The system-side demand curve has already been approved by FERC. The design of demand curves for constrained capacity zones is still ongoing. However, the consensus appears to be emerging with ISO New England presenting a revised design in which it agrees with the proposal developed by the New England State Committee on Electricity (NESCOE)[154]. AESC 2015 modeled the FCM market using the system-wide and zone-specific demand curves described below.

Exhibit 5-25 depicts the system-wide sloped demand curve. The curve expresses the system-wide capacity price as a function of the relative level of supply expressed as a percent of Net ICR. The price floor is zero and the price cap is the maximum between 1.6 times of Net CONE and CONE (CONE stands for the Cost of New Entry).

[154] Presentation of Matt Brewster of ISO New England to the NEPOOL Markets Committee, December 9-10, 2014. Available online at http://www.iso-ne.com/static-assets/documents/2014/12/a10a_iso_presentation_12_10_14.pptx

Exhibit 5-25. System-Wide Sloped Demand Curve



Along the demand curve, the price reaches the cap when the supply falls below 97% of Net ICR and falls to zero when supply exceeds 108% of Net ICR. AESC 2015 assumes the net ICR values for each commitment period will be those specified in Exhibit 5-21.

The proposed CONE and Net CONE values, shown in Exhibit 5-26 are[155]

Exhibit 5-26. CONE and Net CONE Assumptions

Parameter	Value in real 2018 $/kW-month	Value (in real 2015 $/kW-year)
CONE	14.04	159.32
Net CONE	11.08	132.96
1.6 x Net CONE	16.672	212.74

Demand curves for import and export constrained zones are shown in Exhibit 5-27 and Exhibit 5-28, respectively. Structurally these curves are similar to the system-wide curve using the same 97% and 108% parameters. For import-constrained zone, the relationship between the price and quantity also factors in the Total Transfer Capability (import limit) into the zone. For the Maine export constrained zone, the curve is defined in terms of MCL as opposed to the Net ICR used in the definition of the system-wide curve but uses the same coefficients of 97% and 108%.

155 "Testimony of Samuel A. Newell and Christopher D. Ungate on behalf of ISO New England, Inc. Regarding the Net Cost of New Entry for the Forward Capacity Market Demand Curve." April 1, 2014

Exhibit 5-27. Demand Curve for Import Constrained Zone

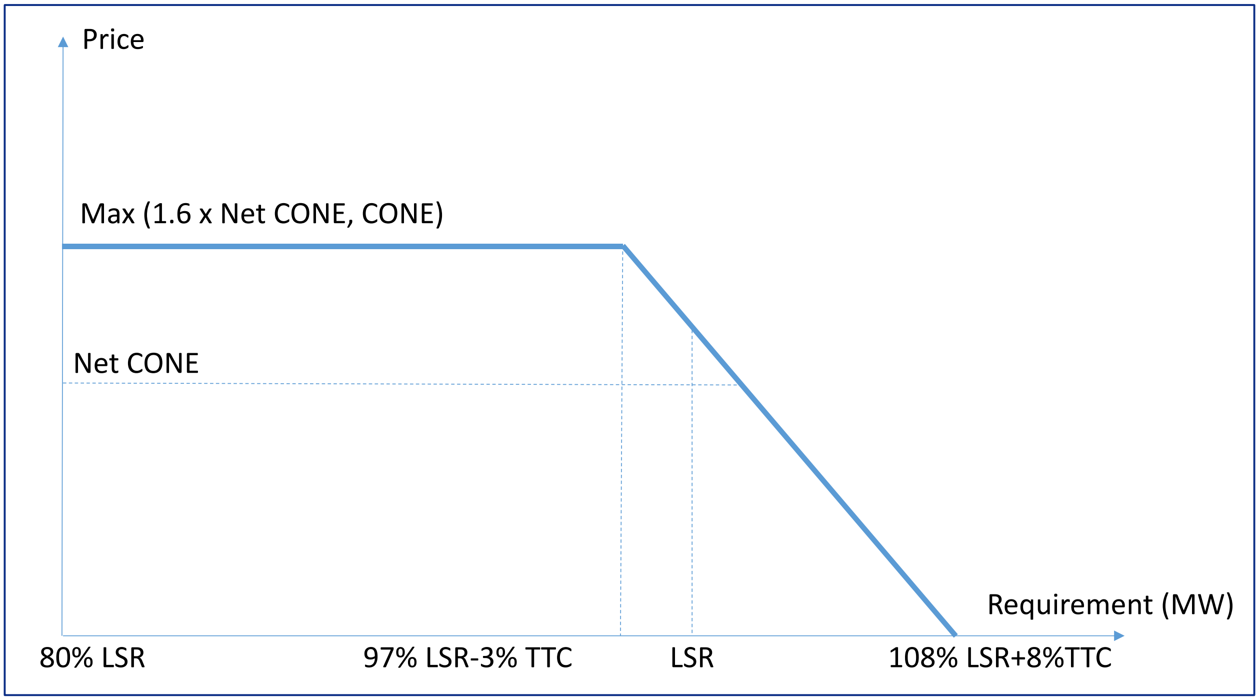
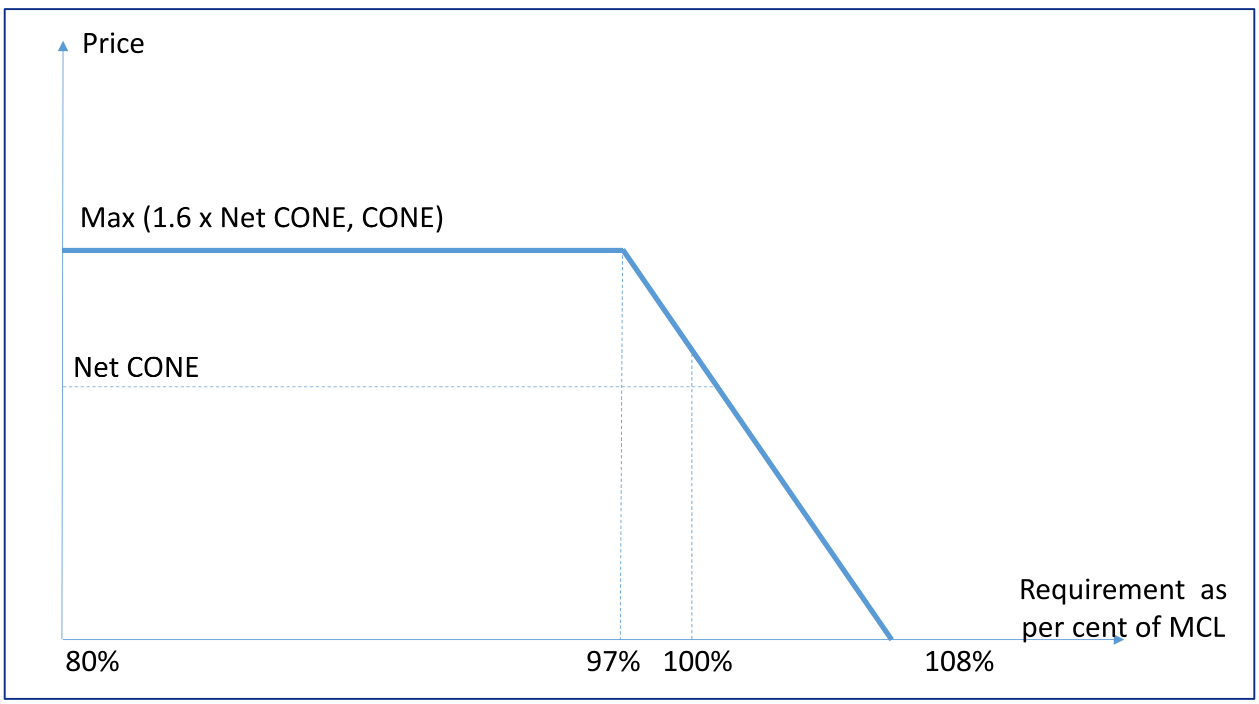


Exhibit 5-28. Demand Curve for Export Constrained Zone



Supply Offers to the FCM

AESC 2015 assumes that generators will set their offers to the FCM at a level which would recover their estimate of the revenue shortfall between the total revenues they require and the net E&AS revenues they expect to receive (i.e., gross E&AS revenues minus their variable operating costs)). The total revenues they require is based on their capital and total operating costs. The net revenues they expect from the energy market is their estimated operating margin from selling energy and ancillary services.

- TCR estimated the offers of existing generators as the difference between estimates of their fixed O&M costs and their net margins per kW of installed capacity per our modeling of the energy market. (We excluded their capital costs since those are "sunk" costs)
- TCR estimated offers from new generators, those to come online during the commitment period, as the difference between the sum of the annualized capital cost and fixed O&M costs and net margins per kW of installed capacity.

The AESC 2015 assumptions for fixed O&M costs of existing generating units are generic by unit type as shown in Exhibit 5-29. These assumptions were reviewed and approved by the stakeholders of the Eastern Interconnection Planning Collaborative **(**EIPC) Phase I study.

Exhibit 5-29. Fixed O&M Assumptions by Unit Type

Unit Type	FOM ($/kW-yr)
STc	52.93
CCg *	32.58
CTg *	18.24
CTo/IC *	18.24
STog	40.78
Nuclear	123.78
Hydro	15.63
PSH	26.06
PV	16.09
Solar Thermal	66.21
Wind Onshore	37.56
Biomass	35.18
Landfill Gas	132.43

Notes:
*Combined Cycle (CC) and Combustion Turbine (CT) assumptions are per "Testimony of Samuel A. Newell and Christopher D. Ungate on behalf of ISO New England, Inc. Regarding the Net Cost of New Entry for the Forward Capacity Market Demand Curve." April 1, 2014

Source:
EIPC Online, http://www.eipconline.com/uploads/MRN-NEEM_Modeling_Assumptions_Draft_Jan_25_2011_Input_Tables_Exhibits.xls

AESC 2015 assumptions with respect to capital costs of new generating units are summarized in Exhibit 5-30 below. For gas fired generating technology AESC 2015 used cost assumptions that are consistent with parameters used to develop CONE estimates and provided in the Brattle Group and Sargent & Lundy study. For other technologies capital cost assumptions are per 2013 EIA Capital Cost Estimates. The EIA study provides only overnight capital costs. To convert overnight costs to annualized capital costs AESC 2015 used Fixed Charge Rates applied in the EIPC study.

Exhibit 5-30. Capital Cost Assumptions.

Unit Type	Annualized Capital Costs ($.kW-yr)
STc *	360.42
CCg **	131.52
CTg **	93.17
CTo/IC **	93.17
Hydro *	366.36
PSH *	659.84
PV *	616.79
Solar Thermal *	632.27
Wind OnShore *	276.14
Wind Offshore *	777.39
Biomass *	504.65
Landfill Gas *	315.07

Sources:
* EIA, "Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants." April 2013.
** "Testimony of Samuel A. Newell and Christopher D. Ungate on behalf of ISO New England, Inc. Regarding the Net Cost of New Entry for the Forward Capacity Market Demand Curve." April 1, 2014

Contribution of Variable Resources toward ICAP Requirements

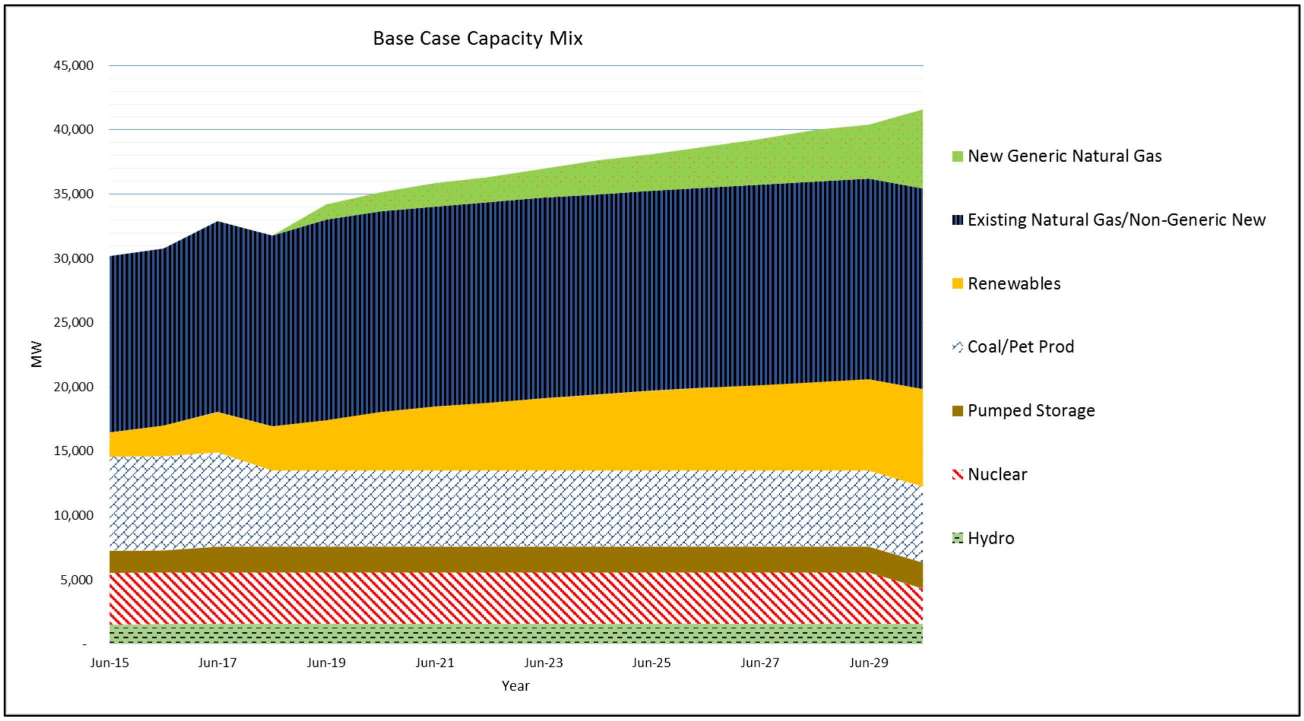
To model the contribution of variable resources such as wind and solar toward ICAP requirements, AESC 2015 followed ISO-NE Market Rule III.13.1.2.2.2.2. According to this rule, Summer Qualified Capacity (contribution to ICAP) should be set as the median of the intermittent source's net output during summer reliability hours (14:00 – 18:00). For each variable resource modeled AESC 2015 used the assumed resource hourly profile to compute the specified median output.

5.5 BASE CASE Projections

5.5.1 Forecast of Capacity and Capacity Prices

The projected level and mix of capacity in the Base Case is presented in Exhibit 5-31. New capacity additions include renewable resources to comply with RPS requirements, as well as new natural gas generators added to meet energy and reserve margin requirements. A substantial portion of the existing oil (Pet Prod) and coal capacity is forecast to retire by 2025. Because of the relatively high price of oil compared to other fuels, these generating plants are rarely dispatched.

Exhibit 5-31. Base Case Capacity by Technology (MW)



Results and Comparison to AESC 2013 Base Case Forecast

The capacity market model explicitly incorporated constraints and demand curves for NEMA-Boston, Connecticut and Maine zones. The modeling results did not show any capacity prices differences between those zones and Rest of Pool.

Exhibit 5-32 compares the AESC 2015 Base Case forecast of capacity prices to the AESC 2013 forecast. The Exhibit presents forecasts of prices by power year (June through May), and by calendar year. On a 15 year levelized basis, the AESC 2015 Base Case forecast by calendar year is approximately 60 percent higher than AESC 2013.

Exhibit 5-32. Capacity Costs – AESC 2015 Base Case and AESC 2013

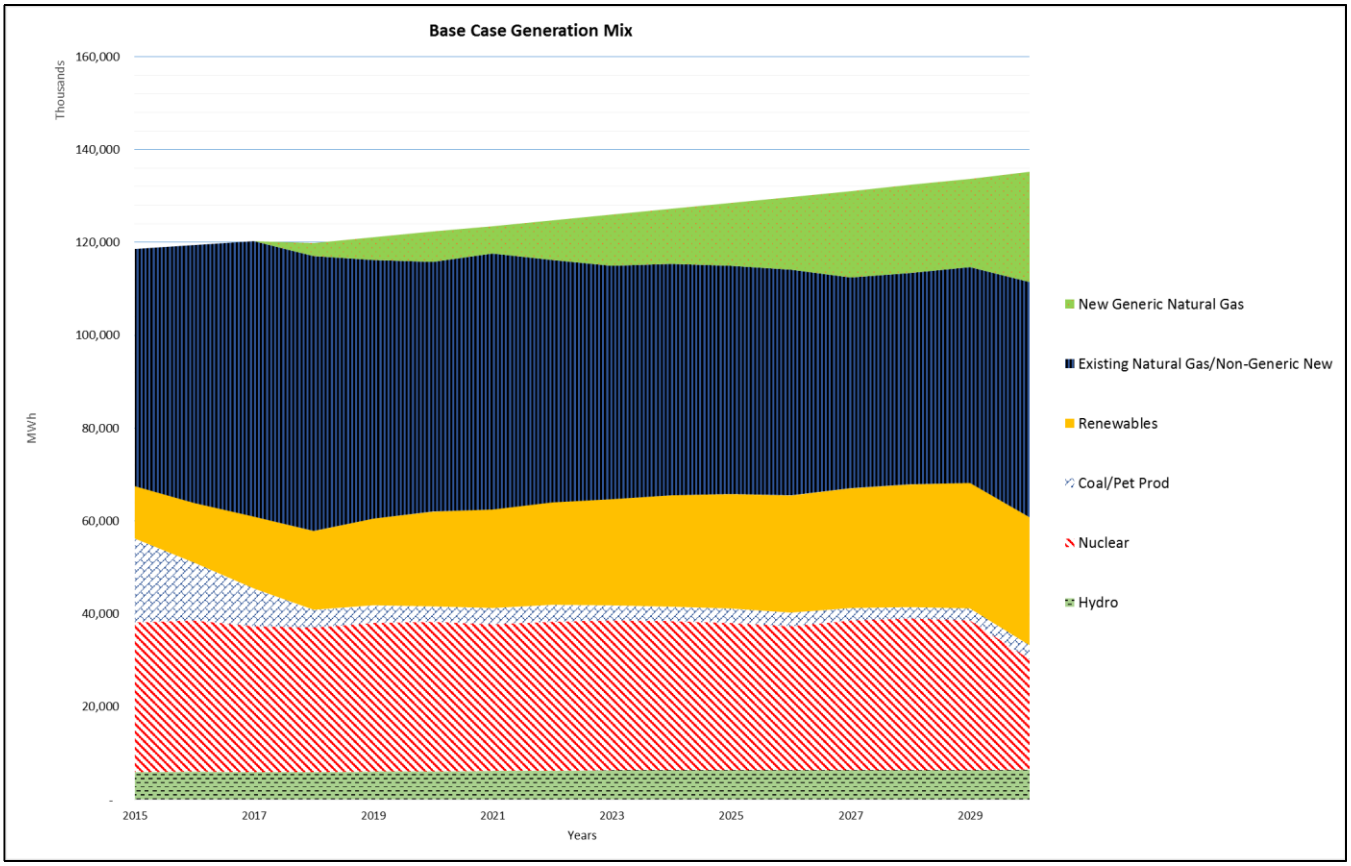
Power Year (June - May)	AESC 2013	AESC 2015 Base Case	Calendar Year	AESC 2013	AESC 2015 Base Case
	2015$/kW-month	2015$/kW-month		2015$/kW-year	2015$/kW-year
2015/16	$ 3.42	$ 3.38	2015	$40.99	$39.67
2016/17	$ 3.26	$ 3.15	2016	$36.89	$38.16
2017/18	$ 3.42	$ 14.19	2017	$40.99	$114.53
2018/19	$ 3.85	$ 12.96	2018	$46.20	$132.93
2019/20	$ 4.25	$ 11.29	2019	$51.05	$123.29
2020/21	$ 7.86	$ 11.33	2020	$94.27	$135.75
2021/22	$ 9.56	$ 11.71	2021	$114.76	$138.60
2022/23	$ 9.56	$ 11.62	2022	$114.76	$139.90
2023/24	$ 9.56	$ 11.37	2023	$114.76	$137.73
2024/25	$ 9.56	$ 11.96	2024	$114.76	$140.57
2025/26	$ 9.56	$ 11.96	2025	$114.76	$143.50
2026/27	$ 9.56	$ 12.04	2026	$114.76	$144.08
2027/28	$ 9.56	$ 11.79	2027	$114.76	$142.75
2028/29	$ 9.56	$ 12.46	2028	$114.76	$146.18
2029/30	$ 9.56	$ 12.79	2029	$114.76	$151.86
			2030	$114.76	$153.53
15 yr Levelized					
15/ 16 to 29/30	$7.95	$11.74	**2016 -2030**	$100.74	$142.08
AESC 2015 vs AESC 2013		48%			41%

The AESC 2015 capacity prices are actuals for the Rest of Pool (ROP) for power years 2015/16 through 2017/18 and are projections for 2018/19 through 2029/30. Note that in 2016/17capacity prices in the NEMA-Boston zone were different from the Rest of Pool. In addition, these projections do not reflect the FCA 9 results for 2018/19, which were not available at the time the AESC 2015 projections were made. However, the avoided electricity costs by zone provided in Appendix B reflect the actual results by zone for FCA 8 and FCA 9.

5.5.2 Forecast of Energy and Energy Prices

The projected level and mix of generation in the Base Case is presented in Exhibit 5-33. Generation from nuclear remains flat until year 2029 and declines in 2030 assuming retirement of Seabrook in March of that year, and coal generation declines substantially as most units are retired. Generation from natural gas is the dominant resource, and renewable generation increases over time in compliance with RPS requirements. Generation mix shown does not add up to the total energy demand because it does not account for the interchange with neighboring systems and for net pumping of energy by pumped storage generators.

Exhibit 5-33. Base Case Generation Mix



Forecast of Wholesale Electric Energy Prices

For AESC 2015, we present streams of energy values for all of New England in the form of the hub price. This is separately presented for four periods—summer on-peak, summer off-peak, winter on-peak, winter off-peak.[156]

The hub price representing the ISO-NE Control Area is located in central Massachusetts, and the WCMA zone in the pCA model is used as the proxy for that location. Exhibit 5-34 presents monthly, on-peak and off-peak energy prices as produced by the model through 2030 for Central Massachusetts. The higher

[156] Summer is defined as the four months June through September, with winter the other eight months, as done in AESC 2013. By combining the true winter season within spring and fall, the effects of high prices during the coldest months are moderated. AESC 2013 defined "on-peak" hours as 7 am – 11 pm.

winter on-peak price in the initial years represents the current high winter natural gas basis prices, which moderate as more pipeline capacity is added.

Exhibit 5-34. AESC 2015 Base Case Wholesale Energy Price Forecast for Central Massachusetts

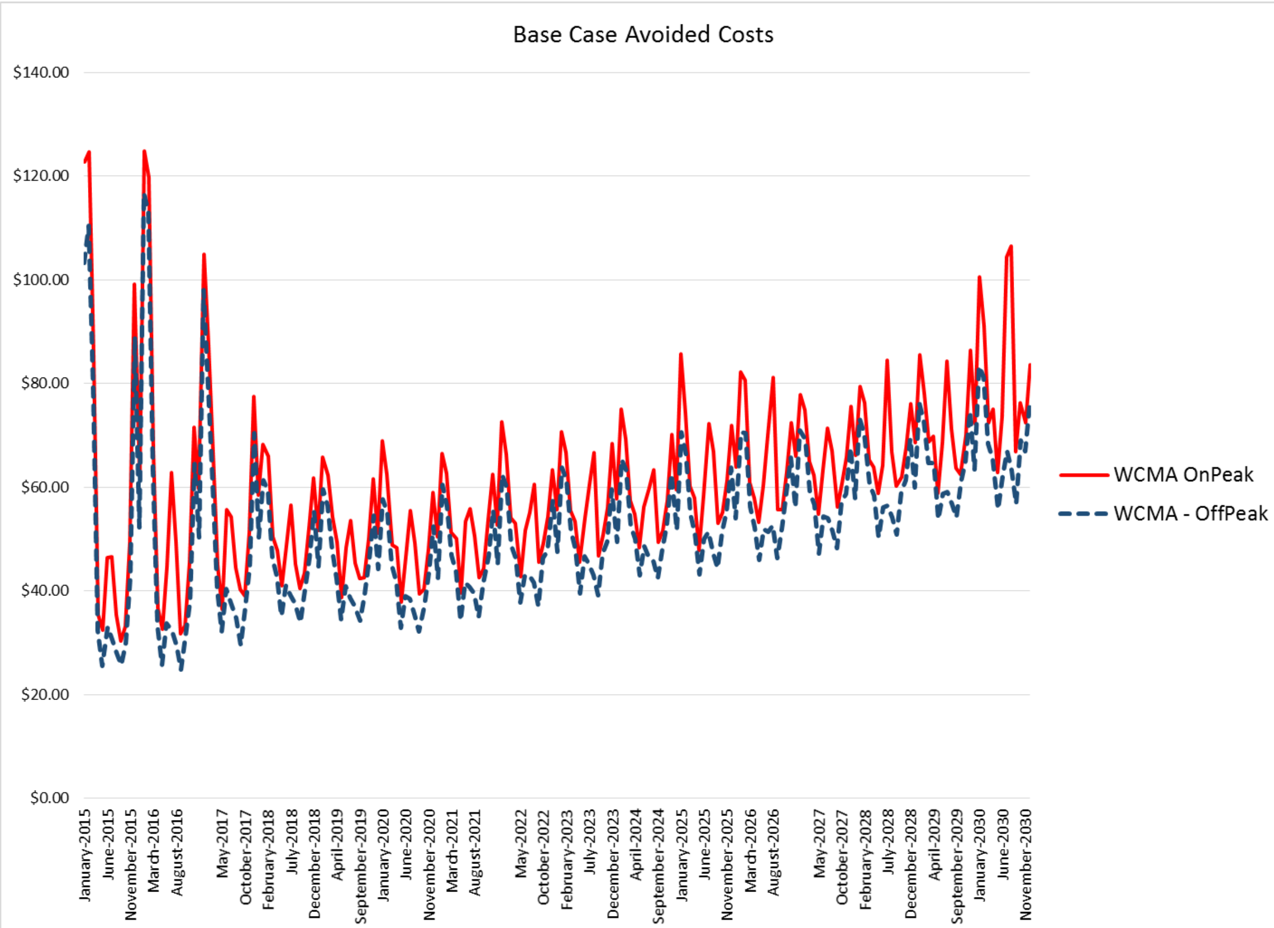


Exhibit 5-35 provides annual summaries by year, season and Peak vs. Off-Peak time periods.

Exhibit 5-35. AESC 2015 Base Case Wholesale Energy Price Forecast for Central Massachusetts (2015$/MWh)

	Summer			Winter		
Year	Off-Peak	OnPeak	AllHours	Off-Peak	OnPeak	AllHours
2015	$30.43	$39.83	$34.99	$64.89	$73.33	$68.90
2016	$30.79	$47.42	$38.67	$61.76	$66.69	$64.10
2017	$36.46	$48.93	$42.36	$59.05	$63.80	$61.30
2018	$39.30	$47.88	$43.34	$49.33	$54.02	$51.58
2019	$38.86	$47.60	$43.01	$48.61	$53.30	$50.86
2020	$37.33	$47.86	$42.38	$46.87	$51.95	$49.31
2021	$40.25	$50.69	$45.26	$49.19	$54.04	$51.50
2022	$42.36	$53.34	$47.65	$51.95	$57.22	$54.43
2023	$44.90	$57.13	$50.74	$53.67	$58.56	$55.98
2024	$47.14	$57.28	$51.95	$55.85	$60.69	$58.19
2025	$49.23	$62.74	$55.65	$57.79	$64.58	$61.07
2026	$51.50	$66.79	$58.74	$60.06	$66.02	$62.89
2027	$53.22	$64.54	$58.63	$61.89	$67.28	$64.46
2028	$55.81	$69.01	$61.99	$64.06	$68.86	$66.32
2029	$58.48	$72.05	$64.90	$68.02	$72.70	$70.24
2030	$63.40	$87.96	$75.13	$71.22	$79.63	$75.30

In sum, these benchmarking results demonstrate that the pCA modeling environment and supporting datasets provide a reliable tool for developing electric energy price projections.

5.5.3 Comparison to AESC 2013 Base Case

The following section summarizes differences between the AESC 2015 Base case and the AESC 2013 Base Case. Exhibit 5-36 compares the two AESC forecasts on a levelized basis. On a levelized annual basis, the AESC 2013 Base Case wholesale energy prices for WCMA are 7%below those of AESC 2013.[157]

The AESC 2015 Base Case levelized values are lower than the AESC 2013 Base Case in winter and summer periods, ranging from 3.3% to 15.6%. The lower summer prices reflect overall lower natural gas prices. The difference in winter prices is relatively small.

[157] Levelized values have been calculated for AESC 2015 using a discount rate of 2.43 percent, and for AESC 2013 using a discount rate of 1.36 percent.

Exhibit 5-36. 15-Year Base Case Levelized Cost Comparison for Central Massachusetts (2015$/MWh)

	Winter Peak Energy	Winter Off-Peak Energy	Summer Peak Energy	Summer Off-Peak Energy	Annual All-Hours Energy
AESC 2015 (2016-2030)	$62.10	$56.82	$57.68	$45.04	$56.58
AESC 2013 (2014 - 2028)	$66.64	$58.78	$66.03	$53.33	$61.95
% Difference	-6.8%	-3.3%	-12.6%	-15.6%	-8.7%

Notes:
All prices expressed in 2015$ per MWh.
Discount Rate 1.36% for AESC 2013, 2.43% for AESC 2015

5.5.4 Forecast of Electric Energy Prices by State

TCR developed monthly on-peak, off-peak and all-hours prices for eight SMD zones, five zones represent individual states and Massachusetts is represented by three zones – NEMA-Boston, SEMA and WCMA. On average, our results show very little price separation between these zones and very little transmission congestion in the future.

5.6 Avoided Cost of Compliance with RPS

The Base Case electric energy and capacity market prices presented in Section 5.5 reflect the projected impact of energy and capacity from renewable resources developed to comply with RPS requirements. This Section describes those resource additions and provides our projection of renewable energy certificates (REC) prices.

5.6.1 Resource Additions to Meet Renewable Portfolio Standards

AESC 2015 assumes load-serving entities (LSEs) will comply fully with RPS requirements, either through acquisition of GIS Certificates/RECs or through making Alternative Compliance Payments (ACP). The rate at which the ACP is set—which varies across the New England states and RPS subcategories[158]—will, however, influence the manner in which compliance is achieved. All else equal (e.g., in the absence of bilateral contracts or asset ownership that would dictate otherwise), states with lower ACPs (Connecticut and New Hampshire) will tend to see a shift from REC to ACP compliance during periods of shortage, while RECs flow to markets where the ACP and REC prices are higher.

The gross requirements for each RPS class were derived by multiplying the load of obligated entities (those retail LSEs subject to RPS requirements, often with exemptions for public power) by the applicable annual class-specific RPS percentage target. The exemptions, which differ somewhat from

[158] State RPS requirements are differentiated by resource type, size/application, or age, resulting in multiple subcategories—also referred to as tiers or classes—within each state's RPS.

those used in AESC 2013, are presented in Exhibit 5-37, along with notes on their derivation. Projected voluntary demand for new resources is added to Class 1 requirements.

Exhibit 5-37. Exemptions from RPS Obligations

State	Percentage of Load Exempt from RPS Requirements	Methodology
CT	6.9%	Determined by comparing 2011 compliance data to ISO-NE real-time load data
MA	17.3%	Mass. DOER forecasts RPS obligated load for 2014 and beyond as 2013 obligated load escalated by ISO-NE CELT MA growth rate.
ME	2.2%	For portion of ME in ISO-NE only. Comparison of 2012 compliance data with ISO-NE real-time load data, using 2010 MPUC load data to determine exempt company load; added exemption for Pine Tree Development Zone.
NH	1.7%	Ratio of EIA municipal load from 2010 EIA-861 to total of that load plus RPS-obligated load from compliance report.
RI	1.2%	Determined by comparing 2012 compliance data to ISO-NE real-time load data

Analysis based on data from the following sources:

CT: "Annual Review Of Connecticut Electric Suppliers' and Electric Distribution Companies' Compliance with Connecticut's Renewable Energy Portfolio Standards in the Year 2011," CT PURA Docket No. 12-09-02, June 4, 2014; ISO-NE real time load data for 2011 available at http://www.iso-ne.com/isoexpress/web/reports/pricing/-/tree/zone-info.

MA: "Massachusetts RPS & APS Annual Compliance Report for 2013," MA DOER, December 17, 2014; ISO-NE CELT forecast data available at http://www.iso-ne.com/static-assets/documents/trans/celt/fsct_detail/2014/isone_fcst_data_2014.xls

ME: "Annual Report on New Renewable Resource Portfolio Requirement Report for 2012 Activity," Presented to the Joint Standing Committee on Energy, Utilities and Technology March 31, 2014, Maine PUC; ISO-NE real time load data for 2012 available at http://www.iso-ne.com/isoexpress/web/reports/pricing/-/tree/zone-info; Maine PUC Electricity Statistics for 2010, available at http://www.maine.gov/mpuc/electricity/delivery_rates.shtml.

NH: "2011 Renewable Energy Portfolio Standard Review," Report of the New Hampshire Public Utilities Commission To the New Hampshire General Court, November 1, 2011; US EIA (2010), Form EIA-861, available at http://www.eia.gov/electricity/data/eia861/index.html.

RI: "Rhode Island Renewable Energy Standard (RES), Annual RES Compliance Report For Compliance Year 2012," Revised 3/25/14, Rhode Island Public Utilities Commission; ISO-NE real time load data for 2012 available at http://www.iso-ne.com/isoexpress/web/reports/pricing/-/tree/zone-info.

The RPS percentage requirements by class and year are listed in Appendix F. The load by state is the AESC 2015 Base Case load forecast (i.e., the gross load forecast assuming no new energy efficiency), as detailed in section 5.3.

The net demand for incremental renewable generation within New England is derived by subtracting from the gross demand:

a) Existing eligible generation already operating

b) Known near-term renewable additions

c) ISO New England's most recent long-term forecast of photovoltaic installations (largely distributed generation), which we extended from 2023 to 2030

d) RPS imports

An estimate of RPS-eligible imports over existing tie lines beyond current certified levels is phased in toward a maximum import, consistent with tie line capacity, competing uses of the lines and appropriate capacity factors of imported resources, the historical trend in RPS-eligible imports, and uncertainties in those factors.

Projected PV generation, based on ISO New England's PV forecast, is netted from demand because PV development is largely driven by policies other than the Class 1 RPS requirements.[159] The majority of PV development is projected to occur in Massachusetts. In AESC 2013, it was assumed that Governor Patrick's April 2013 announcement targeting 1,600 MWdc of solar installed by 2020 increased the MA Solar Carve Out by an incremental 800 MW, for a total Solar Carve-Out obligation of 1,200 MW by 2020. In April 2014, DOER launched the SREC-II program to continue the growth of solar market to meet Governor's 1,600 MWdc by 2020, and has continued to evolve its various incentives to encourage solar development. As of the end of 2014, there were approximately 700 MWdc installed in the state, approximately 280 MW of which was installed in 2014.[160]

In the near term (from 2015 to 2019), we assume that the aggregate net demand for new RPS supply will be met by a mix of renewable resources consistent with: (1) RPS-eligible resources in the New

[159] "2014 Interim Forecast of Solar Photovoltaic (PV) Resources," May 1, 2014, and "PV Energy Forecast Update," September 15, 2014. Presentations to the ISO-NE Distributed Generation Forecast Working Group. The PV forecast includes detailed estimates of installations in each state, developed in conjunction with those states. The projected new entry is primarily policy-forced, but includes a post-policy component; both components embody explicit realization rates that vary over the period.

[160] Analysis based on data from the following sources: MA DOER, "RPS Solar Carve-Out II Qualified Renewable Generation Units," updated February 15, 2015; MA Office of Energy and Environmental Affairs (MA EEA), "Current Status of the Solar Carve-Out II Program," accessed February 22, 2015, available at http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/solar/rps-solar-carve-out-2/current-statis-solar-carve-out-ii.html; MA EEA, "Current Status of the Solar Carve-Out Program," accessed February 22, 2015, available at http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/solar/rps-solar-carve-out/current-status-of-the-rps-solar-carve-out-program.html; Massachusetts 225 CMR 14.00: RENEWABLE ENERGY PORTFOLIO STANDARD - CLASS I.

England administered systems, plus (2) other expected RPS-eligible generation in the development pipeline, which has not entered the queue. This includes both large projects that have not yet filed for interconnection studies, and distributed wind, solar, biomass, small hydro and tidal, and CHP projects, which—due to their size—are not required to go through the large generator interconnection process. Due to the increasing expense of entering and maintaining a position in the interconnection queue, some proposed projects must delay this stage of the process until early site evaluation and permitting progress has been sufficient to attract substantial development capital.

Renewable generation in the ISO interconnection queue that is under construction is listed in Section 5.3.6. Additional proposed generation for which information has entered the public domain, as well as generic renewable supply of various types are added as a result of policies and incentives. This information is grouped by load area as an input to the pCA model.

For the longer term (generally after 2019), we estimate the quantity and types of renewables that will be developed using a supply-curve approach based on resource potential studies. In this approach, discussed further below, resource build decisions are simulated by selecting from a supply curve of potentially available resources based on the resources' REC premium required to attract financing, subject to their ability to qualify under each state's main tier eligibility criteria, given their characteristics. This approach identifies the incremental resources required to meet net incremental Class 1 demand in each year through 2030. The one exception to this approach is solar PV, which as noted above is based on ISO New England's PV forecast.

5.6.2 Impact of Policy Uncertainty on RPS Supply

In some cases, the development and interconnection processes are also delayed by regulatory uncertainty. Examples of such uncertainty are available in each state in today's market—making the regional RPS marketplace increasingly complex and challenging for developers and investors.

A significant example of uncertainty around RPS requirements has to do with resource development in Vermont, the one state in New England without an RPS substantiated by REC retirement. In 2014, Vermont enacted legislation that significantly increased the amount of resources eligible for the state's net-metering program.[161] Formerly capped at 4% of a distribution utilities' load, the quantity of renewable resources eligible for net metering increased to 15%. The legislature has in the past defeated RPS bills and continued to support the resale of RECs associated with SPEED program resources into other New England RPS markets, although that appears to be changing, in part due to developments in other states. The Connecticut PURA was to rule in November 2014 in Docket No. 14-05-36, on whether and to what extent RECs associated with Vermont SPEED resources can be counted for compliance in

[161] State of Vermont, *An Act Relating to Self-Generation and Net Metering*, H.702 (April 2, 2014), http://www.leg.state.vt.us/docs/2014/bills/Passed/H-702.pdf

Connecticut's RPS (or whether that would constitute impermissible double-counting). Other states, notably Massachusetts, are watching the outcome of the proceeding.

The Vermont legislature is currently considering a bill (H.40) to replace the SPEED program with a program called the Renewable Energy Standard and Energy Transformation Program (RESET).[162] As of this writing, the bill is making its way through committee. For the purposes of AESC 2015, we assume no RPS demand for Vermont and that only RECs associated with existing Vermont renewable resources (but not new ones) will be allowed to be counted against RPS obligations in other states, and only through 2016.

5.6.3 REC Prices and Avoided Cost of RPS Compliance

REC prices are, simplistically speaking, effectively the premiums by which the cost of renewable energy exceeds the revenues available to renewable resources through the energy and capacity markets, with the marginal premium setting the market REC price.

RPS targets for Connecticut, Maine, Massachusetts, New Hampshire, and Rhode Island are a percentage of retail load as defined by state-specific legislation and regulation, estimated for AESC 2015 using the provisions in effect as of December 2015. Energy-efficiency programs reduce the cost of compliance because RPS requirements are generally volumetric, in proportion to the total load (in MWh) that must be supplied.[163] Reduction in load due to DSM will reduce the RPS requirements of LSEs and therefore reduce the costs they seek to recover associated with complying with these requirements. The RPS compliance costs that retail customers avoid through reductions in energy usage are equal to the product of REC prices multiplied by the percentage of retail load that a supplier must meet using renewable energy under the RPS regulations.

The following exhibit summarizes the change in Avoided RPS costs between AESC 2013 and AESC 2015. As detailed below, these avoided RPS costs represent a significant increase over the corresponding values in AESC 2013, due primarily to two factors. First, because AESC 2015 Base Case electric energy prices (and generator revenues) are considerably lower than those of AESC 2013, the REC premium for a given resource must be correspondingly higher to make up the shortfall below its levelized cost. The second factor is methodology. AESC 2013 used all-hours average prices to estimate renewable resources' revenues, which would tend to overestimate revenues—and therefore underestimate REC premium—for onshore wind resources, whose output is more heavily weighted toward off-peak / lower-

[162] "New renewable standard would revolutionize energy use in Vermont," J. Herrick, vermontbiz.org, accessed February 28, 2015. Available at: http://www.vermontbiz.com/news/february/new-renewable-standard-would-revolutionize-energy-use-vermont. A draft of the bill can be found at http://legislature.vermont.gov/assets/Documents/2016/WorkGroups/House Natural Resources/Bills/H.40/Draft, Summaries and Amendments/H.40~Aaron Adler~Draft No. 3.1 %282-50pm%29, 2-13-2015~2-17-2015.pdf

[163] Exceptions in New England include solar carve-outs, for which compliance targets are fixed MW quantities.

cost hours. By contrast, AESC 2015 used hourly prices and hourly production for each of the resources in the supply curve.

Exhibit 5-38. Comparison of Avoided RPS Costs

Comparison of Avoided RPS Costs
$/MWh of Load
Levelized Price Impact 2016 - 2030

	CT	ME	MA	NH	RI	VT
AESC 2013 (2013$)	$4.62	$1.82	$6.25	$5.05	$3.45	$0.00
AESC 2013 (2015$)	$4.78	$1.88	$6.48	$5.23	$3.57	$0.00
AESC 2015 (2015$)	**$8.22**	**$0.51**	**$8.81**	**$8.67**	**$5.18**	$0.00
Percent Difference	72%	-73%	36%	66%	45%	-

Notes
Conversion from 2013$ to 2015$: 1.035
AESC 2013 levelization period (2014-2028) using a 1.36 percent discount rate.

Methodology

The method generally used in AESC 2015 to forecast REC prices, similar to that used in AESC 2013, varies by time period, as follows:

- **2015-2016**: Forecast REC prices are based on historical average broker quotations or bid-ask spreads for short-term forward transactions as of February 2015.
- **2017-2019:** Prices are interpolated by scrutinizing the expected balance between RPS-eligible supply and RPS demand.
- **2020 onward**: REC prices reflect the forecasted cost of new entry, modeled as described herein.

Estimating New or Incremental Renewable Additions and the Cost of New Entry

As with AESC 2013, the AESC 2015 analysis assumes that in the long run, the price of renewable energy certificates (and therefore the unit cost of RPS compliance) will be determined by the cost of new entry of the marginal renewable energy unit, relative to energy and capacity market revenues.

To estimate the REC premium, we forecast REC prices for each RPS subcategory, by state and by year, using a renewable resource expansion model that builds the least-cost set of resources needed to satisfy the RPS requirements net of existing resources. The “cost” of each renewable resource in this sense is the premium it needs above the energy and capacity market revenues it would receive, expressed as revenues per unit of energy generated, to equal its levelized cost of energy.

The model captures the various subcategory-specific nuances of the RPS requirements, including the degree to which rules limit resource eligibility based on characteristics and location, limitations on banking and borrowing, and ACPs that change over time.[164] The model also constrains the amount of a given resource that can be built in a given year in a given location to an estimate of technical potential. This is a different approach than AESC 2013, which calculated the market revenues of a renewable resource based on the all-hours average forecast LMP, the resource's capacity factor and forecast capacity prices. AESC 2015 calculates the annual market revenues of a renewable resource for each year based on the location of the resource, the forecast output of the resource in each hour, the AESC forecast of hourly energy prices for that location in that year and the AESC forecast of capacity prices for that location in that year. Revenues past 2030 for post-2020 installations are assumed to stay at the level of 2030 revenues in real terms.

AESC 2015 obtained or derived levelized costs and technical potential data for each resource type from various publicly available resource potential studies and economic analysis.[165] The estimated levelized costs are based on several key assumptions, including projections of capital costs, capital structure, debt terms, required minimum equity returns, and depreciation. Those assumptions are specific to the resource type and size and in some cases cover a range to account for a diversity of arrangements. The assumptions also include fixed and variable operations and maintenance costs, transmission and interconnection costs (as a function of voltage and distance from transmission), and wind integration costs.

As in AESC 2013, our analysis assumes there will be adequate transmission to accommodate the additional generation from these new renewable resources, and that the costs of any needed transmission upgrades will be socialized. Estimating the extent to which existing transmission facilities would require major upgrades (to integrate renewables or for any other reason) was beyond the scope

[164] In the event that an LSE purchases RECs in excess of its current year RPS obligation, states generally allow LSEs to save and count that quantity of compliance against either of the following two compliance years, subject to limitations. This compliance flexibility mechanism is referred to as banking. LSEs are also allowed to meet prior-year deficiencies with current year RECs (again, subject to limitations)—a provision sometimes called "borrowing." LSEs may only bank compliance within a single state, and may not transfer banked compliance credit to other entities.

[165] These assumptions are based on technology data compiled by Longwood Energy Group from a range of publicly available studies and interviews with industry participants. Public studies include: *Renewable Resource Supply Curve Report*, NESCOE, January 2012, *New England Wind Supply Curve*, Sustainable Energy Advantage, November 2011, *Lazard's Levelized Cost of Energy Analysis*—Version 8.0, Lazard, September 2014, *Recent Developments in the Levelized Cost of Energy from U.S. Wind Power Projects*, R. Wiser et al., NREL and LBNL, February 2012, *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014*, EIA, April 2014, *Levelized Costs of Electricity from CHP and PV*, Program Record 14003, T. Nguyen et al., US DOE, March 2014, and *Energy Efficiency and Renewable Energy Potential Study of New York State*, Final Report, Report Number 14-19, NYSERDA, April 2014. Data from these and other sources served as inputs to our own analysis to adjust and control for various parameters including vintage, cost trends, inflation, financing, penetration, geographic location, plant size and capacity factor.

of work for AESC 2015. Hence we do not provide the costs of any such upgrades or include them in our estimates of avoided costs.

AESC 2015 differentiates the levelized costs of resources by type, project size, and geographic location. Each of the resource blocks making up the potential supply curve are characterized by total nameplate capacity, hourly production profile, levelized cost, and operation applicable to projects coming online in each year. The potential supply curve consists of land-based wind, biomass, hydro, landfill gas, and offshore wind.

The Federal Production Tax Credit (PTC), renewed in December 2014, is assumed not to be extended again, such that only resources beginning construction before the end of 2014 are eligible. The Investment Tax Credit (ITC) is assumed to expire after 2016.

Unless the revenue from REC prices can make up the required REC premium, a project is unlikely to be developed, and in our simulation it will not be built. The highest REC premium of any resource built in a given subcategory, i.e., the marginal price, will set the REC price. Our projections assume that Class 1 REC prices for new renewables will not fall below $2/MWh—the estimated transaction cost associated with selling renewable resources into the wholesale energy market—except in the presence of an administratively set floor price. This estimate is consistent with effective market floor prices observed in various markets for renewable resources.

To project Maine Class 1 REC prices, we used an approach different from that of the other states, because Maine has put in place eligibility criteria that depart considerably from regional Class 1 norms, resulting in idiosyncratic market behavior. Under the Maine rules, compliance can be achieved largely with refurbished biomass generation that is ineligible in other states. The potential supply of eligible refurbished biomass resources in and outside Maine is not likely to be constrained in the time horizon of this analysis, given the modest increase in the Base Case Maine RPS obligation over the period. Beyond 2016, we estimated Maine Class 1 REC prices as the greater of (1) the difference between (a) an imputed levelized cost of energy based on 2015 REC prices and simulated biomass revenues and (b) simulated revenues going forward, and (2) the $2/MWh assumed floor described above.

Existing solar facilities across New England are eligible for NH Class II. As such, this market is expected to remain in balance and settle marginally above the MA Class I REC price for the remainder of the study period. As in AESC 2013, New Hampshire Class II REC prices are estimated at the lesser of (1) 90% of the ACP rate and (2) 105% of the Massachusetts/Maine/Rhode Island Class 1 ACP.

For RPS tiers for which we are not projecting prices using simulation, and for which no liquid forward market exists, we assume prices to stay, in real terms, at the level of broker-derived prices across the time horizon. The exception to this approach is for RPS classes focused on existing supply but for which such existing supply has not been certified by the applicable RPS authority in a quantity sufficient to meet demand. Near-term REC prices for such classes are estimated based on current broker quotes and the applicable ACP. REC prices are assumed to trend toward values which reflect a market in equilibrium or modest surplus over time, as existing generators become certified and participate in the program.

Exhibit 5-39 lists near-term REC market prices.

Exhibit 5-39. REC and APS Prices for 2015 and 2016 compliance years

		2014 REC Prices Q3&Q4 2014 Average (2015$/MWh)	2015 REC Prices Feb 2015 (2015$/MWh)	2016 REC Prices Feb 2015 (2015$/MWh)
CT	Class I	$53.66	$53.10	$49.96
	Class II	$0.55	$2.25	$2.46
	Class III	$24.20	$27.25	$26.30
MA	Class I	$55.20	$57.56	$56.34
	Class II – renewable		$26.50	
	Class II – WTE	$9.29	$9.44	
	APS	$20.95	$21.00	
ME	Class I	$2.35	$4.38	$5.41
	Class II		$0.30	
NH	Class I	$53.98	$52.50	$50.02
	Class II – Solar	$51.08		
	Class III			
	Class IV	$25.85		
RI	New	$50.65	$53.50	$49.16
	Existing	$0.80		

Source: Data from Intercontinental Exchange, SNL, and confidential REC brokers' quotations compiled by Longwood Energy Group. Prices for some products/years were not available.

We use the terms "Class 1" or "main tier" generally to refer to new or incremental renewable resources that qualify as Class I in Connecticut, Massachusetts, New Hampshire, Maine, and as "New" in Rhode Island. Class 1 REC prices will be driven both by the costs of renewable resources eligible in each state and by the quantity of state-specific supply compared to state-specific demand. Because RPS eligibility criteria differ by state, REC prices are differentiated by state and reflect state-specific expectations with respect to generator certification.

Massachusetts is unique in its treatment of the solar carve-out portion of its Class 1 obligation. While the carve-out itself is not unique, Massachusetts establishes an annual MWh obligation, which is then allocated among the obligated LSEs. In aggregate, this solar target is converted into a percentage of state load and is removed from the Class 1 percentage target for that year—thereby reducing the Class 1 RPS compliance obligation avoidable through energy efficiency activities. Because the solar carve-out represents an LSE obligation to procure a fixed quantity (MWh) of Solar RECs (SRECs) each year, we therefore treat it as not avoidable through energy efficiency measures that reduce all other RPS obligations.

Connecticut's current eligibility definitions also allow for certain biomass supply to be uniquely eligible in Connecticut, but its RPS targets have increased at a pace such that this supply is now sub-marginal.

Secondary tiers

While Class I RPS requirements generally spur the development of new renewable resources, Class II, III, and IV requirements are generally designed as "maintenance tiers," with the exception of special categories for new thermal and CHP resources. The maintenance tier programs are intended to provide just enough financial incentive to keep the existing fleet of renewable resources in reliable operation. Due to their maintenance orientation, Class II, III and IV percentage targets are generally held constant, with annual obligations varying only based on changes in the demand forecast.

CT Class II, MA Class II-WTE (waste to energy), ME Class II, and RI "Existing" REC markets have been in surplus. Therefore, REC prices in these markets are expected to remain relatively constant at levels just above the transaction cost. The MA Class II-RE (non-waste) market (which has overlapping eligibility with CT Class I), has an obligation that rises annually until 2016, whereas the Class II-WTE obligation remains fixed.

While there is theoretically ample supply to meet MA Class II and New Hampshire Class III, fewer generators than expected have undertaken the steps necessary to comply with the eligibility criteria and become certified. As a result, those two markets have been in shortage. As a result, steps have been taken in both markets to address the imbalance. Retroactive regulatory revisions to MA Class II were announced in February 2014 and completed in June in part to bring the market into a balance more consistent with a policy targeting existing resources, with less reliance on the ACP mechanism. The changes have left the market much less short of demand in 2013 than it was in 2012.[166] The market is still short, however, with obligated entities paying ACPs to cover the shortfall, albeit few of them; the current REC price is essentially unchanged from the then-current price in AESC 2013. For these reasons we continue the assumption that long-run MA Class II REC prices to be the lesser of CT Class I REC prices and 50 percent of the MA Class II ACP rate.

The NH Class III (existing biomass/methane) and NH Class IV (existing small hydro) markets[167] have overlapping eligibility with the higher-priced CT Class I, and have historically competed with that program for resources, resulting in compliance that has relied heavily on ACP payments. The New Hampshire PUC in 2014 solicited comments regarding adjusting RPS requirements for 2013-2015, in particular for Class III.[168] The order reduced only the Class III requirement for 2013 (to 0.5 percent), it is

[166] Massachusetts RPS & APS Annual Compliance Report for 2013, MA DOER, December 17, 2014.

[167] Several Class III biomass and Class IV hydroelectric facilities have been certified in both NH III or IV, respectively, and CT Class I.

[168] Order Reducing Class III Requirements for 2013 to 0.5% of Retail Sales. Order No. 25,674 in Docket No. DE 14-104, ELECTRIC RENEWABLE PORTFOLIO STANDARD, Adjustments to Renewable Portfolio Class Requirements, June 3, 2014.

slated to rise to 8% in 2015, and the PUC may make further changes after continuing to monitor the markets.

Responding to a recommendation by the Connecticut Department Of Energy and Environmental Protection (DEEP) to reduce reliance on out of state biomass and landfill gas to meet Connecticut's Class 1 targets, the legislature in 2013 passed a law requiring the Commissioner of Environmental Protection to "…establish a schedule to commence on January 1, 2015, for assigning a gradually reduced renewable energy credit value to all biomass or landfill methane gas facilities that qualify as a Class I renewable energy source…"[169] Such a change could enhance New Hampshire's ability to meet its Class III targets, although the law is rather vague and it's unclear what shape the changes will take.[170] DEEP is now recommending delaying a reduction in biomass REC values until 2018.[171]

In the long-run, NH-III and NH-IV REC prices are assumed to be the lesser of CT Class I and 90 percent of their respective ACP rates.

The MA Alternative Energy Portfolio Standard (APS), which provides incentives for investments in efficient thermal or storage resources such as CHP (including natural gas fuel cells), flywheel storage, geothermal heat pumps, and waste heat recovery, is in significant shortage. Both the APS and the similar CT Class III are less fungible than other REC markets because of the need to use any thermal energy produced in-state. The CT Class III market, like the APS, has had difficulty meeting its goals, given insufficient CHP development.[172] The CT Class III goal remains fixed at 4 percent, and Connecticut ACPs are fixed in nominal terms, which mean they decline in real terms rather than rise with inflation as those of most other states. By contrast, the APS goal continues to increase, and its ACP is indexed for inflation. REC prices for MA APS are forecasted at 90 percent of the ACP rate; CT Class III prices are expected to remain at about 86 percent of ACP (therefore declining in real terms) over the period.

Existing solar facilities across New England are eligible for NH Class II. As such, this market is expected to remain in balance at about 90 to 95 percent of ACP, as solar resources age out of solar carve outs and competing Class 1 prices drop.

Class I requirements will outpace the other classes on a GWh basis over time. This phenomenon is shown in Exhibit 5-40, which summarizes New England's total renewable energy requirements by year,

[169] Subsection (h) to Connecticut General Statue section 16-245a, effective June 5, 2013.

[170] "The Gradually Reduced Credit for Biomass Energy in Connecticut: A Vague But Still Constitutional Standard," Brian M. Gibbons, Connecticut Law Review, V.47, December 2014.

[171] 2014 Integrated Resource Plan For Connecticut, Draft For Public Comment, Prepared by The Connecticut Department Of Energy and Environmental Protection, December 11, 2014. "The Department proposes to monitor RPS compliance and the capacity market and, in the next IRP, consider establishing a schedule for reduced REC value beginning in 2018 subject to the comments and feedback from stakeholders."

[172] Beginning in 2014, ratepayer-funded energy efficiency resources were no longer eligible in Connecticut Class III formerly included energy conservation and load management. Prior to that time, prices remained near the $10 administratively set floor. Since the phase-out of energy efficiency resources, prices have been more reflective of the gap between demand and supply.

based on the RPS percentage targets by state and the AESC 2015 Base Case / gross load forecast, as discussed in Chapter 5. Exhibit 5-41 distinguishes between the quantities of Class I renewables that are required and the *aggregate* quantity of all other classes of renewables combined.

Exhibit 5-40. Summary of New England RPS Demand

New England Annual RPS Demand (GWh)			
Year	**Class 1**	**Other Classes**	**Total**
2015	10,931	11,387	22,318
2016	12,325	11,872	24,197
2017	13,718	12,051	25,769
2018	14,882	12,145	27,027
2019	16,542	12,378	28,920
2020	17,474	12,613	30,088
2021	18,265	12,853	31,118
2022	19,069	13,097	32,166
2023	19,887	13,343	33,230
2024	20,721	13,594	34,315
2025	21,570	13,848	35,418
2026	22,315	14,106	36,421
2027	23,072	14,368	37,440
2028	23,842	14,634	38,476
2029	24,626	14,903	39,529
2030	25,422	15,177	40,599

Notes:

Based on Base Case load forecast and RPS targets as of 12/31/2014, with exemptions for non-obligated entities, and Maine NMISA demand excluded. Class I includes Solar Carve Outs. Does not include voluntary demand.

The major sources of the renewable supply forecast used to meet the RPS requirements by year are shown in Exhibit 5-41. These sources include wind (onshore and offshore), biomass, and hydro.

Exhibit 5-41. Cumulative Supply of Class 1 Renewable Energy Resources in New England, by Fuel Type

	Class 1 Renewable Energy Supply, by Fuel Type (GWh)						
Year	**Wind**	**Biomass**	**Solar**	**Hydro**	**LFG**	**CHP**	**Total**
	a	b	c	d	e	f	g = sum a to f
2015	2,324	3,363	1,479	410	1,204	1,659	**10,440**
2016	2,983	3,463	1,721	637	1,204	1,765	**11,773**
2017	4,816	3,548	1,817	740	1,204	1,839	**13,963**
2018	5,243	3,841	2,009	842	1,204	1,839	**14,977**
2019	5,521	3,953	2,181	923	1,344	1,948	**15,870**
2020	6,147	4,064	2,337	1,005	1,344	2,077	**16,973**
2021	6,619	4,149	2,448	1,026	1,484	2,208	**17,934**
2022	6,849	4,212	2,514	1,047	1,624	2,342	**18,589**
2023	7,215	4,275	2,580	1,048	1,694	2,465	**19,276**
2024	7,674	4,338	2,645	1,049	1,694	2,589	**19,989**
2025	8,155	4,401	2,710	1,050	1,694	2,716	**20,727**
2026	8,545	4,460	2,776	1,051	1,694	2,846	**21,371**
2027	8,958	4,520	2,841	1,051	1,694	2,977	**22,041**
2028	9,705	4,569	2,906	1,053	1,694	3,111	**23,038**
2029	10,499	4,598	2,971	1,054	1,694	3,248	**24,064**
2030	11,322	4,627	3,037	1,055	1,694	3,386	**25,122**

Includes existing and projected energy production by Class 1 renewables and CHP. Hydro includes tidal. CHP includes natural gas fuel cells. CHP listed in terms of GWhe, except for MA CHP, listed in terms of AEC GWh.

The expected distribution of Class 1 RPS supplies between ISO-NE and adjacent control areas is summarized in Exhibit 5-42. Supply is categorized as follows:

- Existing eligible generation already operating
- Known additions not yet operating
- Projected incremental renewable resources by fuel type
- Energy / RECs currently imported from RPS-eligible facilities located outside of ISO-NE
- Assumed incremental energy / RECs imported from outside of ISO-NE

Exhibit 5-42. Expected Distribution of New Renewable Energy between ISO-NE and Adjacent Control Areas

	Class 1 RPS Supply (GWh)					New Renewable Requirement (GWh)	New Renewable Energy Surplus (Shortage)
	ISO-NE Supply		Imported Supply				
Year	Operating	Incremental	Current	Expected	Total Supply		
	a	b	c	d	e = sum a to d	f	g = e-f
2015	7,882	1,600	1,662	-	11,144	11,046	99
2016	7,882	2,918	1,662	-	12,462	12,457	5
2017	7,181	4,944	1,662	83	13,870	13,870	0
2018	7,181	5,956	1,662	258	15,057	15,057	0
2019	7,181	6,684	1,662	546	16,072	16,743	(671)
2020	7,181	7,688	1,662	845	17,375	17,706	(330)
2021	7,181	8,545	1,662	1,144	18,531	18,531	0
2022	7,181	9,089	1,662	1,443	19,375	19,375	0
2023	7,181	9,654	1,662	1,742	20,239	20,239	0
2024	7,181	10,242	1,662	2,041	21,126	21,126	0
2025	7,181	10,853	1,662	2,340	22,036	22,035	0
2026	7,181	11,368	1,662	2,639	22,850	22,850	0
2027	7,181	11,906	1,662	2,938	23,687	23,687	0
2028	7,181	12,769	1,662	2,938	24,550	24,550	0
2029	7,181	13,659	1,662	2,938	25,440	25,439	0
2030	7,181	14,578	1,662	2,938	26,359	26,358	0

Notes:

RPS requirement is scaled to Base Case load. Requirement and supply quantities here reflect those of main tiers for new renewables, including solar carve-outs, plus voluntary demand. The Massachusetts APS and similar programs are not included here. Vermont supply is included only through 2016, resulting in a decrease in column (a) quantity thereafter. Much of the column (g) shortages shown for 2019-2020 could be offset by banked surpluses from 2014 (not shown) through 2016, parlayed forward by banking in each intervening year.

Exhibit 5-42 also compares total Class 1 RPS supply to total Class 1 RPS demand. The combination of operating supply, projects currently under development, imported supply and resource potential from the renewable energy supply curve analysis are expected to keep supply and demand in balance through 2030.

The eligibility details and target percentages for main tier and secondary tier resources are summarized in Appendix F.

5.6.4 Estimated Cost of Entry for New or Incremental Renewable Energy

Our general approach to estimating the cost of entry for new or incremental renewable supply is described above.

Beginning in 2020, regional REC prices are expected to converge as all states rely on new or incremental renewable resources to meet their RPS demands—with only modest price differentials between states based on eligibility, bank balances and utility-specific decisions to retire the RECs from long-term contracts in satisfaction of RPS obligations. Our projection of the cost of new entry for each state is summarized in Exhibit 5-43.

Exhibit 5-43. REC Premium for Market Entry

AESC 2015 Class 1 REC Premium (2015$/MWh)						
	CT	**ME**	**MA**	**NH**	**RI**	**VT**
2015	$53.10	$4.38	$57.56	$54.97	$53.50	$0.00
2016	$49.96	$5.41	$56.34	$52.50	$49.16	$0.00
2017	$47.62	$4.27	$52.40	$49.52	$47.02	$0.00
2018	$45.27	$5.99	$48.46	$46.54	$44.87	$0.00
2019	$42.92	$7.39	$44.52	$43.56	$42.72	$0.00
2020	$40.57	$8.04	$40.57	$40.57	$40.57	$0.00
2021	$36.75	$5.60	$50.50	$49.61	$48.78	$0.00
2022	$46.63	$2.39	$46.69	$46.69	$46.69	$0.00
2023	$43.94	$2.00	$43.62	$43.94	$43.39	$0.00
2024	$42.00	$2.00	$41.38	$41.38	$41.38	$0.00
2025	$38.74	$2.00	$38.74	$38.74	$38.74	$0.00
2026	$35.79	$2.00	$35.72	$35.72	$35.72	$0.00
2027	$32.86	$2.00	$32.86	$32.86	$32.86	$0.00
2028	$30.13	$2.00	$35.28	$30.13	$30.13	$0.00
2029	$32.66	$2.00	$32.66	$32.66	$32.66	$0.00
2030	$30.46	$2.00	$30.46	$30.46	$30.46	$0.00
2016-2030 levelized	**$40.32**	**$3.84**	**$42.74**	**$41.66**	**$40.93**	**$0.00**

These REC premium results reflect the RPS demands of the post-2018 Base Case load forecast. (The load in the BAU Case is lower and would have a commensurately lower RPS requirement). The REC premiums are highly dependent upon the forecast of wholesale electric energy market prices, including the underlying forecasts of natural gas and carbon allowance prices. A lower forecast of market energy prices would yield higher REC prices than shown, particularly in the long term. In most cases, project developers will need to be able to secure long-term contracts (or financial equivalents, such as synthetic PPAs), and attract financing based on the aforementioned natural gas, carbon, and resulting electricity price forecasts. This presents an important caveat to the projected REC prices, because such long-term electricity price forecasts (particularly to the extent that they are influenced by expected carbon regulation) are not easily taken to the bank.

In contrast to the long-term REC cost of entry, spot prices in the near term will be driven by supply and demand, but are also influenced by REC market dynamics and to a lesser extent to the expected cost of entry (through banking), as follows:

- Market shortage: Prices approach the cap or Alternative Compliance Payment
- Substantial market surplus, or even modest market surplus without banking: Prices crash to approximately $0.50 to $2/MWh, reflecting transaction and risk management costs
- Market surplus with banking: Prices tend towards the cost of entry, discounted by factors including the time-value of money, the amount of banking that has taken place, expectations of when the market will return to equilibrium, and other risk management factors

These Class 1 REC prices, with the exception of Maine, represent a significant increase over the corresponding values in AESC 2013. The increase is due primarily to two factors. First, because AESC 2015 Base Case electric energy prices (and generator revenues) are considerably lower than those of AESC 2013, the REC premium for a given resource must be correspondingly higher to make up the shortfall below its LCOE. Although capacity revenues are higher in AESC 2015 than in 2013, capacity payments don't comprise a large share of market revenues wind resources whose REC premiums set the clearing price for much of the period. Part of the increase is likely attributable to methodology. AESC 2013 used all-hours average LMPs to estimate renewable resources' revenues. By contrast, AESC 2015 used hourly LMPs and hourly production for each of the resources in the supply curve. Onshore wind resources tend to produce more during off-peak periods when prices are lower, so an all-hours average energy price may overestimate energy revenue, leading to an underestimate of the required REC premium. Finally, Class 1 RPS requirements, which on average increase over time, are in many cases higher for the 2015-2030 period than for the 2013-2028 period analyzed in AESC 2013.

In the AESC 2015 analysis, REC prices decline over the period—although not uniformly—as revenues increase and technology learning curves reduce LCOEs—countering the effect of moving further up the supply curve as less expensive resources are exhausted.

REC premiums hit the caps set in the model in only one instance—in Connecticut (2022).[173] This year corresponds to the tightest period of supply relative to net demand, and it is possible that more significant banking might have alleviated the shortfall. Unlike in all other states where ACPs are indexed to inflation (CPI) , Class 1 ACPs in Connecticut and New Hampshire decline in real terms over time, while demand increases.[174] As a result, during times when REC premiums are high, supply naturally flows to other states.

[173] The caps were set at 90% of ACP in all states but Connecticut and New Hampshire, set at 97% of ACP.

[174] ACPs in Connecticut are fixed in nominal terms; Class I and II ACPs in New Hampshire escalate at only half of CPI, and thus also decrease in real terms.

As described above, Maine is an outlier with regard to Class 1 market prices, owing to its eligibility criteria significantly less constraining than those of other states. Compliance with Maine's Class 1 requirement is predominantly achieved using new or refurbished biomass resources that are ineligible in other states. As a result, the market there is somewhat oversupplied, with prices currently in the range of $5 per MWh. Prices rise somewhat before falling to the assumed floor in 2023.[175]

Detailed projections of REC prices by state for Class I renewables are presented in Appendix F.

5.6.5 Calculating Avoided RPS Compliance Cost per MWh Reduction

The RPS compliance costs that retail customers avoid through reductions in their energy usage is equal to the price of renewable energy in excess of market prices (e.g., the REC price) multiplied by the portion of retail load that a supplier must meet from renewable energy under the RPS. In other words,

Avoided RPS cost = REC price × RPS requirement as a percentage of load

We calculate the RPS compliance costs that retail customers in each state avoid through reductions in their energy usage in each year for each major applicable RPS tier as follows:

$$\frac{\sum_n P_n \times R_n}{1 - L}$$

Where:

n = the RPS class

P_n = projected price of RECs for RPS class n

R_n = RPS requirement, expressed as a percentage of energy load, for RPS class n, from Appendix F

L = the load-weighted average loss rate from ISO wholesale load accounts to retail meters

For example, in a year in which REC prices are $30/MWh and the RPS percentage target is 10 percent, the avoided RPS cost to a retail customer would be $30 × 10% = $3/MWh. Detailed results from Appendix C are incorporated into the Appendix B Avoided Cost Worksheets by costing period.

For the purposes of calculating the avoided RPS cost associated with the MA Class 1 requirement, of which the MA Solar Carve-Out is a subset, we project the incremental capacity of SCO resources installed in each year and the energy generated during the first ten years after installation, and divide

[175] A scenario in which Maine Class 1 prices fall even sooner is possible should Governor Paul LePage's proposal to lift the 100 MW cap on hydro resources be adopted. The Governor has pushed for this policy change four years in a row, but it has failed amid bipartisan opposition.

the cumulative energy generated by the RPS-eligible load to yield a load percentage for each year that is subtracted from the MA Class 1 requirement. The carve-out percentage increases to a maximum of 3.6% in 2020, and decreases to 0.1% by 2030.

The year-by-year RPS percentages for each RPS class are shown in Appendix F. The levelized RPS price impact for the 2016 to 2030 period, in 2015$ per MWh of load, is shown below.

Exhibit 5-44. Avoided RPS Cost by Class, Levelized Price Impact 2016 - 2030

	CT	ME	MA	NH	RI	VT
Class 1	$7.13	$0.41	$6.72	$4.90	$5.17	$0.00
All Other Classes	$1.08	$0.10	$2.09	$3.77	$0.02	$0.00
Total	$8.22	$0.51	$8.81	$8.67	$5.18	$0.00

The exhibit shows (with the exception of Maine) levelized avoided costs of 1.4 - 1.9 times those of AESC 2013, with the increase attributable primarily to higher REC premiums, and to a lesser extent, RPS requirements that increase with time.[176]

5.7 Assessment of Alternative Electric Energy Costing Periods

The Study Group asked the AESC 2015 project team to recommend alternative costing periods if an analysis of avoided cost results indicates that the alternative costing periods may more accurately and reasonably reflect seasonal and hourly variation of marginal energy costs than the existing on-peak and off-peak costing periods. In essence the goal is to determine whether more granular costing periods, referred to as "super on-peak" periods, may provide a more accurate value of reductions which occur primarily during that time period. This section describes our analyses and recommendations regarding super on-peak periods.

5.7.1 Analysis of alternative costing periods

AESC 2015 analyzed electric energy prices by hour in summer on-peak periods and in winter on-peak periods in four steps.

First it identified the months within each season during which on-peak period energy prices by hour were consistently the highest. That analysis indicated that on-peak period energy prices by hour in June,

[176] AESC 2013 calculated 15-year levelized costs for 2014-2028, while the period 2016-2030 is used here. This has the effect of dropping the two years with the lowest RPS requirements (2014-2015) while adding two years with the highest (2028-2030).

July and August were consistently higher than September. Using a similar approach we identified three winter months for further assessment - December, January and February.

Second, it analyzed five data sets of hourly prices for the WCMA zone for each of those months, three sets of historical energy prices and two sets of projected energy prices. The historical data sets are from 2012, 2013 and 2014, the projected prices are from the Base Case for June 2019 through May 2020 and for June 2025 to May 2026. For each dataset we computed average prices for each on-peak hour in each of the three summer months and each of the three winter months. For example, for June 2012 we computed average hourly prices for each of the 16 on-peak hours, i.e. hours beginning at 07:00 and ending at 23:00.

Third, it analyzed energy prices by hour in blocks of four consecutive hours for several different possible blocks in order to identify candidate super on-peak periods by season. For winter months we analyzed the following 4 hour blocks: between hours beginning at 14:00 and ending at 18:00, 15:00 -19:00, 16:00 -20:00 and 17:00 -21:00. For summer months we analyzed the following 4 hour blocks: between hours beginning at 11:00 and ending at 15:00, 12:00 -16:0, 13:00 -17:00 and 14:00 -18:00.

Fourth, it ranked each different 4 hour block within each season according to the block's average price of energy by hour during each season. The block with the highest average price was ranked 1 and the block with the lowest average price was ranked 4. Exhibit 5-45 presents the ranking results.

Exhibit 5-45. Ranking of candidate super on-peak Periods for avoided energy costs

Winter Blocks	**2012**	**2013**	**2014**	**2019/20**	**2025/26**	**Total of Ranks**
14:00-18:00	4	3	4	4	3	18
15:00-19:00	3	2	3	3	2	13
16:00-20:00	**1**	**1**	**2**	**2**	**1**	**7**
17:00-21:00	2	4	1	1	4	12
Summer Blocks	**2012**	**2013**	**2014**	**2019/20**	**2025/26**	**Total of Ranks**
11:00-15:00	4	3	4	4	4	19
12:00-16:00	3	1	3	2	1	10
13:00-17:00	**1**	**2**	**1**	**1**	**2**	**7**
14:00-18:00	2	4	2	3	3	14

The summer block with the highest ranking begins at hour 13:00 and ends at 17:00. This block coincides with the summer Demand Resource Forecast Peak Hours defined by ISO-NE.[177] The winter block with the highest ranking begins at 16:00 and ends at 20:00 in the winter. This block encompasses the winter Demand Resource Forecast Peak Hours defined by ISO-NE as the two-hour block beginning at 17:00 and ending at 19:00 on non-holiday weekdays during the months of December and January.

[177] ISO-NE Tariff, Section I – General Terms and Conditions, Definition of Demand Resource Forecast Peak Hours.

Exhibit 5-46 presents the key statistics on the duration and prices during super-peak hours relative to the average on-peak period price for that season for each of the five datasets.

Exhibit 5-46. Ratio of average price in top ranked candidate super-peak to average price for season on-peak

	2012	2013	2014	2019/20	2025/26	Average
Winter						
HOURS						
Peak (Oct – May, 1)	2800	2800	2784	2784	2768	2787
Super-Peak (Dec – Feb, 16 thru 20)	256	260	264	260	260	260
Non-super Peak	2544	2540	2520	2524	2508	2527
Prices ($/MWh)						
Peak	$40.77	$71.25	$93.20	$52.81	$65.67	$64.74
Super-Peak	$51.14	$129.72	$165.97	$74.10	$91.02	$102.39
Non-super Peak	$39.73	$65.27	$85.58	$50.62	$63.04	$60.85
Price Ratios						
Super-Peak/Peak	1.25	1.82	1.78	1.40	1.39	1.58
Non super Peak / Peak	0.97	0.92	0.92	0.96	0.96	0.94
Summer						
HOURS						
Peak (June – Sept))	1376	1376	1392	1376	1392	1382
Super-Peak (June – August; 13:00 thru 17:00)	264	260	260	260	260	261
Non-super Peak	1112	1116	1132	1116	1132	1122
Prices ($/MWh)						
Peak	47.23	48.97	42.89	47.60	62.74	$49.89
Super-Peak	64.65	59.79	50.57	55.60	79.84	$62.09
Non-super Peak	43.09	46.45	41.13	45.74	58.81	$47.04
Price Ratios						
Super-Peak/Peak	1.37	1.22	1.18	1.17	1.27	1.24
Non super Peak/Peak	0.91	0.95	0.96	0.96	0.94	0.94

Notes

1. Peak period is weekday hours, 7 am to 11 pm.

Based on the results of this analysis, AESC 2015 recommends the following super on-peak periods for avoided electric energy costs. For summer months of June through August, weekdays only (excluding holidays defined by ISO-NE), four hour interval from hour beginning at 13:00 to hour ending at 17:00, EDT. For winter months of January, February and December, weekdays only (excluding holidays defined by ISO-NE), four hour interval from hour beginning at 16:00 to hour ending at 20:00, EST.

Chapter 6: Sensitivity Cases

AESC 2015 prepared two sensitivity analyses, a lower load case and a higher gas price case, to provide information on how major changes to key assumptions used in the Base Case may affect electric avoided costs. The two sensitivity cases are a BAU Case, which is the lower load case, and a High Gas Price Case.

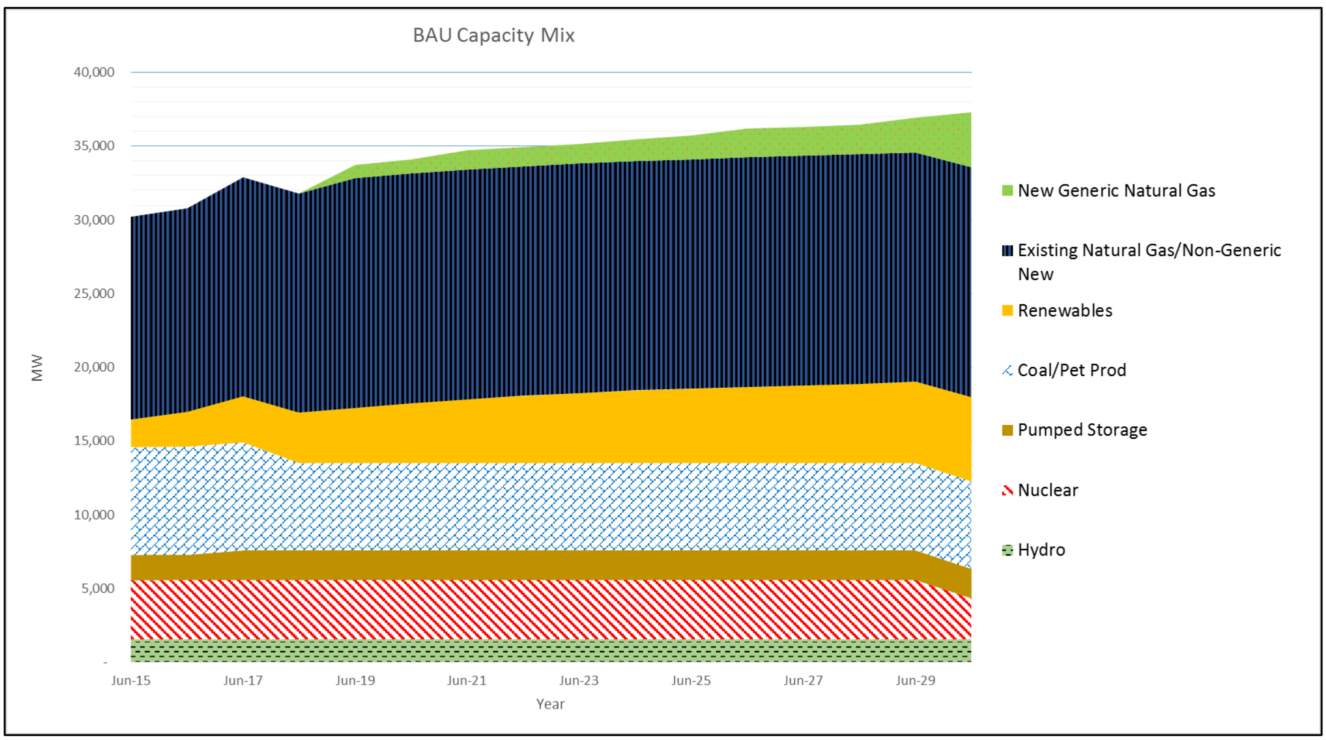
6.1 BAU Case

The BAU Case, also referred to as the market price sensitivity Case, represents a future under which ratepayer energy efficiency continues to be approved at the levels projected by ISO NE. The projected prices are a forecast of market prices under this future.

6.1.1 Forecast of Capacity and Capacity Prices

The projected level and mix of capacity in the BAU Case is presented in Exhibit 6-1. New capacity additions include renewable resources to comply with RPS requirements, as well as new natural gas generators added to meet energy and reserve margin requirements. A substantial portion of the existing oil (Pet Prod) and coal capacity is forecast to retire by 2025. Because of the relatively high price of oil compared to other fuels, these generating plants are rarely dispatched.

Exhibit 6-1. BAU Case Capacity by Technology vs. Peak Demand (MW)



6.1.2 Forecast of Energy and Energy Prices

Exhibit 6-2 illustrates the projected level and mix of generation in the BAU Case.

Generation from nuclear remains flat until year 2029 and declines in 2030 assuming retirement of Seabrook in March of that year, and coal generation declines substantially as most units are retired. Generation from natural gas is the dominant resource, and renewable generation increases over time in compliance with RPS requirements. However, given the absence of the load growth during the planning horizon under the BAU/ Case the projected growth of renewable generation is relatively mild. Generation mix shown does not add up to the total energy demand because it does not account for the interchange with neighboring systems and for net pumping of energy by pumped storage generators.

Exhibit 6-2. BAU Case Generation by Fuel (MWh)

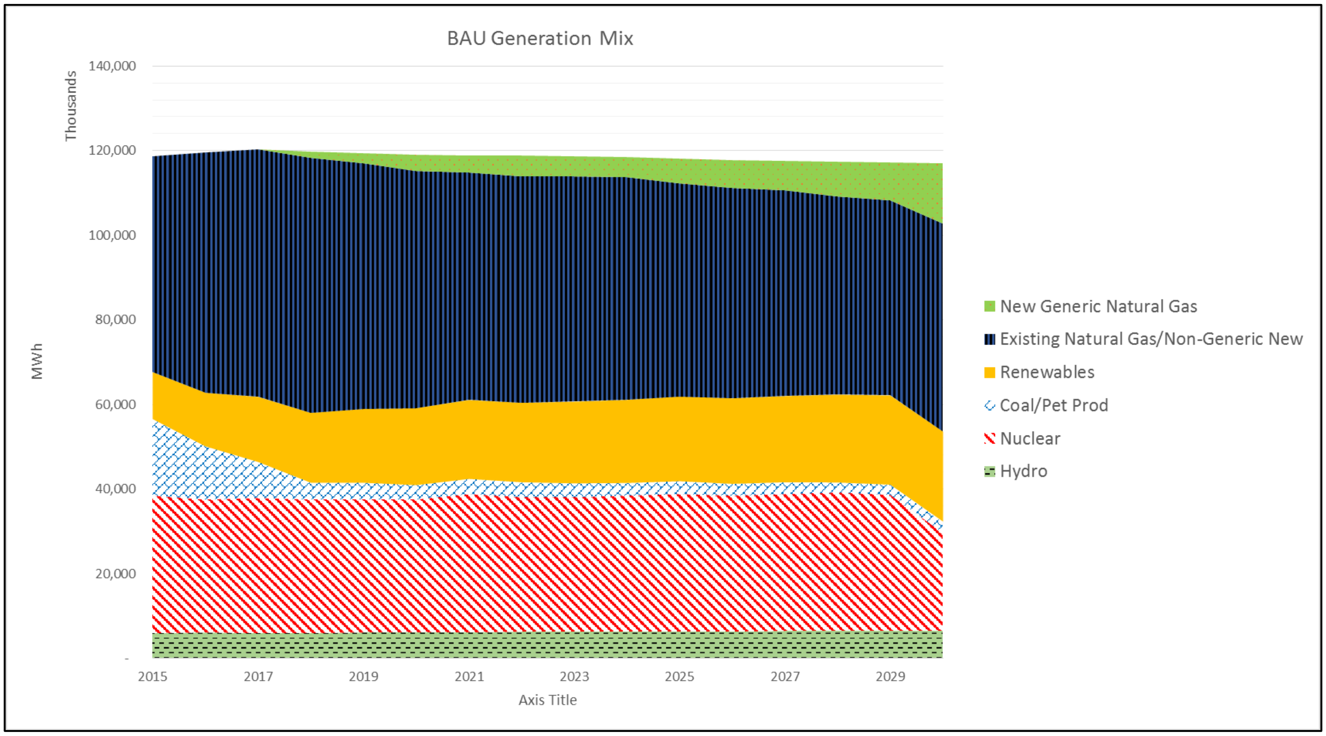


Exhibit 6-3 provides annual summaries by year, season and Peak vs. Off-Peak time periods.

Exhibit 6-3. Wholesale Energy Price Forecast for Central Massachusetts (2015$/MWh)

	Summer			Winter		
Year	Off-Peak	OnPeak	AllHours	Off-Peak	OnPeak	AllHours
2015	$30.50	$39.46	$34.84	$64.88	$73.24	$68.85
2016	$30.93	$47.01	$38.54	$61.75	$66.61	$64.05
2017	$36.63	$48.58	$42.29	$59.06	$63.74	$61.28
2018	$39.86	$48.03	$44.19	$49.04	$53.70	$51.35
2019	$38.85	$50.00	$44.16	$48.74	$53.29	$51.26
2020	$36.96	$46.27	$41.43	$47.72	$53.13	$50.29
2021	$40.25	$48.69	$44.29	$50.22	$54.13	$52.06
2022	$43.00	$58.05	$50.21	$52.15	$57.21	$54.54
2023	$45.13	$56.94	$50.76	$53.77	$58.72	$56.11
2024	$47.22	$58.45	$52.54	$56.02	$61.89	$58.85
2025	$49.27	$63.20	$55.86	$59.09	$65.95	$62.39
2026	$51.14	$63.23	$56.93	$60.30	$67.21	$63.58
2027	$53.54	$69.23	$61.02	$62.78	$68.17	$65.35
2028	$55.81	$68.11	$61.69	$64.48	$69.87	$67.04
2029	$58.36	$71.54	$64.61	$67.50	$74.82	$71.01
2030	$61.77	$82.38	$71.66	$70.22	$77.51	$73.73

6.1.3 Benchmarking of Energy Model

The scope of work requested the following analyses of the AESC 2015 wholesale electric energy price forecast:

- Comparisons with other trends and forecasts, including comparisons to a trend of actual monthly prices from ISO-NE and a forecast as represented by the NYMEX futures market and the most recent relevant EIA forecast;
- A high-level discussion of reasons for differences identified in the comparisons; and
- Explanation of any apparent price spikes and key variables that affect the outcome, as well as identification of potential cases worthy of investigation.

6.1.4 ISO NE 2013 Actuals

TCR benchmarked the ability of its model to simulate the actual operation of the energy market by doing a “back cast” simulation of the ISO New England system for 2013. In that simulation, TCR used pCa to project hourly energy prices in 2013 using as inputs actual hourly loads by zone, actual interchange schedules between ISO-NE and neighboring systems, actual daily natural gas prices and estimated daily distillate and residual fuel oil prices derived from actual daily crude oil prices and TCR regression models. TCR compared its simulated prices to actual 2013 Day-ahead LMPs. The comparison of simulated prices by SMD Zone is presented in Exhibit 6-4. The solid bars in that Exhibit represent actual prices and the patterned bars represent simulated prices. As shown in that Exhibit, pCA model accurately captures the magnitudes and the locations spread of LMPs in New England over that historical time period.

Exhibit 6-4. Comparison of Actual and Simulated Locational Marginal Prices in ISO New England by SMD Zone (2015$/MWh)

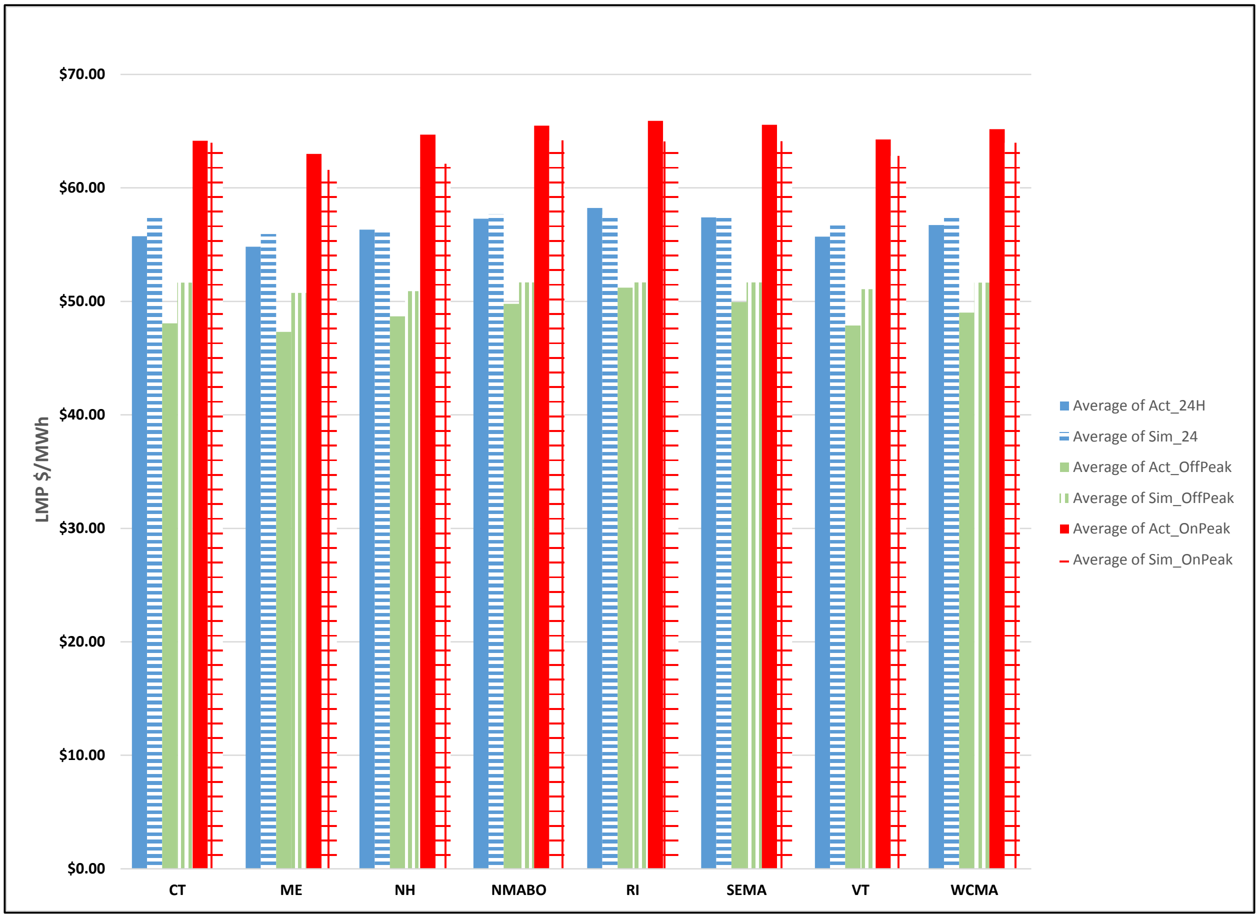
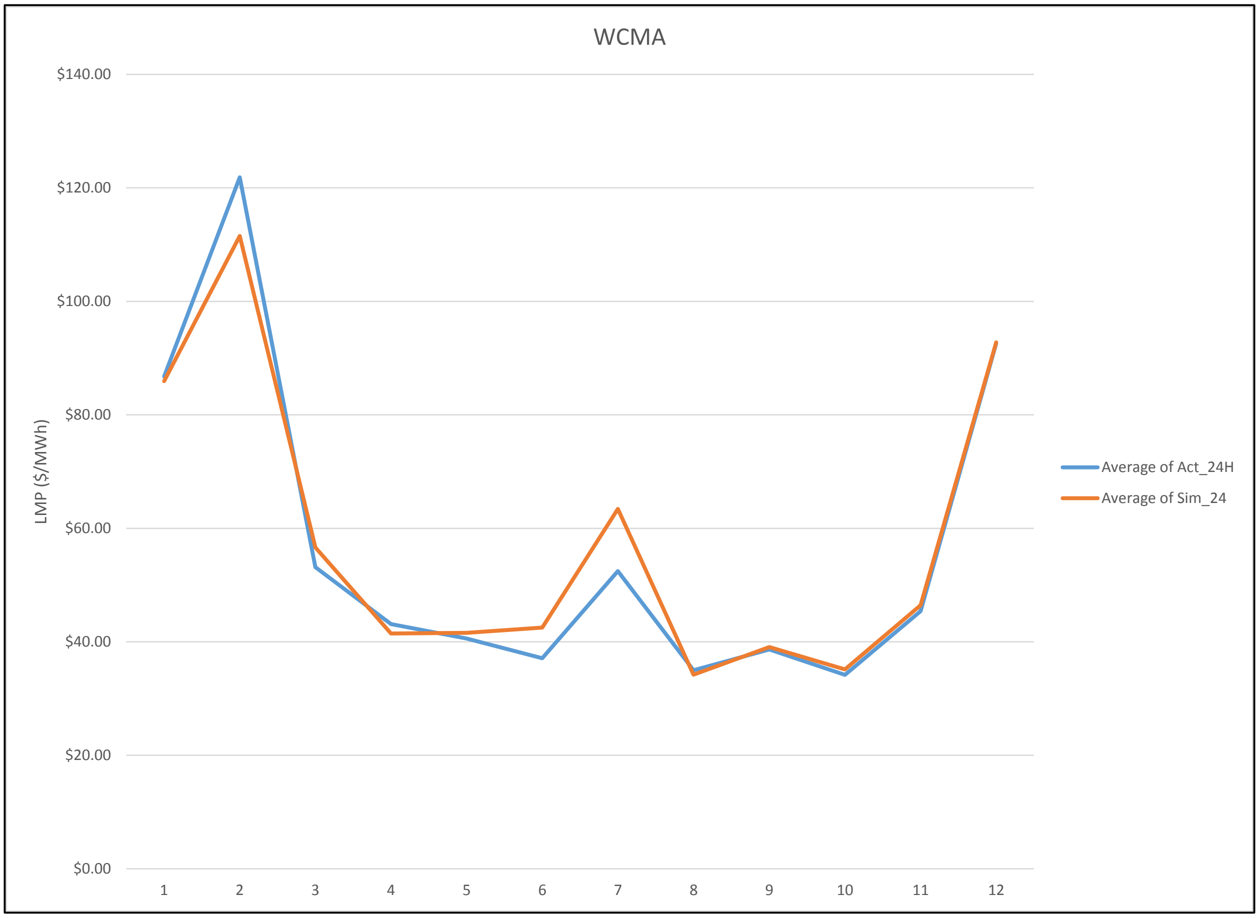


Exhibit 6-5 compares simulated and actual monthly prices for the WCMA Zone.

Exhibit 6-5. Comparison of Actual and Simulated Locational Marginal Prices in ISO New England, Monthly for WCMA Zone, 2015$/MWh



As shown in this Exhibit, the pCA simulation replicated actual price patterns in 9 out of 12 months. This benchmarking validates the pCA commitment and dispatch algorithms and the quality of the heat rate data provided by pCA vendor – Newton Energy Group. The simulations results somewhat under-estimated actual prices in February and over-estimated actual prices in June and July. This could be related to the difference between assumed and actual generator and transmission forced outages and maintenance schedules and well as other factors, such as operator discretion, which are difficult to fully represent in the model.

New England Hub Futures

TCR also benchmarked BAU/ simulation results for years 2015-2017 against futures prices for the New England Internal Hub as cleared on NYMEX on December 18, 2014. This clearing date coincides with the clearing date for natural gas and oil prices used in the development of fuel price inputs. The comparison of futures and projected On-Peak and Off-Peak prices is presented graphically in

Exhibit 6-6 and Exhibit 6-7 respectively. As these exhibits indicate, pCA projections well correspond to NYMEX futures both for on-peak and off-peak products.

Exhibit 6-6. On-Peak LMPs: Projection vs. Futures, 2015$/MWh

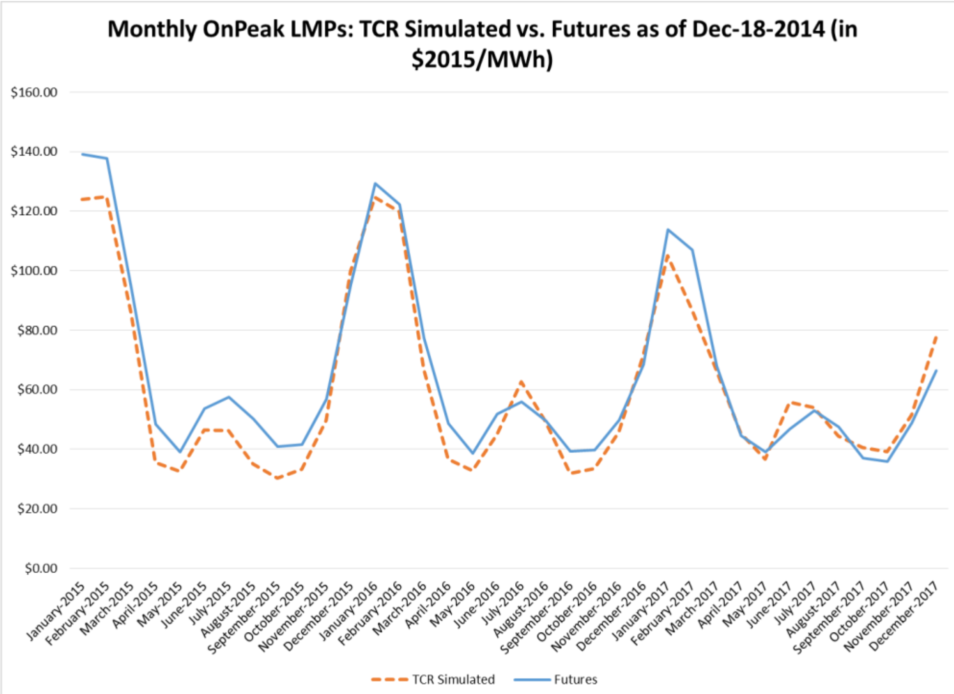
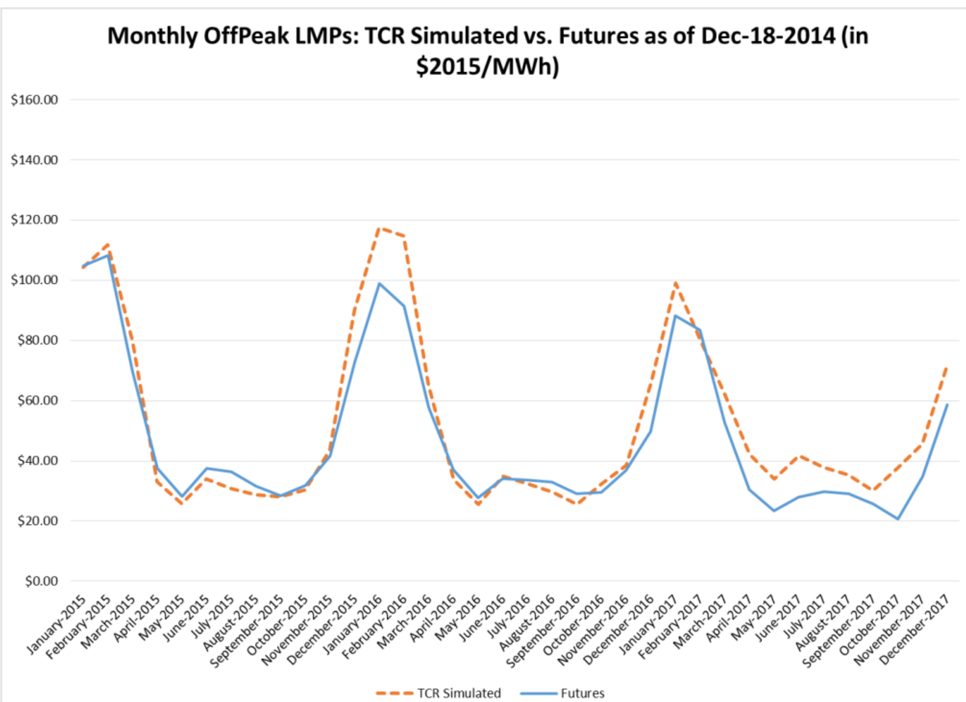


Exhibit 6-7. Off-Peak LMPs, Projections vs. Futures, 2015$/MWh



In sum, these benchmarking results demonstrate that the pCA modeling environment and supporting datasets provide a reliable tool for developing electric energy price projections.

Comparison to the Base Case

On a 15 year levelized basis, the Base Case avoided costs for Central Massachusetts are within 1 % of the BAU avoided costs, as shown in Exhibit 6-20. The levelized Base Case avoided costs are slightly lower than BAU avoided costs. The differences vary by seasons and time periods, ranging between 0.17% (summer off-peak) and negative 0.8% (winter peak).

Exhibit 6-8. 15-Year Levelized Cost Comparison for Central Massachusetts, Base Case v. BAU Case (2015$/MWh)

	Winter Peak Energy	Winter Off-Peak Energy	Summer Peak Energy	Summer Off-Peak Energy	Annual All-Hours Energy
BAU Case	$62.59	$57.06	$57.89	$44.96	$56.87
Base Case	$62.10	$56.82	$57.68	$45.04	$56.58
% Difference	-0.8%	-0.4%	-0.4%	0.17%	-0.5%

A year-to year comparison of Base Case and BAU avoided costs for the summer and winter season is presented in Exhibit 6-9 and Exhibit 6-10, respectively. Avoided costs are identical in the first three years (2015-2017) since the load forecasts are identical during that period. Beyond 2017 the differences between the Base Case and BAU Case do not exhibit a consistent trend. As this comparison shows, the year-to-year deviations are small, especially during off-peak hours. Summer off-peak deviations are between -2% and +2%, winter – between -2% and +2%. On-peak fluctuations are bigger in magnitude, ranging between -9% and +7% in summer and between -3% and +3% in winter.

Exhibit 6-9. Base Case as a Percent Difference from the BAU Case, Summer Season Comparison

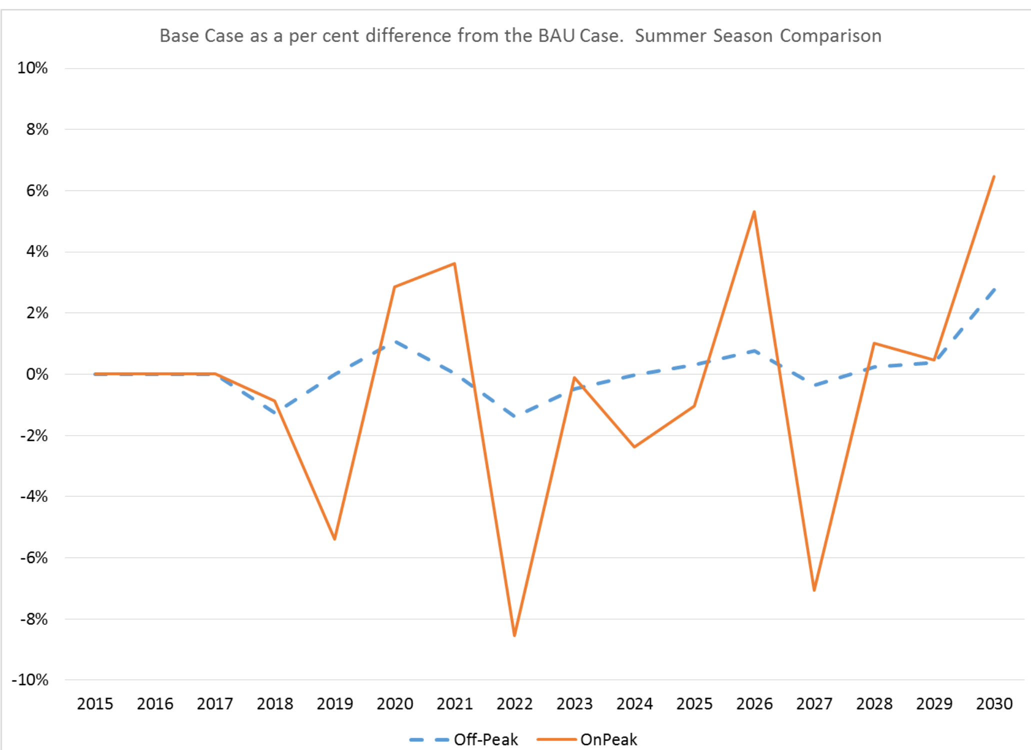
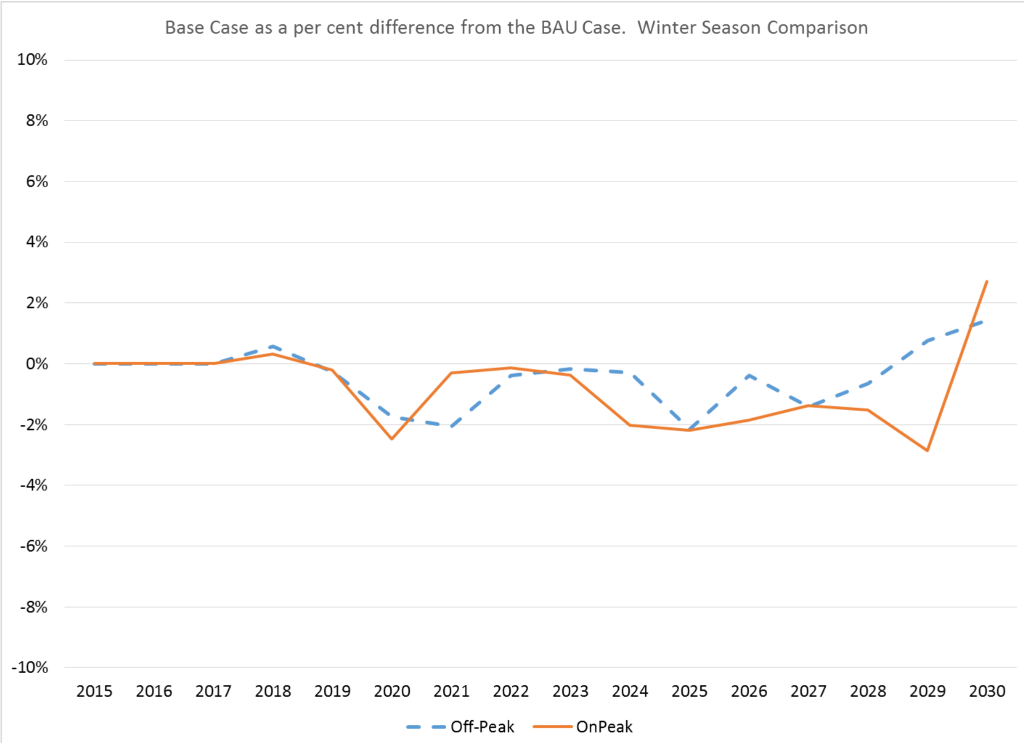


Exhibit 6-10. Base Case as a Percent Difference from the BAU Case, Winter Season Comparison



6.2 Explanation of BAU Case Results Relative to Base Case

In the long-term, from 2015 through 2029, AESC 2015 has not identified any material, statistically significant, difference in energy or capacity prices between the Base Case and the BAU case. We conclude that there is no long-term price suppression or DRIPE impact under the current outlook for the power system in New England.

The results of our two sets of simulations, and our conclusion, is explained by the following three major factors which are driving the DRIPE effect in the New England electric market over the study period:

- Close coordination between investments in energy efficiency and investments in capacity additions,
- Marginal sources of capacity with very similar cost characteristics, and
- A market which is in equilibrium.

The magnitude of the DRIPE effect of energy efficiency investments in a particular electric market over a given study period is dependent on three major conditions or factors in that particular market. The three factors are coordination between investments in energy efficiency and investments in capacity additions, cost characteristics of capacity additions, and whether the market is in surplus or in equilibrium.

Coordination of Energy Efficiency and Capacity Investments

In New England, investments in energy efficiency are well-coordinated with investments in new capacity additions and with decisions to retire existing capacity. The forward capacity auction (FCA) enables decisions to retire existing generating capacity and to add new generating capacity to be well coordinated with investments in energy efficiency. The FCA simultaneously clears energy efficiency investments, in the form of Passive Demand Resources (PDR) and investments in new generation capacity. As a result, investments in energy efficiency can have a virtually instantaneous impact on investments in new capacity additions.

Cost Characteristics of Capacity Additions

In New England, the marginal sources of new capacity are gas-fired combined cycle (CC) units and gas-fired combustion turbine (CT) units. All new gas CCs have very similar cost characteristics and all new gas CTs have very similar cost characteristics.

Market in Surplus or Equilibrium

Prior to 2013, the New England market was generally forecast to be in surplus; now it is forecast to be in equilibrium. DRIPE effects fall along a continuum: DRIPE is most likely to be material in an electric market in surplus and least likely to be material in an electric market in equilibrium.

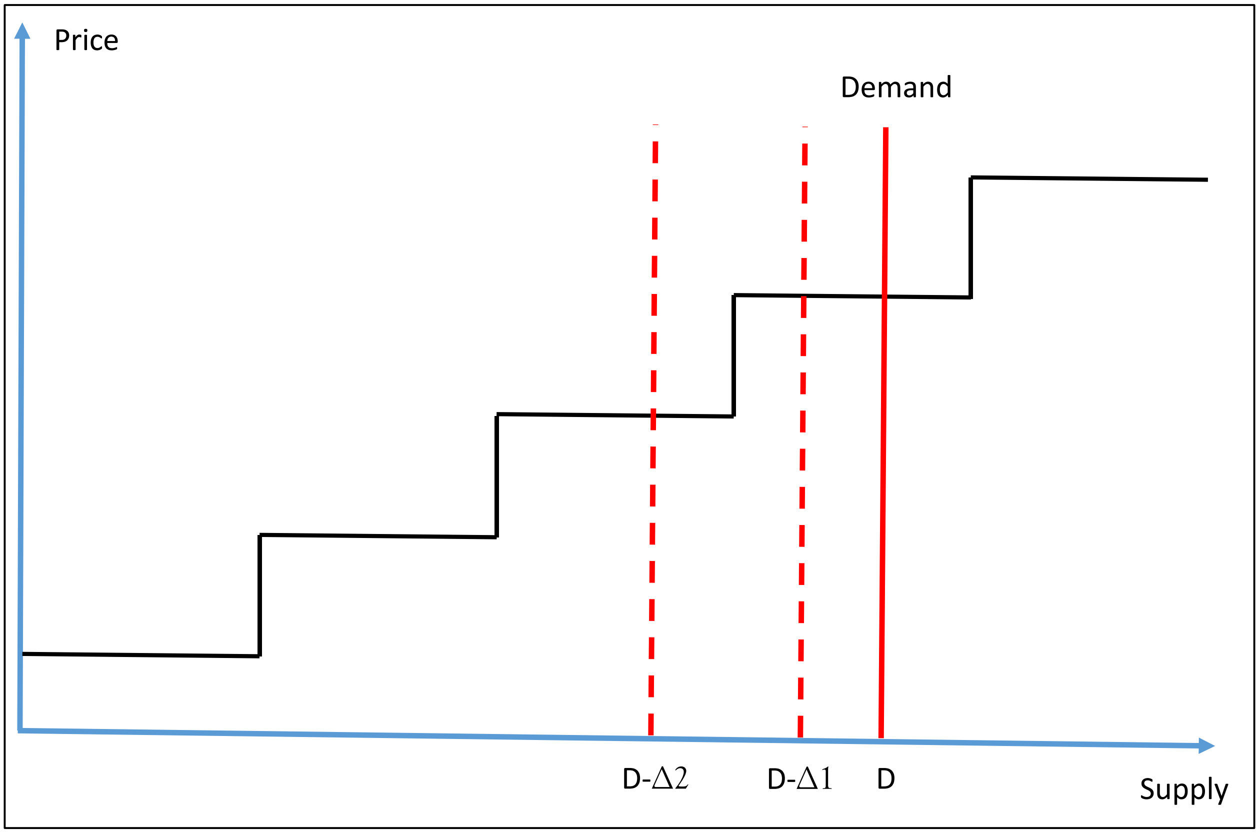
- In a power system which is in surplus, i.e., its existing generating capacity exceeds reserve requirements, investments in energy efficiency increase the level of surplus and delay the timing of new generating capacity additions. These incremental investments in energy efficiency tend to affect both capacity and energy markets. Energy efficiency reduces capacity prices through the delay of new additions; it reduces energy prices by reducing the need to use more expensive generation resources, which will be dispatched less frequently when demand is reduced

- In a power system which is in equilibrium, i.e., in which just enough new capacity is being added to meet reserve requirements, incremental investments in energy efficiency reduce the quantity of new capacity additions through FCA, and similarly reductions in energy efficiency investments increase the quantity of capacity additions through the FCA. As a result, increments or decrements in energy efficiency investments are unlikely to materially reduce prices in either the capacity or energy markets under equilibrium conditions. Capacity prices are not affected because capacity prices are set by new capacity additions, all of which have similar cost characteristics. Energy prices are not affected because the supply curve remains virtually the same relative to load—when demand increases (decreases), the supply curve expands (shrinks). The shape of the supply curve, however, remains virtually the same—which results in almost no impact on the marginal costs of serving the load.

6.2.1 Magnitude and Shape of Demand Reduction

As Exhibit 6-11 illustrates, very small levels of load reduction may not impact electricity prices. Their impact depends on the shape of the supply curve in the vicinity of the change in demand. As the exhibit shows, supply curves in the electric system are typically shaped as step functions with significant blocks of capacity offered to the market at the same price. As a result, a small reduction in electricity demand (Δ1 in the exhibit) causes no reduction in the price of electricity. To create a discernible price impact, the demand reduction must be sufficiently large (Δ2 in the exhibit). Furthermore, because supply curves are essentially non-linear, demand reductions of different magnitudes will result in different magnitudes of price reduction not only in absolute but also in relative terms. The relative price impact per MW of demand reduction associated with a 100 MW reduction will be different from the relative per MW price suppression associated with a 500 MW reduction.

Exhibit 6-11. DRIPE is Function of the Size and Shape of Load Reduction



The magnitude of the price impact of a load reduction during a specific time period also depends on the shape of that load reduction. The shape of the load reduction not only affects the price resulting from a shift along the supply curve, it can also affect the shape of the supply curve itself due to the unit commitment process, discussed in Section 5. 1. Because of the unit commitment process the supply, demand, price relationship in the New England energy market is much more complex than shown in Exhibit 6-11. A given day with a high load may have a supply curve that is different from the supply curve that would be used if the load on that day was much lower.

BAU Case vs Base Case

Exhibit 6-12 reports the difference in system-wide peak demand between the Base Case and the BAU Case. That difference ranges from 239 MW in 2018/19 to 2,531 MW in 2029/30.

Exhibit 6-12. Difference in System Peak Demand between Base Case and BAU Case

Period	Difference
2018/19	239
2019/20	464
2020/21	675
2021/22	873
2022/23	1,059
2023/24	1,233
2024/25	1,441
2025/26	1,653
2026/27	1,867
2027/28	2,085
2028/29	2,306
2029/30	2,531

Despite this large difference in projected demand, the projections of energy prices and capacity prices in the BAU Case are very close to those in the Base Case. On a 15-year levelized basis energy prices under the Base Case are 0.7% **lower** than under the BAU Case. Capacity prices under the Base Case are 0.09% lower than under the BAU Case. Thus there is virtually no direct relationship between the assumed reductions from new energy efficiency and prices.

Analysis of Energy Prices – BAU Case versus BASE Case

The lack of a material difference in prices under the two Cases can be attributed to the following factors:

- Absence of significant transmission congestion effectively combining all generating resources into a single supply stack serving the entire market
- Significant reliance of the New England on combined cycle gas fired generation technology driving prices in the majority of hours
- A market in equilibrium in which long-term increases (decreases) in demand are matched with corresponding increases (decreases) in capacity additions

Absence of significant transmission congestion creates a competitive electricity market in which geographically dispersed generating resources could compete for serving electricity demand in all states and zones almost all the time. As a result, the supply stack in New England is effectively market wide and not fractured into smaller sub-zones.

Exhibit 6-13 presents the supply stack and load duration curve for the New England system as modeled for the month of July of 2025 under the BAU Case. This exhibit shows supply (a blue curve) and demand (a red curve) measured in MW along the horizontal axis. Two vertical axes in this exhibit show short-run production costs (left axis) for the supply curve and hours (right axis). The supply curve here is a “real” supply stack already accounting for generator outages and for average availability for hydro and renewable resources. The first flat zero cost portion of the supply stack represents hydro, wind and solar generation. The second flat segment primarily corresponds to nuclear capacity, the third and the largest flat portion of the supply stack corresponds to the combined cycle technology.

A vertical line connecting the load curve with the supply curve identifies the “marginal cost” of serving that level of supply. Letters A through E positioned along the demand curve identify different segments of that curve with different generating technologies on the margin. Thus, for segment A – B, marginal technology will be hydro and nuclear, for B – C – biomass, cogeneration, refuse and other technologies that have lower costs than CCs. For C – D the marginal technology is CC and for D – E – gas –fired and oil-fired peakers. The bars along the y (hours) axis indicate number of hours the technology is considered marginal. Peakers appear marginal for approximately 70 hours out of 744 (9% of the time); CCTGs appear marginal for approximately 510 hours (69% of the time). The remaining 22% of low load hours are typically hours when baseload generators are dispatched at minimum operating conditions with some of baseload technologies being on the margin.

Exhibit 6-13. Generation Supply Stack. BAU Case, July 2025

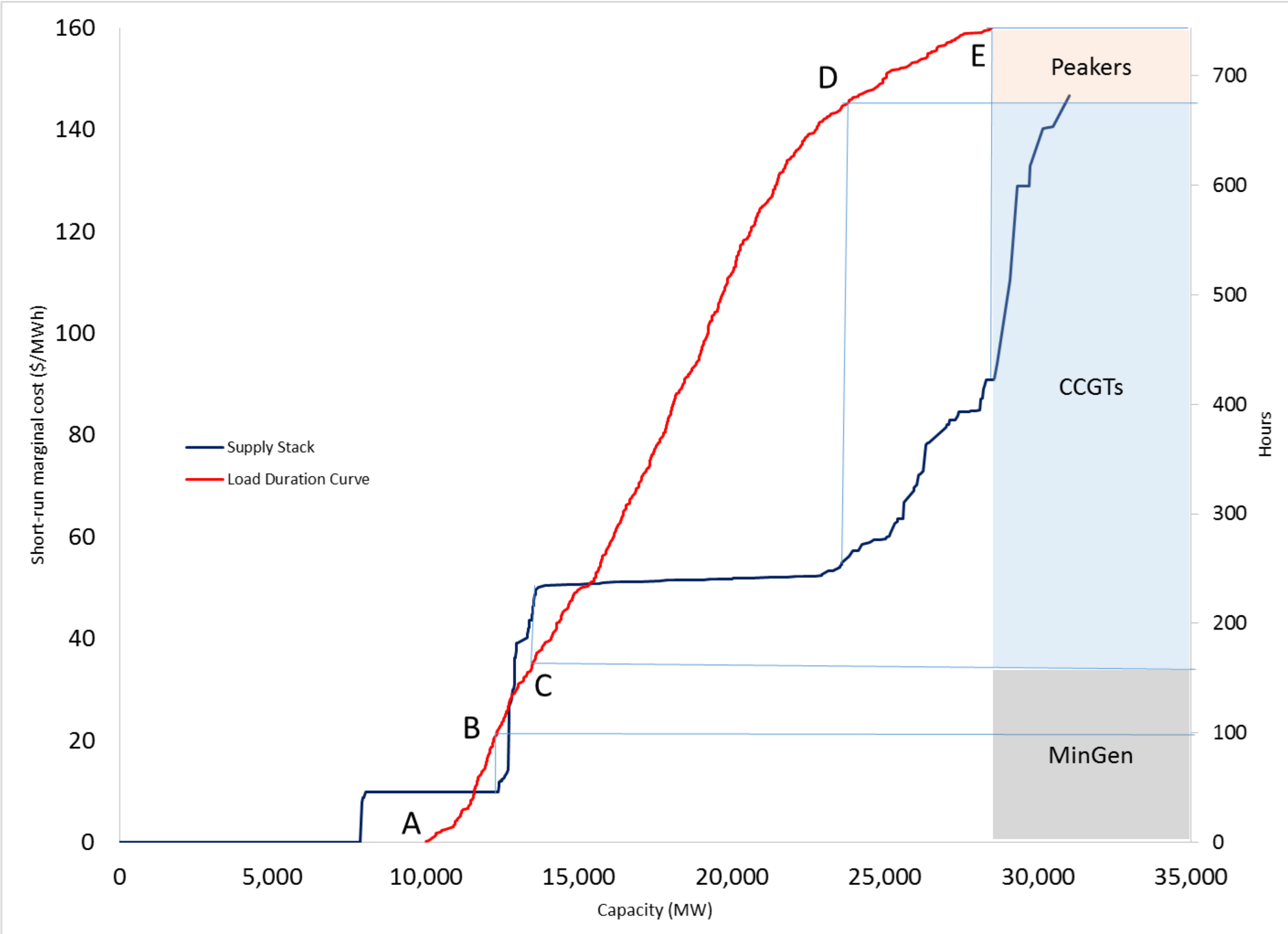
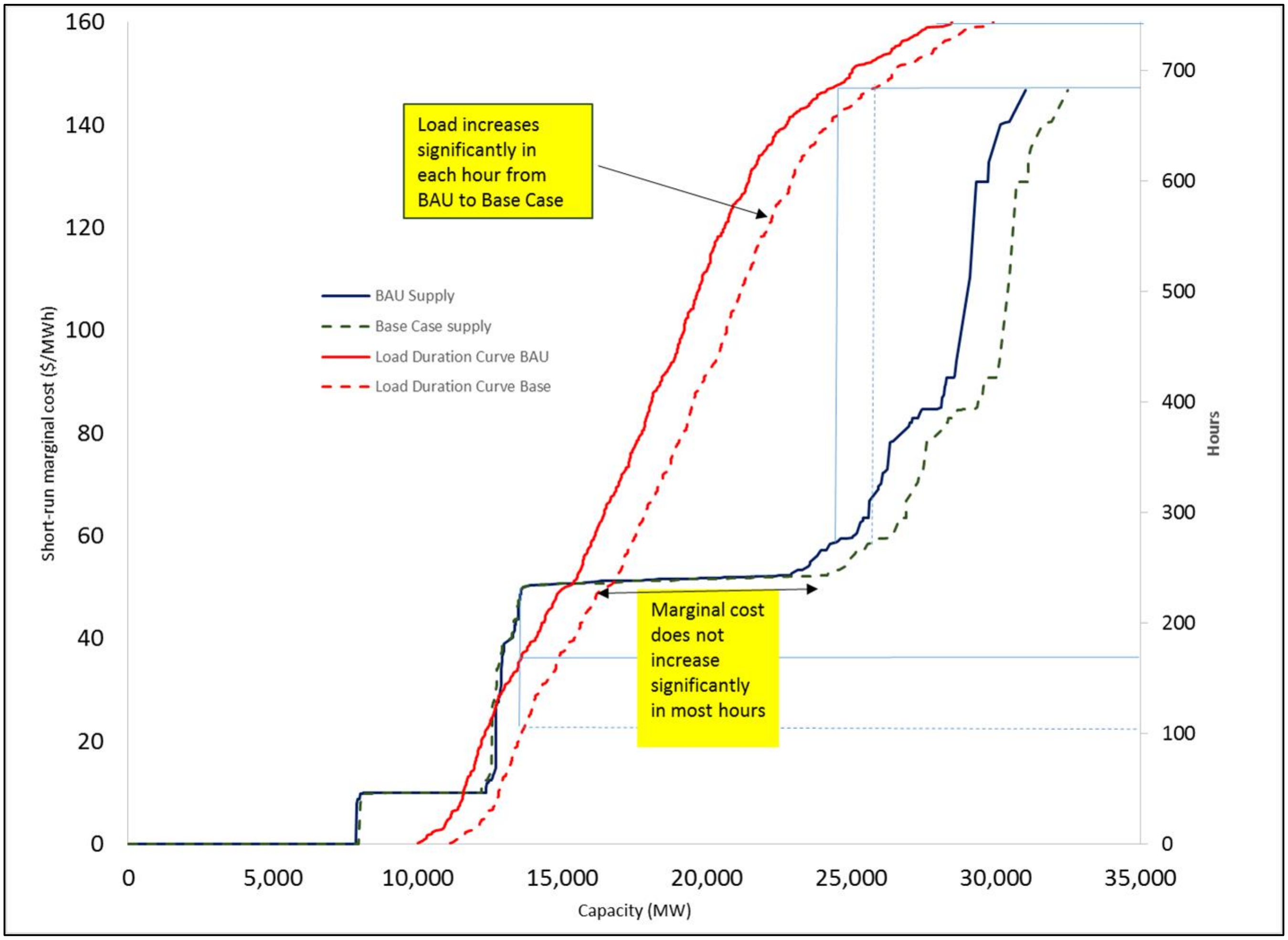


Exhibit 6-14 compares supply stacks and load duration curves under the BAU and Base Cases. Base Case characteristics are represented by dashed lines. As shown in this exhibit, the Base case supply stack is similar to the BAU Case but in a very special way. The parts of the stack that are left of the combined cycle segment are almost identical.

Under the Base Case demand curve shifts to the right, but so does the portion of the supply curve – combined cycle segment gets extended and portion to the right of the combined cycle segment shifts to the right. What is important here is that under both cases the number of hours when peaking units, typically CTs, are on the margin (segments D-E and D’-E’) is approximately the same. Under the Base Case, the number of hours when CCs are theoretically on the margin (segment C’ – D’) is bigger than under the BAU scenario. However, some of these hours are low load hours. In other words, Exhibit 1-5 demonstrates that although Base Case load exceeds the BAU load by over 1400 MW, the short-run marginal costs of serving the load in the Base Case and BAU case are essentially the same.

Exhibit 6-14. Supply Stacks BAU and Base Cases, July 2025

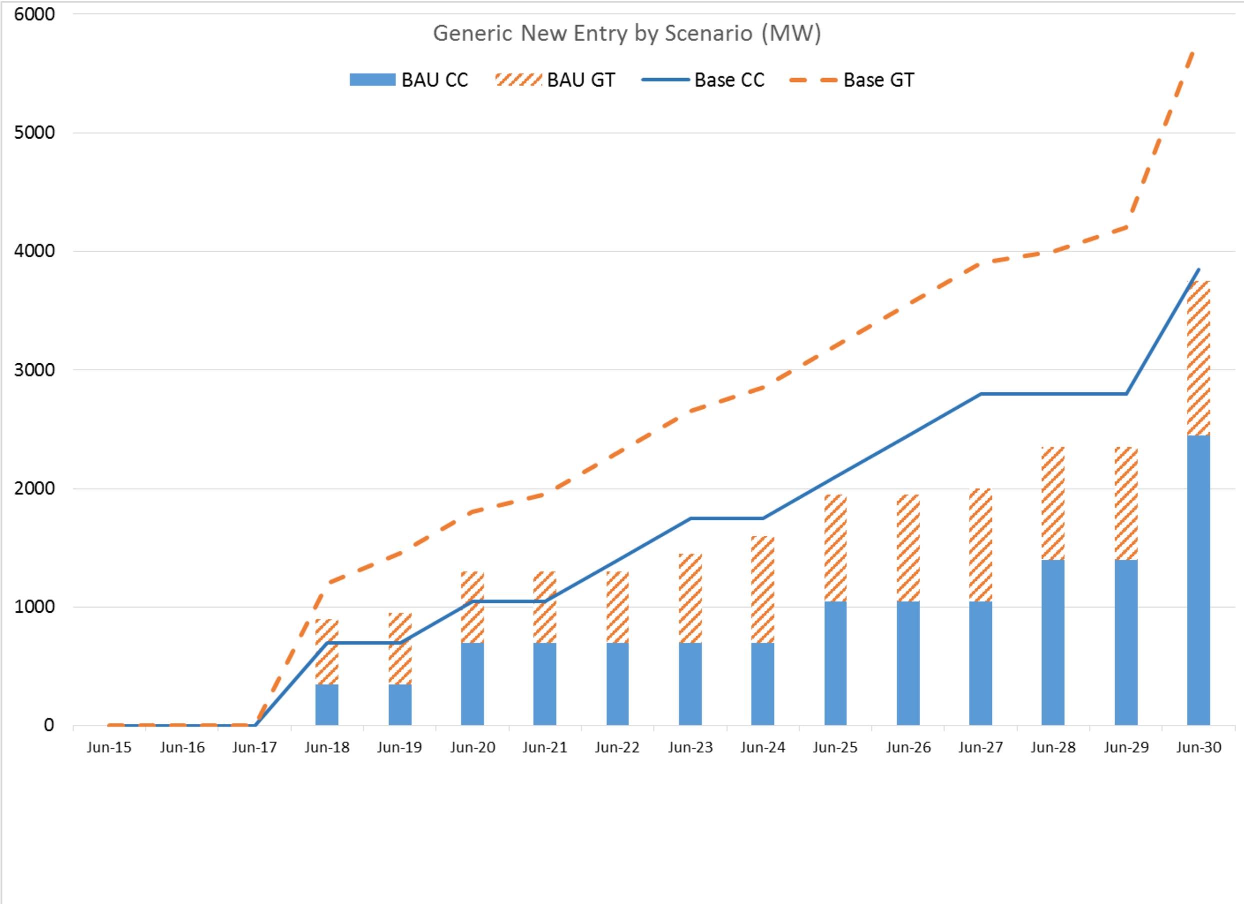


Analysis of Capacity Prices – BAU Case versus BASE Case

Starting with FCA #9 (2018/19) capacity prices in New England are driven by the cost of new entry reflecting the system need for new capacity[178]. To meet system-wide and locational installed capacity requirements, AESC 2015 added new capacity in the form of combined cycle or (CC) and simple cycle (CT) gas-fired generating units. The dynamics of generic capacity additions under both scenarios is shown in Exhibit 6-15.

[178] When TCR prepared its capacity price projections, the FCA 9 results for 2018/19 were not known. However, the avoided electricity costs in Appendix B are based on FCA9 results for 2018/19.)

Exhibit 6-15. Additions of Generic New Capacity under Base and BAU Cases



Simulated capacity prices begin with FCA#9 (2018/19). The differences between capacity prices over the 2018/19 to 2029/30 period is within a plus/minus 6% range each year. However, on average over 15 years levelized capacity prices are within 0.09%.

Exhibit 6-16. Capacity Prices – BAU Case vs. BASE Case

	ASEC 2015 BAU	AESC 2015 Base	Base Case vs BAU Case
	2015$/kW-month	2015$/kW-month	% difference
2015/16	3.38	3.38	0.00%
2016/17	3.15	3.15	0.00%
2017/18	14.19	14.19	0.00%
2018/19	13.13	12.96	-1.27%
2019/20	11.54	11.29	-2.17%
2020/21	11.45	11.33	-1.08%
2021/22	11.21	11.71	4.48%
2022/23	11.87	11.62	-2.11%
2023/24	11.87	11.37	-4.23%
2024/25	12.04	11.96	-0.69%
2025/26	11.29	11.96	5.93%
2026/27	12.04	12.04	0.00%
2027/28	12.54	11.79	-6.00%
2028/29	11.79	12.46	5.67%
2029/30	12.54	12.79	2.00%
15 yr Levelized	10.76	10.75	-0.09%

Market Equilibrium

AESC 2015 considers the New England capacity market to be in equilibrium through the operation of the Forward Capacity Auctions (FCAs). The FCAs are designed to acquire just enough new capacity for a given power year to meet the reserve requirements for that year. Those auctions give supply-side resources and demand-side resources the opportunity to bid to provide that additional capacity. As a result, in any given FCA, the greater the reduction from investments in energy efficiency that is bid in, i.e. "passive demand resources (PDR), the lower the quantity of supply side resources will be selected. Similarly, the lower the level of PDRs that is bid in, the greater the quantity of supply side resources will be selected. Under these market conditions increments or decrements in energy efficiency investments are unlikely to materially reduce prices in either the capacity or energy markets under. Capacity prices are not affected because capacity prices are set by new capacity additions, all of which have similar cost characteristics. Energy prices are not affected because the supply curve remains virtually the same relative to load. Under a Case in which demand increases, the supply curve expands correspondingly. Under a Case when the demand does not increase, the supply curve does not increase. However, the shape of the supply curve remains virtually the same under each Case. As a result, the marginal costs of serving the load is essentially the same under each Case.

It is possible that the New England capacity market might not be in equilibrium in a given year but we do not believe that circumstance would result in DRIPE values materially higher than our estimates for several reasons.

First, for the market to be in a material surplus year after year, PAs would have to not be bidding a material percent of their efficiency reductions into the FCAs causing actual demand to be materially less than ISO NE forecast year after year, such that ISO NE would continue to acquire more new capacity in each FCA than was ultimately required to be brought on year after year. It is not reasonable to assume ISO NE would fail to notice these material discrepancies. On the contrary, ISO NE is clearly aware of this possibility, as indicated by the following text from Energy Efficiency Forecast 2018 to 2023 (footnotes excluded):

Given the significant changes that have occurred in the New England EE programs over the past 10 years, some New England states believed that significant EE resources that had been developed as a result of state-sponsored EE programs did not participate in the FCM and were therefore unaccounted for by the ISO. To address this issue, in 2011, the ISO conducted a detailed survey of the region's EE program administrators concerning their participation in the FCM. The results of this analysis showed that essentially all the EE capacity the PAs developed was indeed participating in the FCM. While stakeholders indicted that other non-regulated entities may be engaged in deploying EE through performance contracts, these projects were small relative to the state-funded programs. Consequently, the projections of EE in the ISO's planning process only focus on state-sponsored EE programs.

> 2.3 Development of the Energy-Efficiency Forecast
>
> In addition to the one-to-four-year planning timeframe of the FCM, the ISO routinely plans and forecasts energy and demand looking 10 years into the future, but grid planners had assumed constant levels of EE in the long-term planning, four to 10 years out. This resulted in the planning assumption that there would be no additional growth in EE beyond the FCM. Concerned that the presumption of constant levels of future EE, beyond the FCM horizon, would not capture the anticipated growth in EE resources from year to year, stakeholders and the ISO investigated possible methods to forecast future savings in the annual and peak use of electric energy from EE programs.
>
> Beginning in 2009, the ISO and the region's energy-efficiency stakeholders conducted an intensive, multiyear research, data-collection, and analysis process resulting in a comprehensive assessment of historical spending on EE programs by PAs. The study analyzed EE programs and studied how to model incremental, future long-term EE savings for four to 10 years into the future. This deliberate and analytic effort advanced the anecdotal understanding of EE to empirical knowledge about production costs, spend rates, realization rates, and performance at the program level. The result of this effort was a fully vetted approach to accounting for future EE investment and savings and the nation's first regional (multistate) long-term forecast of energy efficiency. The current EE forecast now equips system planners and stakeholders with reliable information about the long-term impacts of state-sponsored EE programs.

Second, if actual demand in a given year was less than the forecast for that year would have little or no effect on capacity prices in that year or subsequent years. First, capacity prices are set through FCAs that are run 3 years in advance of the power year. Second, the categories of new capacity being added have the same cost and operating characteristics.

6.3 High Gas Price Case

The High Gas Price case assumes a higher Henry Hub price forecast than the AESC 2015 Base Case and less new pipeline capacity additions to serve New England over the study period than the Base Case.

- Those two assumptions result in higher avoided wholesale gas supply costs in New England than under the Base Case. For example, the 15 year levelized wholesale city-gate cost of gas under the high gas price Case is $ 7.03/MMBtu (2015$), 18% higher than under the Base Case.
- Those higher avoided wholesale gas supply costs also result in correspondingly higher avoided wholesale electric energy costs. For example the 15 year levelized avoided wholesale electric energy cost in central Massachusetts under the high gas price Case is $65.09/MWh (2015$), 17% higher than under the Base Case.
- The avoided electric capacity costs under the High Gas Price case are essentially the same as under the AESC 2015 Base Case.

The AESC 2015 high gas price Case reflects two major differences in assumptions from the Base Case, as summarized in Exhibit 6-17.

Exhibit 6-17. Major assumptions in AESC 2015 Base Case and High Gas Price Case

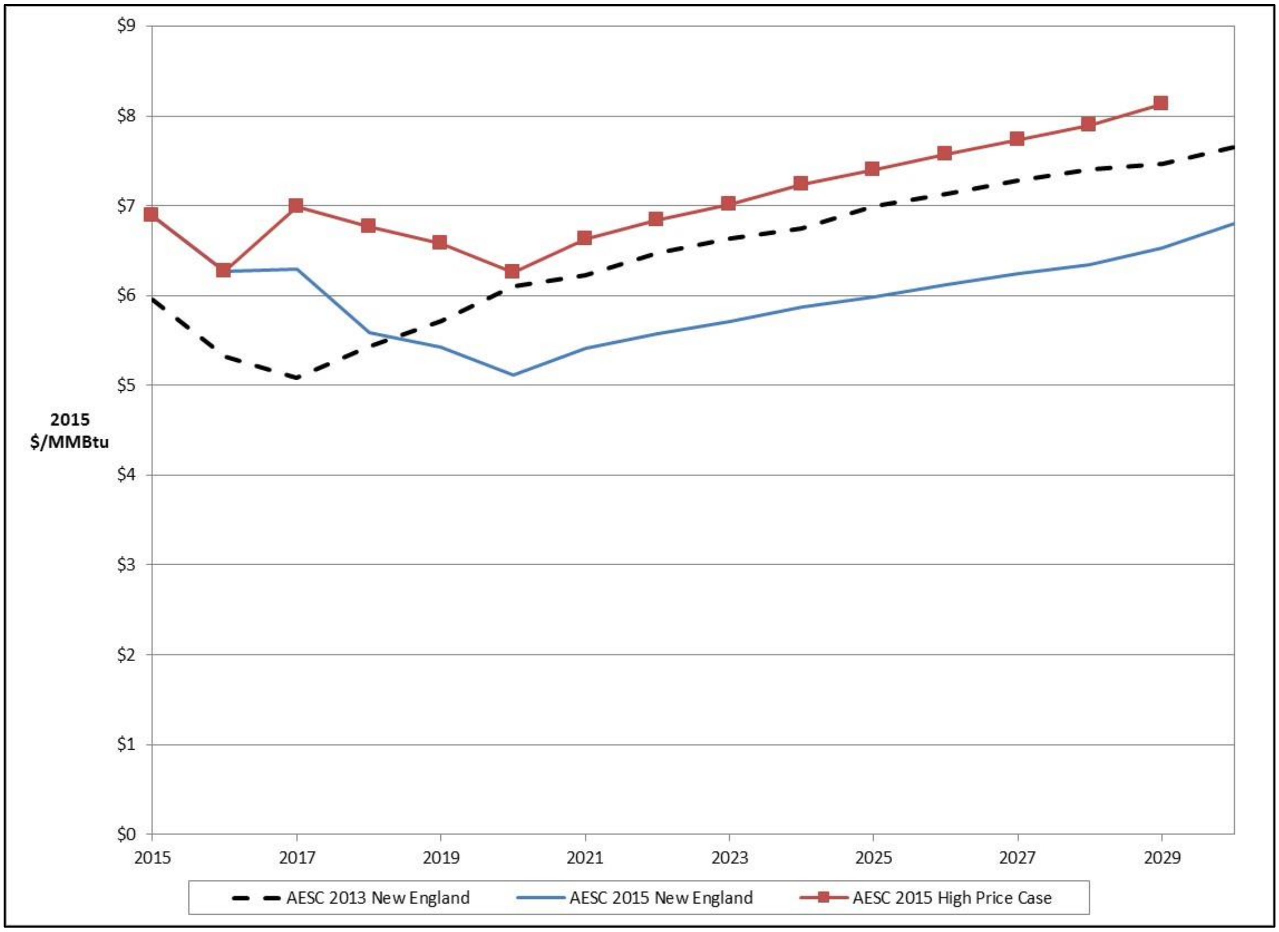
Assumption	Base Case	High Price Case
Henry Hub Prices	NYMEX Futures through 2016, AEO 2014 Reference Case from 2017 onward	NYMEX Futures through 2016, AEO 2014 Reference Case plus 15% from 2017 onward.
New pipeline capacity able to deliver gas to New England from producing areas west of New England	AIM &Tennessee CT expansions enter service 11/2017 (0.4 Bcf/day); Kinder Morgan capacity expansion enters service 11/2018 11/2018 (0.6 Bcf/day)	AIM &Tennessee Connecticut pipeline expansions enter service in 11/2017 (0.4 Bcf/day).

The High Gas Price Case reflects less aggressive shale gas development than under the Base Case and less gas pipeline capacity expansion. It assumes LDC load in New England will grow supplied by the new pipeline capacity that is added and additional supplies of LNG. Internationally, LNG prices ease as non-U.S. supplies increase and demand falls as Asia Pacific countries complete nuclear plants non-Mediterranean Europe replaces high-cost gas supplies with coal and, eventually, nuclear power and renewables.

This Case contrasts with the AESC 2015 Base Case, in which a broad array of U.S. dry gas-prone shale regions continue to develop, and Marcellus/Utica gas production rises to approx. 25 Bcf/day by 2020. All currently subscribed pipeline capacity proceeds to construction and enters service before 2020, as described in the Task 3A report. LNG market prices fall only slightly, remaining costly, thus LDC growth is limited to levels enabled by expanded gas pipeline capacity.

Exhibit 6-18 presents a year-by-year comparison of the avoided wholesale city-gate cost of gas under the High Gas Price Case and the Base Case respectively. The major difference in avoided costs between the two Cases begins in 2017 for two reasons. First, Henry Hub prices under both Cases are based on NYMEX futures through 2016. Second, pipeline capacity into New England under both cases is the same through November 2018.

Exhibit 6-18. Annual Wholesale City-Gate Cost of Gas in New England High Price Case vs. Base Case ($/MMBtu) (2015$)



6.3.1 Electric Energy Prices under the High Gas Price Case

On a 15 year levelized basis, the High Gas Case avoided electric energy costs for Central Massachusetts are 18% higher than the Base Case avoided costs, as shown in Exhibit 6-20. The magnitude of High Gas Case avoided cost increases above the Base Case varies by pricing zone, season and time period, ranging between 8.8% (summer peak) and 21% (winter off-peak).

Exhibit 6-20. New England wholesale gas costs and Electric Energy Prices, High Gas Case vs Base Case

Year	Annual Wholesale Gas Price, AGT hub (2015$/MMBtu)				Annual Energy Price, WCMA (2015$/MWh)			
	CASES		High Gas Case - Base Case		CASES		High Gas Case - Base Case	
	Base	High Gas	absolute difference	% change from Base Case	Base	High Gas	absolute difference	% change from Base Case
	a	b	c = b - a	d = c / a	e	f	g = f - e	h = g / e
2015	$ 6.96	$ 6.96	$0.00	0%	$57.59	$57.59	$0.00	0%
2016	$ 6.32	$ 6.32	$0.00	0%	$55.62	$55.62	$0.00	0%
2017	$ 6.33	$ 7.02	$0.69	11%	$54.99	$57.46	$2.48	5%
2018	$ 5.59	$ 6.78	$1.19	21%	$48.83	$60.04	$11.21	23%
2019	$ 5.43	$ 6.59	$1.16	21%	$48.24	$59.37	$11.13	23%
2020	$ 5.13	$ 6.27	$1.15	22%	$47.00	$57.68	$10.68	23%
2021	$ 5.42	$ 6.64	$1.22	22%	$49.42	$61.03	$11.61	23%
2022	$ 5.58	$ 6.85	$1.27	23%	$52.17	$63.88	$11.71	22%
2023	$ 5.72	$ 7.04	$1.32	23%	$54.23	$65.93	$11.70	22%
2024	$ 5.88	$ 7.25	$1.37	23%	$56.11	$68.07	$11.96	21%
2025	$ 5.99	$ 7.41	$1.42	24%	$59.26	$71.81	$12.55	21%
2026	$ 6.12	$ 7.59	$1.47	24%	$61.51	$74.15	$12.64	21%
2027	$ 6.25	$ 7.76	$1.51	24%	$62.52	$75.02	$12.51	20%
2028	$ 6.35	$ 7.91	$1.56	24%	$64.88	$77.63	$12.75	20%
2029	$ 6.54	$ 8.15	$1.61	25%	$68.46	$80.88	$12.42	18%
2030	$ 6.81	$ 8.48	$1.68	25%	$75.24	$87.93	$12.68	17%
15 yrs Levelized (2016-2030)								
	$5.94	$7.14	$1.21	20%	$56.58	$66.83	$10.25	18%

Exhibit 6-20 and **Exhibit 6-21** present year-by-year comparisons of avoided energy costs under the High Gas Price Case and the Base Case respectively. The major difference in avoided energy costs between the two Cases begins in 2017 because city-gas gas prices are basically the same under both Cases through 2016 for the reasons discussed above. After 2016 the summer differences between the High Gas Price Case and Base Case fluctuate between 7% and 12 % during On-peak hours and between 10% and 13% in off-peak hours. In winter, under the High Gas Price case, avoided costs are 6%-8% above the Base Case in 2017 and 20% - 30% above Base Case in 2018 and beyond.

It is also worth noting that in relative terms, higher gas prices have a greater impact on electric avoided costs during off-peak hours than during on-peak hours. In absolute terms, over the long-term in a given season the changes in on-peak and off-peak prices are of similar magnitude, as shown in Exhibit 6-20.

Exhibit 6-20. High Gas Case as a Percent Difference from the Base Case, Summer Season Comparison

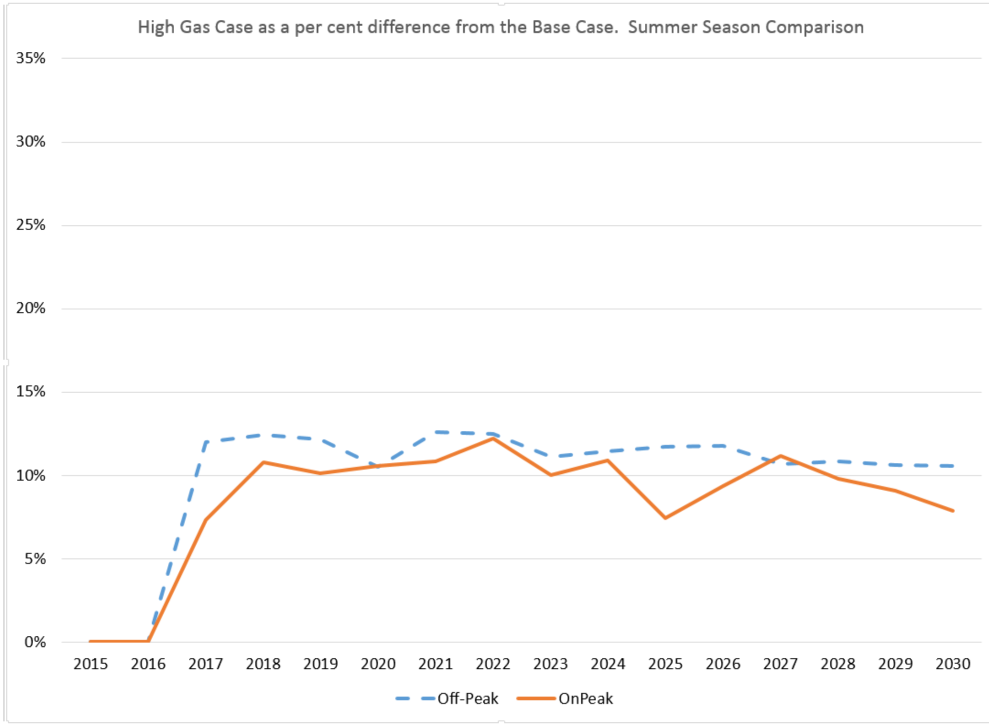
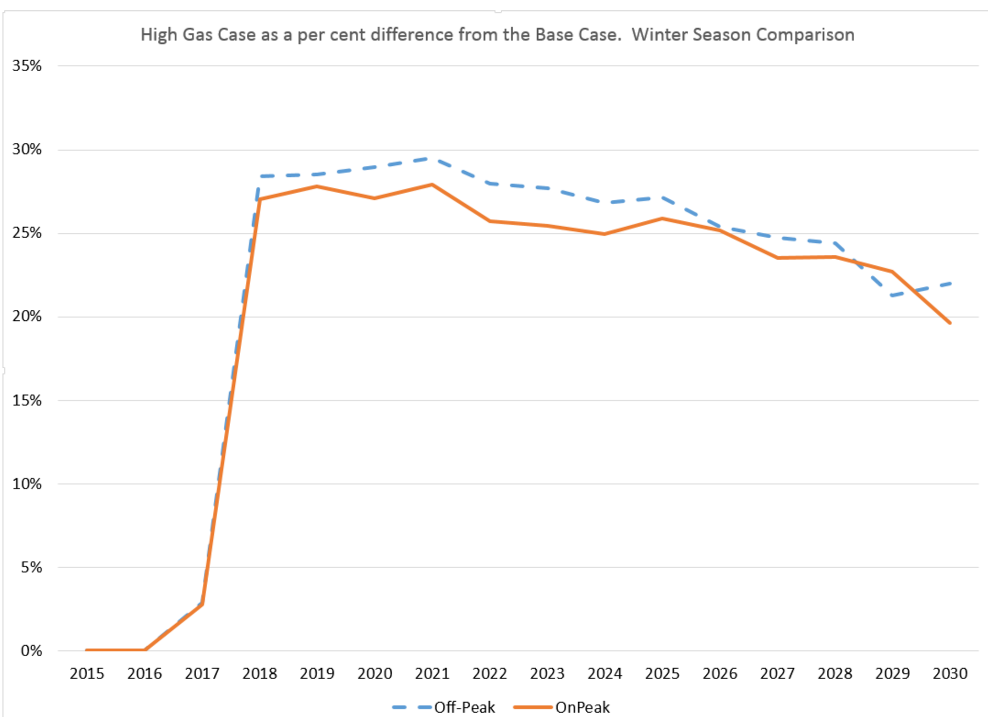


Exhibit 6-21. High Gas Case as a Percent Difference from the Base Case, Winter Season Comparison



6.3.2 Electric Capacity Prices under High Gas Price Case

The projected level and mix of capacity in the High Gas Price Case is identical to that of the Base Case. As a result, as shown in Exhibit 6-22, the avoided capacity costs under the High Gas Price Case are very close to those under the Base Case. Capacity prices are set by marginal capacity units – newly constructed CT generators which earn little net revenues in the energy market. Since both Cases have the same generation mix and identical patterns of new entry, the revenue requirements that new capacity bid into the capacity market are very similar under both the Base Case and the High Gas Price Case.

Exhibit 6-22. Capacity Prices under High Gas Price Case and Base Case

	ASEC 2015 High Gas	AESC 2015 Base	Base Case vs BAU Case
	2015$/kW-month	2015$/kW-month	% difference
2015/16	3.38	3.38	0.00%
2016/17	3.15	3.15	0.00%
2017/18	14.19	14.19	0.00%
2018/19	12.96	12.96	0.00%
2019/20	11.29	11.29	0.00%
2020/21	11.06	11.33	2.44%
2021/22	11.71	11.71	0.00%
2022/23	11.62	11.62	0.00%
2023/24	11.37	11.37	0.00%
2024/25	11.96	11.96	0.00%
2025/26	11.96	11.96	0.00%
2026/27	12.04	12.04	0.00%
2027/28	11.79	11.79	0.00%
2028/29	12.46	12.46	0.00%
2029/30	12.79	12.79	0.00%
15 yr Levelized	10.73	10.75	0.18%

Chapter 7: Demand Reduction Induced Price Effect

7.1 Introduction

DRIPE refers to the reduction in wholesale market prices for energy and/or capacity expected from reductions in the quantities of energy and/or capacity required from those markets during a given period due to the impact of efficiency and/or demand response programs. Thus, DRIPE is a measure of the value of efficiency received by all retail customers during a given period in the form of expected reductions in wholesale prices.

DRIPE effects are typically very small when expressed in terms of their impact on wholesale market prices, i.e., reductions of a fraction of a percent. However, DRIPE effects may be material when expressed in absolute dollar terms, e.g., a small reduction in wholesale electric energy price multiplied by the quantity of electric energy purchased for all consumers at that wholesale market price, or at prices / rates tied to that wholesale price.

- The avoided cost value of DRIPE during a given time period is equal to the projected impact on the wholesale market price during that period, expressed as a $ per unit of energy, multiplied by the quantity of energy purchased at rates or prices tied directly to that given market price. As illustrated in

Exhibit 7-1, this chapter calculates the avoided cost value of three broad categories of DRIPE:

- **Electric efficiency direct DRIPE:** The value of reductions in retail electricity use resulting from reductions in wholesale electric energy and capacity prices from the operation of those wholesale markets.
- **Natural gas efficiency direct and cross-fuel DRIPE:** The value of reductions in retail gas use from reductions in wholesale gas supply prices and reductions in basis to New England. Gas efficiency cross-fuel DRIPE is the value of the reductions in those prices in terms of reducing the fuel cost of gas-fired electric generating units, and through them wholesale electric energy prices.
- **Electric efficiency fuel-related and cross-fuel DRIPE:** The value of reductions in retail electricity use from reductions in wholesale gas supply prices and reductions in basis to New England. The reductions in those prices reduces the fuel cost of gas-fired electric generating units, and through them wholesale electric energy prices. Electric efficiency cross-fuel DRIPE is the value of the reductions in the wholesale gas supply price to retail gas users.

Exhibit 7-1. Overview of Impacts of wholesale DRIPE

Reduction in Retail Load	Cost Component Affected	DRIPE Category	Exhibit Reporting Results
Electricity	Electric Energy Prices	Own-price (energy DRIPE)	
Natural Gas	Gas Production Cost	Own-price (gas Supply DRIPE)	
	Gas Production Cost	Cross-fuel (gas to electric)	
	Basis to New England	Cross-fuel (gas to electric)	
Electricity	Gas Production Cost	Own-price (gas Supply DRIPE)	
	Basis to New England	Own- price (basis DRIPE)	
	Gas Production Cost	Cross - fuel (electric to gas)	

The AESC 2015 DRIPE results are lower than the corresponding AESC 2013 DRIPE results. The electric efficiency direct DRIPE results are lower primarily because the New England market is not projected to have surplus capacity during the study period and because AESC 2015 has reflected this change in market condition on a forward looking basis using a differential approach based on a direct simulation of these projected market conditions. The natural gas efficiency direct and cross-fuel DRIPE results and the electric efficiency fuel-related and cross-fuel DRIPE results are lower primarily because of the lower AESC 2015 estimate of basis.

This chapter describes the methods and assumptions AESC 2015 used to calculate electric and gas DRIPE effects, and the results of those calculations. This chapter is organized as follows:

- Section 7.2 describes the methods, assumptions and calculation of wholesale electric DRIPE.
- Section 7.2.4 describes the methods, assumptions and calculation of wholesale gas DRIPE.
- Section 7.4 describes the methods, assumptions and calculation of direct DRIPE effects from electric efficiency on retail customers.
- Section 7.5 describes the methods, assumptions and calculation of gas supply and gas basis DRIPE effects of gas efficiency and of electric efficiency.
- Section 7.6 describes the calculation of own-price and cross-fuel DRIPE effects from gas efficiency.
- Section 7.7 describes the calculation of own-fuel and cross-fuel fuel DRIPE effects from electric efficiency.

7.2 Wholesale Electric DRIPE

This section describes the AESC 2015 projections of the size of the capacity and energy price effects, provides empirical evidence which confirms these projections are reasonable, and explains why the projections are smaller than those in AESC 2013. As explained below, Section 6-10 provides an explanation of why our projections of electricity DRIPE duration is shorter than the AESC 2013 projection.

7.2.1 Overview

The value of DRIPE is a function of the projected impact of a given load reduction on wholesale capacity and/or energy market prices, and the projected duration of those price effects. Analysts cannot directly measure either the size of the price effect, or its duration. Instead analysts must estimate both of those two driving actors using some form of "counterfactual". For example, looking back in time we know the actual energy prices in 2013 but we do not know the counterfactual, i.e., what energy prices would have been in 2013 had load been higher due to less reduction from efficiency measures. Looking forward, we do not know future prices. However, we can project market prices under a Case that assumes some level of reductions from continued ratepayer funding of efficiency and also project market prices under a "counterfactual" Case without those assume reductions. We can then estimate the size of the DRIPE effect on prices, and the duration of that DRIPE effect, by comparing the projections of market prices under the two Cases.

The analytical approach most commonly used to estimate DRIPE, or price suppression, is a "differential approach" based on market simulations. A list of studies which have estimate DRIPE and price suppression is provided in in Tables 1 and 2 of Appendix A. The other, less common, approach is regression analysis. Under that approach the analyst determine the relationship between electric prices and load during a past period and then use that relationship to forecast DRIPE based on an assumption that the historical relationship will apply in the future.

AESC 2015 estimated electricity DRIPE in New England, both capacity and energy, by projecting market prices under several different cases. AESC 2015 used the BAU Case, described in Chapter 6, as the reference point against which it measured the size and duration of DRIPE effects under each of the other Cases. The other cases are the BAU Case, described in Chapter 5, and state-specific DRIPE Cases for each New England state, which we will describe in this section. AESC developed the projections of market prices for each Case directly by simulating the operation of the market for the load forecasts used in that Case. The projected electric DRIPE effects from this approach are smaller than those projected in AESC 2013 because the projected price effects are smaller in size and shorter in duration.

AESC 2015 is projecting the price effects to be shorter in duration for the reasons presented earlier in the comparison between the Base Case and the BAU Case in Section 6.10. In summary, the projected shorter duration is attributable to differences between the two studies in terms of projected market conditions and differences in analytical approach. AESC 2015 projects that ISO-NE will begin adding gas-fired capacity in all zones starting in the 2018/19 power year under both the Base Case and the BAU

Case, approximately 3 years earlier than ASESC 2013. Also, AESC 2015 developed its projections of capacity and energy DRIPE from 2018 onward directly using simulation modelling of the energy market. The AESC 2013 projections of energy DRIPE duration are based on qualitative estimates of price effect duration.

Size of Electricity DRIPE effects

AESC 2015 is projecting a capacity price DRIPE effect of zero. In the short term ISO-NE has already set capacity prices through the 2018 power year. In the long term, as discussed in Section 6.10, ISO-NE has designed its auctions to avoid acquiring surplus capacity and because the cost characteristics of the new gas CT and CC units that will be setting the capacity market price are essentially the same. Note, however, that AESC 2013 is projecting much higher capacity prices than AESC 2013.

AESC 2015 is projecting energy DRIPE effects from January 2015 through May 2018. During that period all Cases rely on the same installed capacity, i.e., there is no difference in new generation additions or retirements. As a result, the difference in demand between the Cases is the primary driver of energy prices.

Exhibit 7-2. Incements in state DRIPE cases, 2017 provides an illustration of the levels of increments used in each state specific DRIPE Case, from 2017. These levels are small relative to total ISO-NE load. They vary in size and shape by state.

Exhibit 7-2. Incements in state DRIPE cases, 2017

Summer		CT	MA	ME	NH	RI	VT	ISO-NE Total
BAU Case Peak	MW	7,319	12,743	2,016	2,603	1,836	1,003	27,520
BAU Case load	GWh	12,058	21,910	4,010	4,379	2,968	2,011	47,336
Load Factor	%	56%	59%	68%	57%	55%	68%	59%
State-Specific DRIPE Cases								
PDR Increment	GWh	846	2,121	410	192	372	301	
PDR as % intrastate load	%	7.0%	9.7%	10.2%	4.4%	12.5%	14.9%	
PDR as % ISO-NE Total	%	1.8%	4.5%	0.9%	0.4%	0.8%	0.6%	
PDR Increment	MW	421	1077	184	97	179	132	
PDR load factor	%	69%	67%	76%	68%	71%	78%	
Winter		CT	MA	ME	NH	RI	VT	ISO-NE Total
BAU Case Peak	MW	5,530	9,659	1,789	2,041	1,250	974	21,243
BAU Case load	GWh	21,242	38,928	7,540	8,013	5,082	3,983	84,788
Load Factor	%	66%	69%	72%	67%	70%	70%	68%
State-Specific DRIPE Cases								
PDR Increment	GWh	1,489	3,776	770	351	638	595	
PDR as % intrastate load	%	7.0%	9.7%	10.2%	4.4%	12.5%	14.9%	
PDR as % ISO-NE Total	%	1.8%	4.5%	0.9%	0.4%	0.8%	0.7%	
PDR Increment	MW	270	1006	171	79	175	131	
PDR load factor	%	95%	64%	77%	76%	62%	78%	
Annual		CT	MA	ME	NH	RI	VT	ISO-NE Total
BAU Case Peak	MW	7,319	12,743	2,016	2,603	1,836	1,003	27,520
BAU Case load	GWh	33,300	60,838	11,550	12,392	8,050	5,994	132,124
Load Factor	%	52%	55%	65%	54%	50%	68%	55%
State-Specific DRIPE Cases								
PDR Increment	GWh	2,335	5,897	1,180	543	1,010	896	
PDR as % intrastate load	%	7.0%	9.7%	10.2%	4.4%	12.5%	14.9%	
PDR as % ISO-NE Total	%	1.8%	4.5%	0.9%	0.4%	0.8%	0.7%	
PDR Increment	MW	421	1077	184	97	179	132	
PDR load factor	%	63%	63%	73%	64%	64%	77%	

Using those increments, AESC 2015 found electric energy DRIPE effects from each state-specific DRIPE Case relative to the BAU Case over the first two and approximately one-half years of the study period (January 2016 through May 2018). Exhibit 7-3 presents the energy DRIPE coefficients for each state by season and pricing period.

Exhibit 7-3 State-Specific Energy DRIPE Coefficients

Average % Reduction in Electric Energy Prices, January 2015 through May 2018, for 1% Reduction in Intrastate Load

CT	Intrastate			Interstate - ROP		
	OnPeak	OffPeak	AllHours	OnPeak	OffPeak	AllHours
Summer	0.0620	0.2934	0.1050	0.0575	0.1577	0.0625
Winter	0.0989	0.1423	0.0852	0.0874	0.1269	0.0743
Annual	0.0881	0.1865	0.0910	0.0787	0.1359	0.0709

MA	Intrastate			Interstate - ROP		
	OnPeak	OffPeak	AllHours	OnPeak	OffPeak	AllHours
Summer	**0.7210**	0.3272	0.4511	0.6145	0.3006	0.4557
Winter	0.3067	0.1651	0.2241	0.2744	0.1692	0.2223
Annual	0.4280	0.2126	0.2905	0.3739	0.2077	0.2906

NH	Intrastate			Interstate - ROP		
	OnPeak	OffPeak	AllHours	OnPeak	OffPeak	AllHours
Summer	0.2432	-0.0008	0.1039	0.0936	-0.0001	0.0638
Winter	0.0499	0.0582	0.0671	0.0542	0.0596	0.0714
Annual	0.1065	0.0409	0.0779	0.0657	0.0421	0.0692

RI	Intrastate			Interstate - ROP		
	OnPeak	OffPeak	AllHours	OnPeak	OffPeak	AllHours
Summer	0.2462	0.0233	0.1367	0.1347	0.0131	0.0817
Winter	0.0365	0.0163	0.0311	0.0181	0.0147	0.0213
Annual	0.0978	0.0183	0.0620	0.0522	0.0142	0.0390

ME	Intrastate			Interstate - ROP		
	OnPeak	OffPeak	AllHours	OnPeak	OffPeak	AllHours
Summer	-0.0487	0.0233	-0.0103	-0.0581	0.0292	-0.0095
Winter	0.0559	0.0368	0.0469	0.0582	0.0397	0.0495
Annual	0.0252	0.0328	0.0302	0.0241	0.0366	0.0322

VT	Intrastate			Interstate - ROP		
	OnPeak	OffPeak	AllHours	OnPeak	OffPeak	AllHours
Summer	-0.0268	0.0306	0.0013	-0.0644	0.0174	-0.0146
Winter	0.0245	0.0217	0.0238	0.0219	0.0222	0.0226
Annual	0.0095	0.0243	0.0172	-0.0033	0.0208	0.0117

The negative results for a few seasonal periods in a few zones are consistent with actual experience, as indicated by a third of the days experiencing higher prices despite lower loads. Those results are explained by the impact of various factors in addition to unit commitment, including zone-specific transmission constraints on certain days and differences in PDR size and shape.

7.2.2 Impact of Supply Curve and Unit Commitment on Size of Energy DRIPE

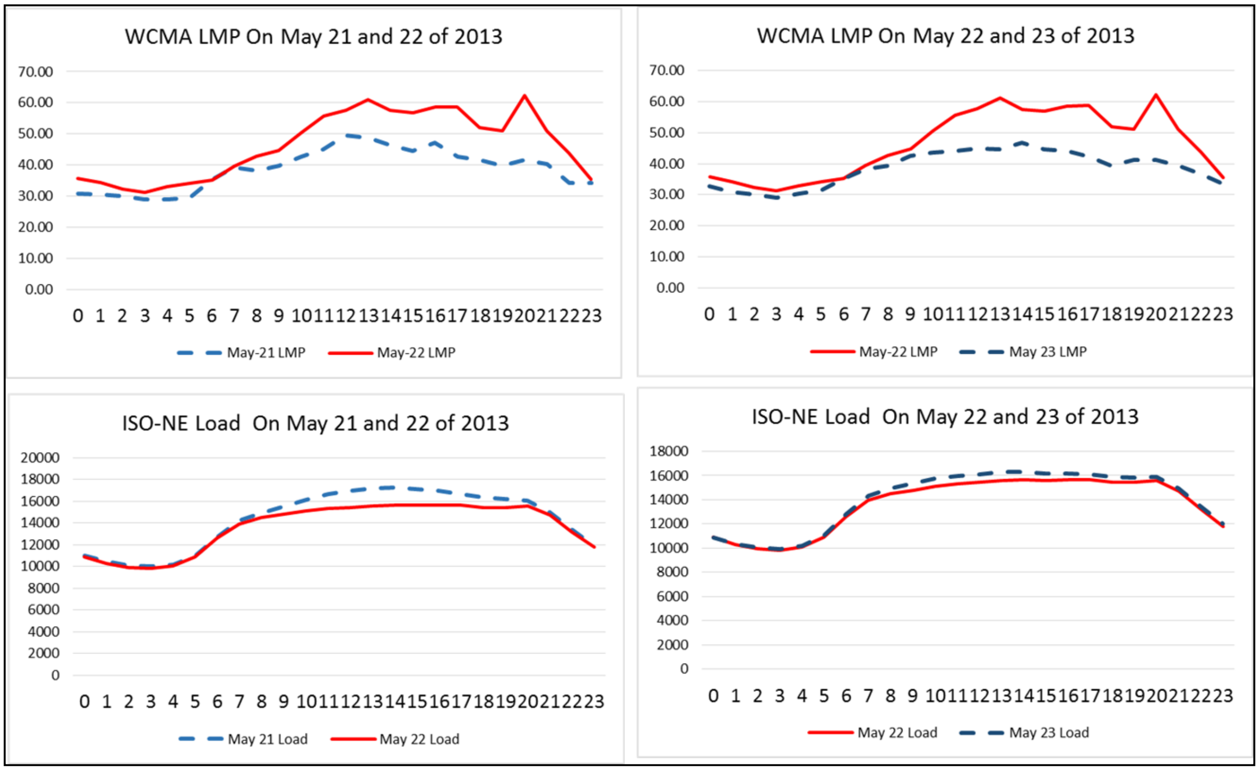
AESC 2015 projects the energy market prices under the BAU case and each state specific DRIPE case by simulating the formation of energy prices based on the energy supply curve and the ISO-NE unit commitment process. The formation of energy prices under those cases is largely driven by two main factors, the supply curve and unit commitment. As a result, the size of the energy DRIPE AESC 2015 is projecting is also largely driven by those two factors, both of which tend to dampen the size of energy DRIPE.

The supply curve dampens the energy DRIPE because the section which sets energy prices on most days is essentially flat, as described in Section 6.10. The unit commitment process dampens the energy DRIPE because ISO NE makes its decisions regarding which units to commit to serving load based on its projection of load for 24 hours, not for just 1 hour, as described in Chapter 5. Because of those two factors, there is not a simple linear relationship between the energy load in a given hour and the load in that hour. Instead, the relationship between energy prices and loads is affected by load on a given day, fuel prices on that day and unit availability on that day.

There will be days on which actual conditions will differ from the ISO NE forecast conditions due to market conditions that ISO-NE did not expect, e.g., an unexpected outage, oversupply or unexpectedly high or low demand. However, it is not clear that energy DRIPE effects would occur under those types of unexpected market conditions, i.e. when the market did not operate exactly as planned, i.e. “perfectly” or according to perfect foresight. We are not aware of specific examples of energy DRIPE impacts during days or hours when the energy market did not work “perfectly”. On the contrary, many factors can cause unexpected market conditions, and one would have to identify and analyze those factors in order to determine if lower load due to reductions from energy efficiency would have had any effect on prices under those conditions. In other words, to estimate the energy DRIPE effect of efficiency reductions on a day when actual conditions are materially different from forecast conditions, one must know the specific cause of the difference in prices between actual and forecast market conditions. It is also important to note that reduction in load from efficiency is a long-term, passive demand resource. As such, it is very different from a reduction in load from Active Demand Resources, which provide reductions only at the time of and only in response to unexpected market conditions.

To demonstrate the impact of unit commitment on energy prices we have assembled empirical evidence from 2013. To start, consider the following example based on actual New England loads and LMPs for three consecutive days: May 21, 22 and 23 of 2013 as shown in **Exhibit 7-4**.

Exhibit 7-4. Loads and LMPs for May 21, 22, 23 of 2013

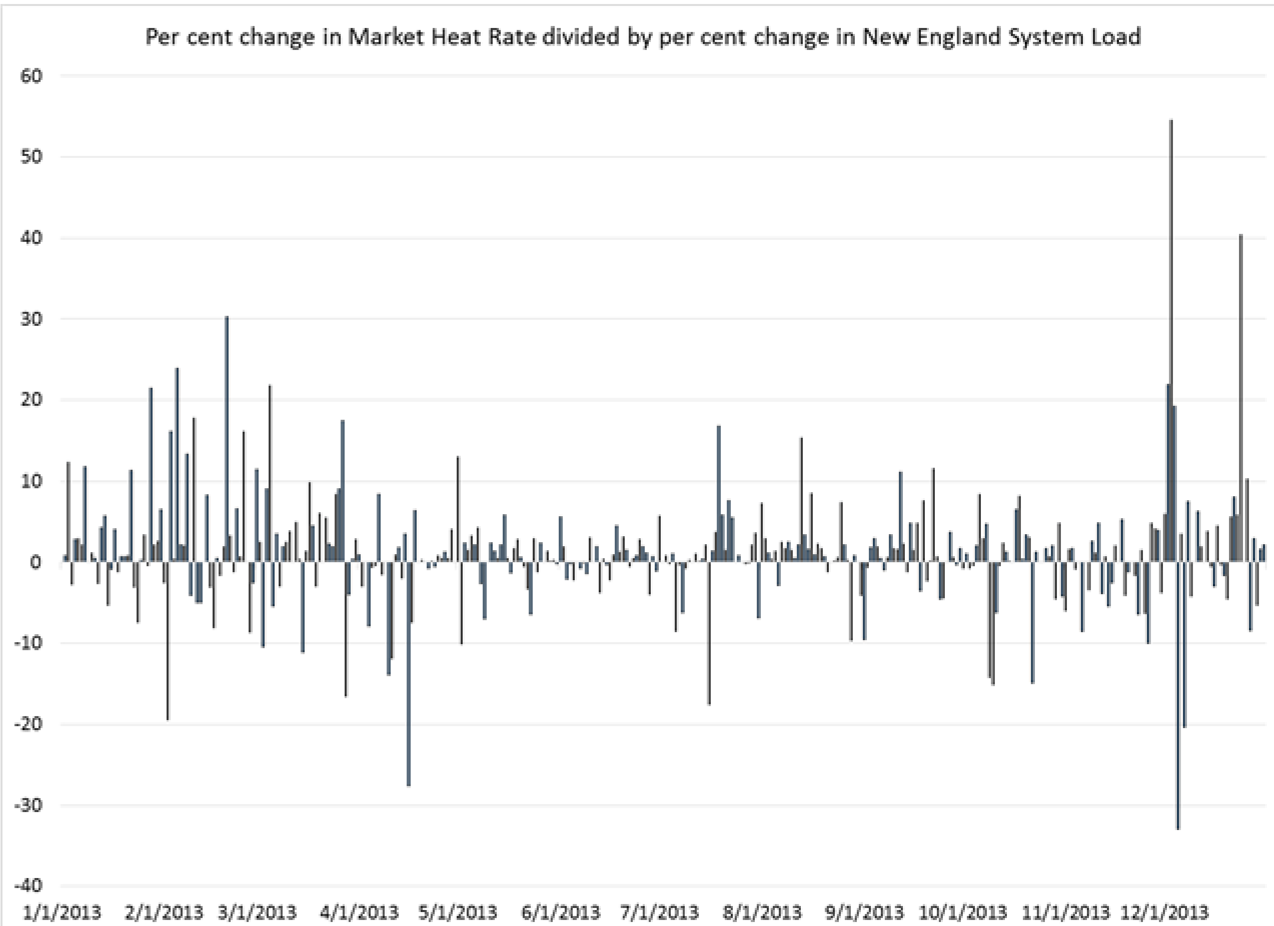


On all three days natural gas prices were close: $4.47, $4.64, and $4.63 per MMBtu on May 21, 22 and 23, respectively. As one can see, load on May 22 was lower than on May 21 in every hour of the day. In fact, at 14:00 on May 22 load was 1,625 MW less than at 14:00 on May 21. In contrast, LMPs on May 22 were higher than on May 21. For example, at 20:00 on May 22 the price was $20/MWh higher than at 20:00 on May 21 Similarly, load on May 23 increased from May 22 levels by as much as 682 MW (hours 12:00 and 13:00) but LMPs declined by as much as $21/MWh at 20:00. The hourly energy prices corresponding to the hourly loads on these three days is not consistent with, and cannot be explained by, a single high-level supply curve.

That Exhibit provides a clear illustration of why a market simulation approach, one that reflects the unit commitment process and other market factors that drive the formation of energy prices each day, is required to develop an accurate estimate of energy DRIPE. The difference in load between May 21 and May 22 could be interpreted as a demand reduction on May 21 to the May 22 level. However, on that day, demand reduction would result in price increase. Similarly, demand reduction on May 23 to the May 22 level would again result in price increase.

Second, to estimate the frequency of these price effects we analyzed changes in average daily LMPs during 2013 relative to changes in daily loads. The goal of this analysis was to assess how often an increase in demand from one day to another would result in a decrease in the average daily LMPs, and vice versa. In other words, the frequency of changes in price moving in the opposite direction to changes in demand. Recognizing that load on a given day is not the only determinant of average prices for that day we controlled for differences in gas prices from day to day. We did this by computing the average market heat rate for each day, which is the ratio of the average LMP each day to the average spot price of gas on that day. Then we computed the ratio of the change in market heat rates from day to day to the change in daily load from day to day. (We removed outliers where small changes in load resulted in very large ratios). The results are plotted in Exhibit 7-5. Again, these actual results are not consistent with, and cannot be explained by, a single high-level supply curve.

Exhibit 7-5. Change in Average daily Market Heat Rate versus Change in average daily System Load



Finally, Exhibit 7-6 and Exhibit 7-7 further illustrate that many days in 2013 had the same or similar loads but a range of energy prices. These two figures plot daily on-peak period market heat rates versus daily on-peak loads from 2013 for the summer and winter seasons respectively. This actual data demonstrate that energy prices are not solely driven by load, they are affected by the unit commitment process, fuel prices and outages.

Exhibit 7-6

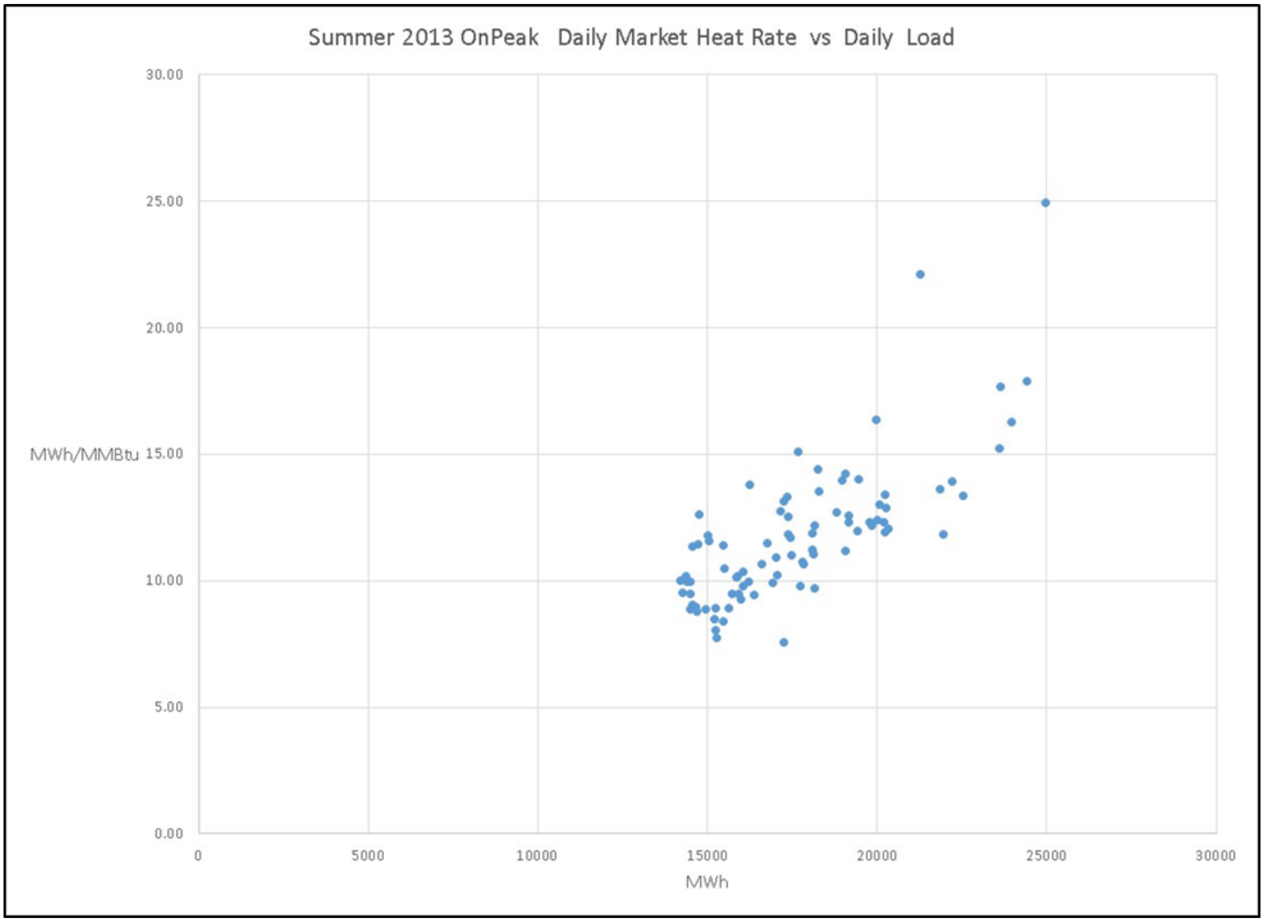
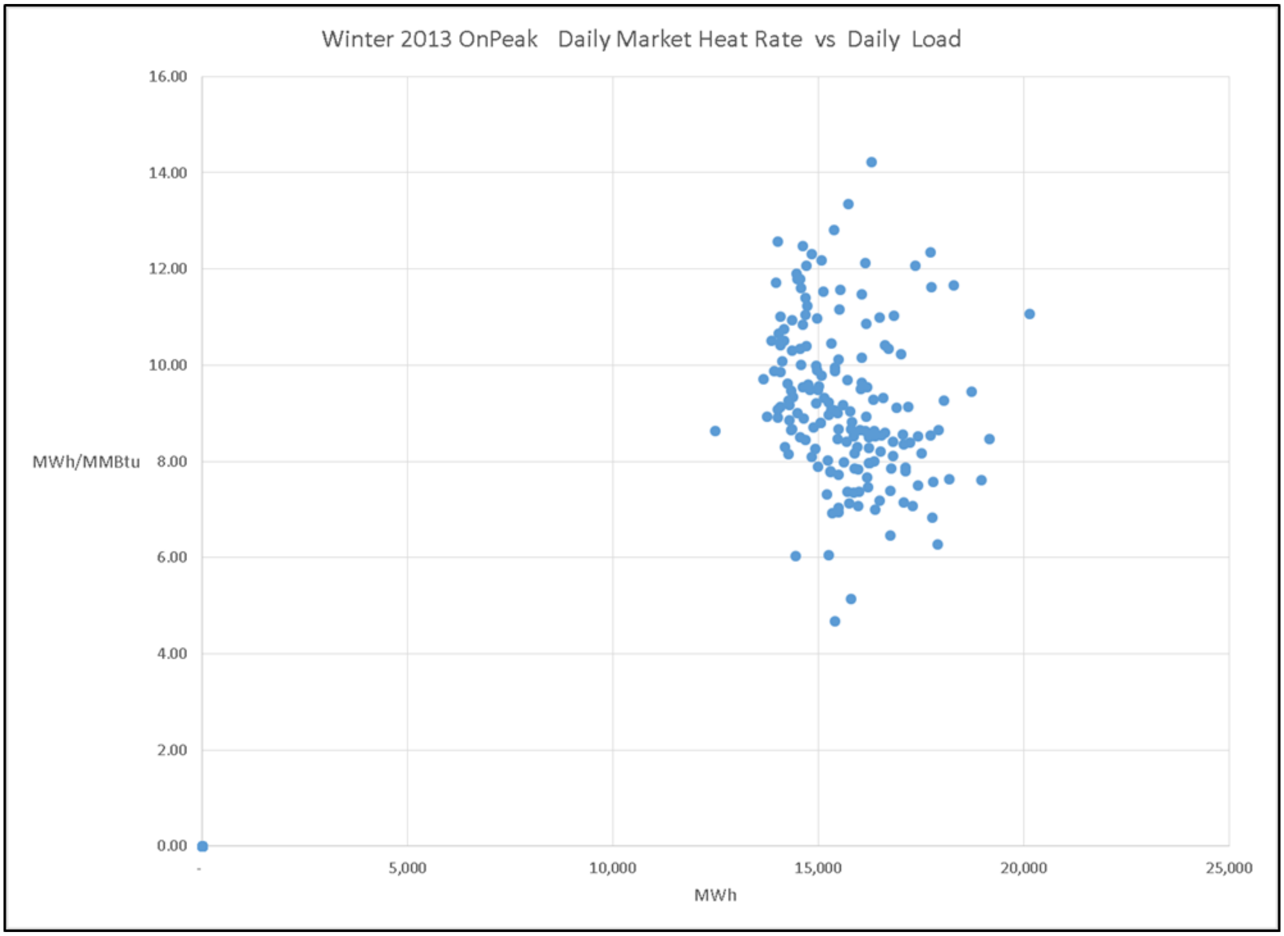

Summer 2013 OnPeak Daily Market Heat Rate vs Daily Load
MWh/MMBtu
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
5000
10000
15000
20000
25000
30000
MWh

Exhibit 7-7



7.2.3 Comparison with regression analysis of 2013 data

TCR prepared two different regression analyses of 2013 hourly prices and loads and compared them to the coefficients from its simulation modeling to compare against the AESC 2015 modeled DRIPE methodology. Exhibit 7-8 provides these comparisons for annual on-peak periods.

Row 1 of the Exhibit reports the projected energy DRIPE coefficients for 2015 to 2017 from the state-specific DRIPE Case. The coefficients represent the % change in average daily price in the state for the relevant period divided by the change in average daily load in the state as a % of ISO NE system wide load. (The coefficients are computed monthly and averaged across all months between January 2015 and May 2018). These coefficients measure change in price versus load in the period by day rather than by hour because the model simulates the operation of the market by ISO NE, which sets the prices each day through its unit commitment process. The on-peak energy DRIPE coefficients range from 0.33 to 1.4, The range in coefficients is attributable to the fact that the decrement in each state specific DRIPE Case occurs in a different state (i.e. location) and is of a different size and load shape. On a state load weighted basis, the resulting coefficient for New England is 0.7 which rounds to 1.

Row 2 of the Exhibit reports energy DRIPE coefficients in 2013 Cases from a TCR multi-regression analyses of 2013 actual average period prices by day versus actual period system-wide loads by day and fuel prices by day. (TCR did the regression for load and fuel price to control for variation in fuel prices from day to day.)   The on-peak result is an energy DRIPE coefficient of 1.1, which also rounds to 1. These result are the same order of magnitude as the coefficients from the state-specific DRIPE Cases. (The regression has an R^2 of 0.83, which is not an explanatory variable, instead it is a measure of how well the regression model / formula explains variances in the dependent variable)

Row 3 of the Exhibit reports energy DRIPE coefficients in 2013 Cases from a TCR multi-regression analyses of 2013 actual hourly on-peak prices versus actual hourly on-peak system-wide loads and daily fuel prices. TCR did this regression for hourly prices and loads to demonstrate that the energy DRIPE coefficient will be less accurate, in this case, 1.3 instead of 1.1, because it does not reflect the impact of the unit commitment process on the formation of energy prices each day. (The AESC 2013 energy DRIPE coefficients, which are higher, are based upon a regression of hourly prices by period versus hourly loads by period from 2009 to 2012).

The results from the regression analysis of 2013 hourly prices and loads, presented in row 3 of Table 1, are less accurate than the regression analysis of 2013 hourly prices by day and loads by day, presented in row 2 of Table 1, because the row 3 regression does not reflect the impact of the daily unit commitment process.

The results from the regression analysis of 2013 hourly prices by day and loads by day, presented in row 2 of Table 1, to be less accurate than the coefficients from the simulation model because the simulation model reflects differences in impacts by state due to differences in size and shape of PDR.

Exhibit 7-8. Electric Energy DRIPE coefficients, peak periods, AESC 2015 simulation versus regression analyses of 2013 data

Electric energy DRIPE. % change in energy price for a % change in load relative to ISO NE load

Table 1. Annual On-Peak Period

Source	Data source / Time Period	Dependent Variable	Independent Variables	CT	MA	ME	NH	RI	VT	ISO NE (1)
state-specific DRIPE Cases	2015 - 2018	peak period energy prices by day in state	peak period load and fuel price by day in state	0.33	0.89	0.27	1.13	1.4	0.19	0.72
TCR regression analysis daily prices	2013	peak period energy prices by day at WCMA	peak period load and fuel price by day							1.10
TCR regression analysis hourly prices	2013	peak period energy prices by hour at WCMA	peak period load by hour and fuel price by day							1.30

Note 1: ISO NE result is a state load weighted average per 2015 annual loads

7.2.4 Comparison with AESC 2013 estimated size of energy DRIPE effect

The AESC 2015 projections of energy DRIPE price effects are smaller than the AESC 2013 projections for peak periods, which ranged from 1.9 to 2.2[179]. The differences between the energy DRIPE estimates from the two studies is primarily attributable to a difference in analytical approach. AESC 2015 projections are developed directly by simulating the operation of the energy market under the BAU Case and under each of the state-specific Cases (i.e., CT, ME, MA, NH, RI, VT). The AESC 2015 simulation modelling reflects the impact of the ISO-NE daily unit commitment process as well as differences in impacts by state due to differences in size and shape of PDRs. The AESC 2013 regression analysis of hourly prices and loads from 2009 to 2012 provides a less accurate projection because it does not reflect that detailed level of market operation.

7.3 Wholesale Gas DRIPE

Reducing natural gas demand for electricity generation in a market area such as New England is, all else being equal, expected to reduce the quantity of gas supplied to that location. Classical economic theory suggests, in turn, that we may expect the price of natural gas at that location to fall in response to the reduction in gas requirements. The AESC 2015 RFP refers to this response as a gas demand reduction-induced price effect (herein, gas DRIPE).

This section presents the basic assumptions and methodology that underpin the AESC 2015 analysis of gas DRIPE, which consists of two components, production area price DRIPE and New England basis DRIPE.

Based upon our review of gas supply price elasticity (also referred to as the price elasticity of gas supply), we are assuming a production area supply price elasticity of 1.52 which indicates a percentage change of 1.52% in quantity for a 1% change in price. This implies an inverse price elasticity of 0.6579 (1/ 1.52) under which, for example, a 10% change in gas demand in the relevant production area would produce a 6.58% change in the price of gas production. The inverse supply price elasticity is used for the gas DRIPE analysis, i.e., the greater the supply elasticity, the less the DRIPE effect. The AESC 2015 estimate of production area gas DRIPE is approximately 23% less than the AESC 2013 estimate (i.e., $0.49/MMbtu for a 1 quad decrease in demand versus $0.632/MMBtu).

The AESC 2015 estimate of New England basis DRIPE in the three peak winter months is less than the AESC 2013 estimates, ranging from 50% less in the winter of 2014 to 80% less in the winter of 2019.

[179] AESC 2013, page 7-8.

7.3.1 Supply Price Elasticity Methodology

Our gas DRIPE analysis is based on the identification and assessment of estimates of the price elasticity of gas supply acquired at two different locations, gas production areas and the New England market area. As such, it is worthwhile to begin by referring to a standard economics textbook definition of supply price elasticity. In her widely used energy economics textbook,[180] Carol Dahl defines supply elasticity this way: "The responsiveness of quantity supplied to a variable is called the elasticity of supply with respect to that variable." (Dahl, 2004). Dahl then simplifies: "[Supply elasticity] is the percentage change in quantity divided by the percentage change in the variable. We can write the elasticity of supply [*Q*] with respect to price P as:

$$\varepsilon_s = \frac{\%\text{ change } Q_s}{\%\text{ change P}} = \frac{\frac{\Delta Q_s}{Q_s}}{\frac{\Delta P}{P}}.$$

Where delta represents a discrete change in the variable." (Dahl 2004, p. 32)

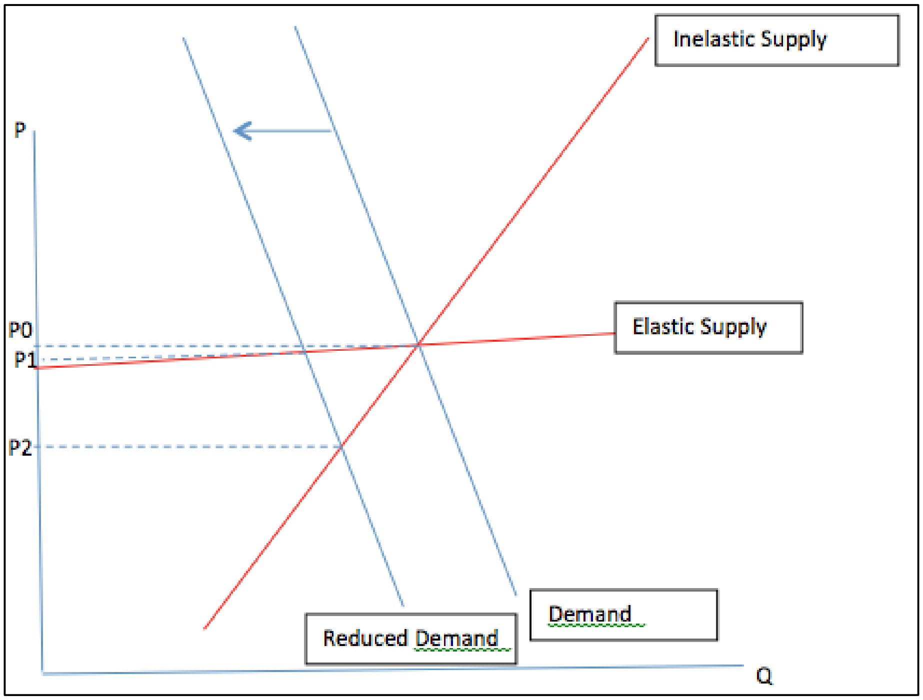
In the foregoing definition, the quantity (Q) and price (P) refer to the same commodity, in other words, "own price elasticity," as opposed to a cross-elasticity. In effect, price elasticity of supply (herein, supply elasticity) is the % change in quantity supplied divided by the % change in supply price. This is distinct from the price elasticity of demand (demand elasticity), which characterizes quantity demanded at a price.

We take the elasticity of gas supply (in shorthand: gas supply elasticity), then, to be related to the slope of the price-quantity (P-Q) supply curve for gas at the relevant location. This kind of curve is illustrated in the diagram in Exhibit 7-9.

As in AESC 2013, we also assume the cause-effect relationship works both ways i.e., symmetrically. Thus, for example, if the P-Q supply curve is steep (the line labeled "Inelastic Supply" in Exhibit 7-9, supply elasticity is relatively low, so a given change in gas demand would produce a relatively large change in price i.e., a large gas DRIPE effect as P0 falls to P2. Conversely, if the P-Q supply curve is flat (the line labeled "Elastic Supply" in Exhibit 7-9), then supply elasticity is high, so a given change in gas demand would produce a relatively small change in price (i.e., P0 to P1, a small gas DRIPE effect). In the latter case, Elastic Supply, the gas DRIPE effect would be low because even a large decrease in demand would induce only a small price reduction.

180 Carol A. Dahl, Professor Emeritus, Mineral and Energy Economics Program, Division of Economics and Business, Colorado School of Mines, "International Energy Markets: Understanding Pricing, Policies & Profits," Pennwell Press, April 2004. Note this definition remains in Dahl's revised edition, forthcoming in 2015.

Exhibit 7-9: Illustrative Supply Price-Quantity Curves



Thus, the analysis of gas DRIPE is actually a study of gas supply elasticity. Studying gas supply elasticity requires statistical analysis of a large number of relevant quantity and price data points in order to establish a P-Q supply curve. The data making up the P-Q gas supply curve must be accurate or the curve, and its elasticity at the point where the demand reduction takes place, will not be useful. In addition, the data must be able to "explain" the majority of a change in quantity as a function of change in price, or vice versa, otherwise the curves will not provide a reasonable estimate. For example, R2 is a generally accepted statistical test of the correlation of one set of data with another, i.e., to explain changes in the dependent variable as a function of changes in the independent variable. For example, sets of data with an R2 over 0.8 are considered to correlate well, while sets of data with an R2 of less than 0.4 are not considered to correlate. Thus, in the latter case of a 40% R2 correlation, variations in one data set cannot be used to explain variations in the other.

7.3.2 Production Area Price Gas DRIPE: Assumptions and Methodology

The 2013 AESC report considered a number of data sources, but ultimately developed production area price gas DRIPE based on a summary-level analysis involving comparisons of gas production quantities and Henry Hub prices from a number of AEO 2012 cases. The AESC 2015 team has also reviewed numerous estimates of production area gas supply elasticities. In light of the rapid changes taking place in the Northeast U.S. gas industry as a result of burgeoning Marcellus/Utica and other shale gas production, however, we have attempted to confine our focus on relatively recent estimates of supply curves and elasticities that hopefully reflect these dramatic changes.

Before reviewing this literature, it can be seen in plain terms that supply elasticity in rapidly growing shale fields like the Marcellus/Utica formation is obviously quite high, even to the point of being almost flat in the short-term time frame. In other words, the P-Q supply curve for the Marcellus/Utica shale basin is much like the flat curve marked “Elastic Supply” in Exhibit 7-9, so that even a large decrease in gas demand is unlikely to induce a downward price effect because local supplies already outstrip demand. In a business in which further drilling awaits further demand, and in which drilling productivity is rising dramatically in response to very low prices, there can be almost no gas DRIPE effect in the short term. Longer-term gas DRIPE is possible, of course, in the expectation that some kind of movement may take place toward the kind of supply-demand balance that would enable gas DRIPE to take place – i.e., gas DRIPE would be enabled because it would be set in a context of otherwise rising gas demand and, ultimately, gas production cost increases consistent with the beginnings of local resource depletion.

The frustrations of trying to develop supply elasticity in the unique economic environment we find ourselves in with respect to gas development for New England are only beginning to surface in the literature. A recent report by Resources for the Future (Mason et al 2014)[181] cites findings by Arora and others (Arora 2014)[182] that the supply based on shale production is more elastic than conventional sources. In looking at 2008-2012 data, Arora notes his data suggest, “…supply based on shale production is more elastic than conventional sources.” (Arora 2014). Rice University professor Kenneth B. Medlock has been far more pointed: “The domestic supply curve is much more elastic as a result of shale gas developments. Domestic long run elasticity with shale = 1.52; without = 0.29.”[183] Medlock, whose work relies on experientially derived field-by-field gas supply curves, is indicating findings that suggest earlier estimates of gas supply elasticity may be off by a factor of as much as five.

The difficulty in estimating supply elasticity with precision in a changing world (and with varying data sets) is illustrated in Exhibit 7-10, taken from Stanford University’s Energy Modeling Forum (EMF) recent comparison of energy models.[184] The EMF results, and its past studies, show that different models are likely to produce a very wide range of estimates of supply elasticity, even if provided with similar macroeconomic, resource base, and other common assumptions.

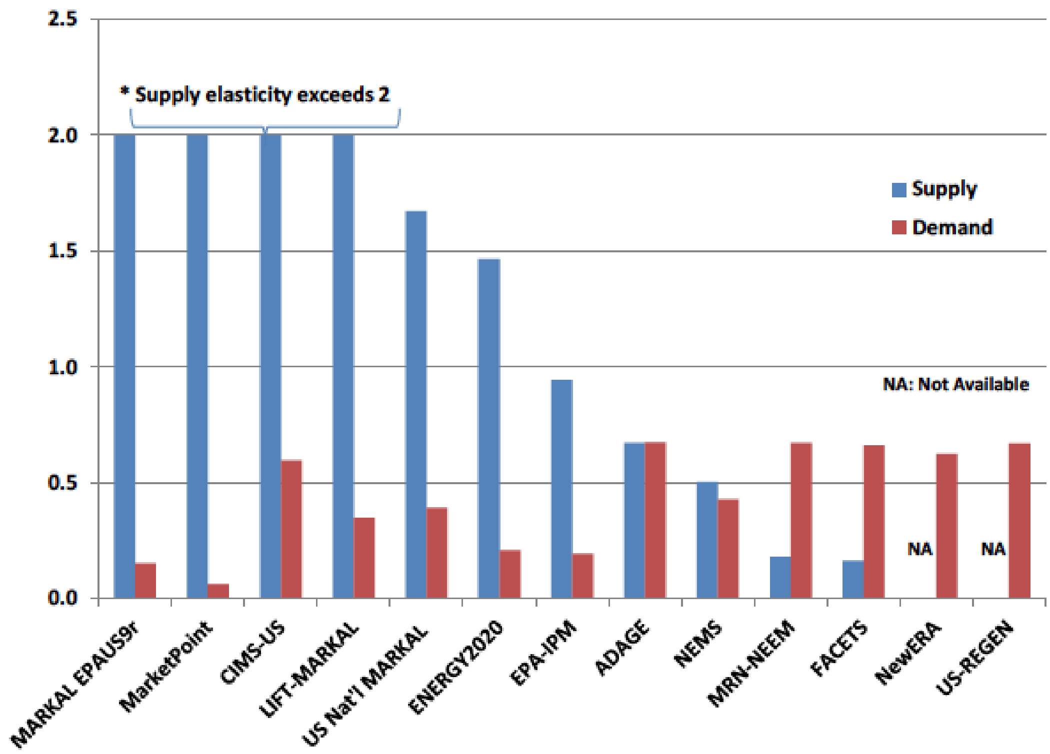
[181] Charles F. Mason, Lucija A. Muehlenbachs, and Sheila M. Olmstead, The Economics of Shale Gas Development, November 2014 (RFF DP 14-42), http://www.rff.org.

[182] Vipin Arora, Estimates of the Price Elasticities of Natural Gas Supply and Demand in the United States, March 2014, MPRA Paper No. 54232, http://mpra.ub.uni-muenchen.de/54232/

[183] Kenneth B Medlock III, PhD, Senior Director, Center for Energy Studies, James A. Baker, III, and Susan G. Baker Institute for Public Policy, Rice University (“Rice/Baker”), “Shale: Well Behavior, Demand Response and Exports,” based on the BIPP Center for Energy Studies publications: “Panel Analysis of Barnett Shale Production”; “US LNG Exports: Truth and Consequence”; and SENR Testimony Feb 12, 2013, Rice/Baker Center for Energy Studies, April 15, 2013. Note the Rice/Baker analysis model is a generalized equilibrium model (i.e., much like separate supply-demand-price calculation models for each gas supply region) with continual supply-price information updates gleaned from shale and other unconventional drilling operations.

[184] Energy Modeling Forum, Stanford University, “Changing The Game? Emissions And Market Implications of New Natural Gas Supplies,” EMF Report 26, Volume I, September 2013, page 24.

Exhibit 7-10: Inferred Price Elasticities for 2035 in 13 Forecasting Models



As a surrogate for precise field elasticities that are unavailable, therefore, we consider three separate approaches to estimate gas production area price DRIPE:

- Extracting gas supply elasticities implicit in a number of recent studies of the impacts of changes in gas demand caused by LNG exports.
- Following the methodology that underpinned calculations of gas production area price DRIPE in AESC 2013, i.e., inferring elasticities inherent in the NEMS model, as developed through analysis of different AEO 2014 cases.[185]
- Relying on the Rice/Baker modeling results.

Recent Assessments of the Impact of LNG Exports on Gas Prices

A number of analysis reports have been produced in the past several years describing the potential extent of US LNG exports and their domestic economic impact. AESC 2013 contained a useful review of

[185] It should be noted that AESC 2013 rejected a number of outdated elasticity estimates but, even so, events have moved quickly beyond the elasticity estimates it finally relied on.

the reports that were available at that time. We summarize below these and another, more recent EIA report, with respect to their implied gas supply elasticities:

***EIA, 2014*[186]**

In its update of earlier studies, the EIA states it reached these conclusions regarding domestic natural gas prices:

> Starting from the AEO2014 Reference case baseline, projected average natural gas prices in the Lower 48 states received by producers in the export scenarios are 4% (12-Bcf/d scenario) to 11% (20-Bcf/d scenario) more than their base projection over the 2015-40 period. Percentage changes in delivered natural gas prices, which include charges for gas transportation and distribution, are lower than percentage changes in producer prices, particularly for residential and commercial customers. Starting from the AEO2014 Reference case baseline, projected average Lower 48 states residential natural gas prices in the export scenarios are 2% (12-Bcf/d scenario) to 5% (20-Bcf/d scenario) above their base projection over the 2015-40 period. (EIA 2014)

The lower end of the range studied by EIA, 12 Bcf/day, represents about 16.25% of projected U.S. gas demand in the AEO 2014 Reference Case. Dividing the 16.25% increase in demand by the 4% increase in production area price (apart from costs of transportation and distribution) yields an estimated elasticity of 4.06, which implies that a 10% change in overall U.S. gas quantity would produce a 2.46% change in price.

***NERA, 2012*[187,188]**

The DOE-sanctioned study of U.S. domestic economic effects of LNG exports examined two scenarios in terms of export volumes – 6 Bcf/day and 12 Bcf/day (NERA 2012). Under sponsorship from Cheniere Energy, Inc., not the government, NERA prepared a follow-up of its report for the DOE (Baron et al 2014) that examined a large number of additional LNG export scenarios, ranging from 1 Bcf/day up to 19.5 Bcf/day. In each case, NERA based its forecasts in part on Annual Energy Outlook scenarios that were available at the time it prepared the studies, AEO 2012 in the case of NERA 2012 and AEO 2013 in the case of its follow-up report (Baron, et al 2014).

186 EIA, Effect of Increased Levels of Liquefied Natural Gas Exports on U.S. Energy Markets, October 2014, http://www.eia.gov/analysis/requests/fe/

187 National Economic Research Associates (NERA), Macroeconomic Impacts of LNG Exports from the United States, December 2012, http://energy.gov/sites/prod/files/2013/04/f0/nera_lng_report.pdf.

188 Robert Baron, Dr. Paul Bernstein, Dr. W. David Montgomery, and Dr. Sugandha D. Tuladhar, Updated Macroeconomic Impacts of LNG Exports from the United States," NERA, February 2014. http://www.nera.com/publications/archive/2014/updated-macroeconomic-impacts-of-lng-exports-from-the-united-sta.html.

NERA's more recent report assumes the natural gas resource supply elasticity varies with the U.S. natural gas supply scenario. In the study's reference scenario, the elasticity of supply for North American natural gas begins at 0.3 in 2018 and increases to 0.68 by 2038." (Baron, 2014, p. 159). We note these estimates were grounded in EIA/NEMS model runs that have since been updated. In other words, since AEO 2014 has long since replaced AEO 2013, and EIA's efforts toward AEO 2015 are well underway, the reasonable course here would be to examine updated AEO cases for this purpose, see the following subsection.

Deloitte MarketPoint, 2012[189]

Deloitte's analytic group issued two successive analysis reports, in November 2011 and November 2012. Both projecting the effects of exporting 6 Bcf/d of LNG, mainly from the US Gulf Coast. Deloitte's MarketPoint group licenses and includes authors of the most widely regarded natural gas analysis methodology, the World Gas Trade Model (WGTM), which was developed out of the North American Regional Gas Model (NARG). In the November 2012 study, Deloitte projected LNG exportation of 6 Bcf/day would cause a producer price increase of about $0.22/MMBtu, on average, in 2020-2030. This estimate represents an average 3.86% change in price from 2020 to 2030[190] and the 6 Bcf/day assumed by Deloitte represents an 8.13% change in quantity, as above. Hence, Deloitte's result implies a supply elasticity of 2.11, i.e., a 10% change in quantity would produce a 4.74% change in price.

Other LNG Export Impact Studies

Results of the foregoing studies are corroborated by a number of other reports, including those issued by:

- Brookings Institution – a compendium and critique of all US LNG export studies issued up to its publication in May 2012, entitled "Liquid Markets: Assessing the Case for U.S. Exports of Liquefied Natural Gas." The Brookings report, which was assembled by a panel consisting of the authors of each major study and other gas industry experts, is a useful review of the issues that each study is attempting to address, and a summary of their collective results from a policy perspective. This report concludes that macroeconomic effects of LNG exports would greatly outweigh effects on domestic gas consumers.

[189] Deloitte Center for Energy Solutions and Deloitte MarketPoint LLC, Exporting the American Renaissance Global impacts of LNG exports from the United States, November 2012, https://www2.deloitte.com/content/dam/Deloitte/global/Documents/dttl-er-exportingamericanrenaissance-08072013.pdf.

[190] Deloitte's gas price projection is shown in Exhibit 1-8.

- Rice/Baker – an analysis using the same generalized equilibrium model discussed above (and below) of the likely global effects of US LNG exportation, and likely volumes.[191] Rice/Baker's World Gas Model (WGM) employs essentially the same methodology as the Deloitte WGTM, with some differences in data and assumptions. In particular, Deloitte's version of the same basic model incorporates a large number of foreign contractual realities (as constraints); the Rice/Baker model generally does not embody such constraints and provides, therefore, an assessment of purely economic effects.[192] Rice/Baker's analysis concludes that US gas consumers will experience virtually no increase in retail gas prices due to LNG exports and that only minor volumes (about 2 Bcf/d) of US LNG will be exported because other world gas suppliers will out-compete the US.
- Council on Foreign Relations – a special report that critiques existing studies. This influential report provides a review of more in-depth studies it considers to be the best information available, and concludes that LNG exports are in the nation's economic and strategic interest.

In summary, the crop of LNG export impact studies conducted in the past several years provides an important, although mixed, source of information about gas supply elasticity for the gas production area price DRIPE study.

AEO 2014 Low Economic Growth Case versus AEO Reference Case

Following along lines of the methodology employed to calculate gas DRIPE in the AESC 2013 report, we estimated gas supply elasticities implicit in the NEMS model, as gleaned from a comparison of AEO 2014 cases.[193] AESC 2013 compared a large number of AEO 2012 cases to assess elasticities, and based its conclusions on that part of its review. Instead, AESC 2015 makes only a single comparison, namely, that most directly related to a gas demand reduction in isolation of other factors. In effect, this method tries to identify gas supply elasticities inherent in the NEMS model – not really different from the methodology in the AESC 2013 report, but simpler, again, with the realization that the pace of ongoing change has been so great in the Marcellus/Utica shale fields, that use of AEO's models represents a

[191] Reported in Kenneth B. Medlock III, "U.S. LNG Exports: Truth or Consequence," Rice/Baker, August 10, 2012.

[192] Unlike in the U.S., long-term take-or-pay gas sales and purchase contracts (SPAs) dominate commerce in most other gas industries, including pipeline gas and LNG markets. In the U.S., Canada and the UK, however, gas is traded fluidly in short term or spot arrangements; even where long-term SPAs exist, they take pricing signals from spot gas indices. Consequently, differences between the Deloitte and Baker/Rice models with respect to treatment of SPAs are confined to gas markets outside the U.S., as these kinds of constraints would not be relevant in the U.S, including in the Marcellus/Utica region.

[193] Note, this step is problematic because the NEMS model specifically eschews the use of price-quantity supply curves (thus supply elasticities) in its methodology and, instead, bases its analysis on the extant mix of drilling opportunities known at the time. In other words, EIA recognizes that the real world of gas well drilling actually does not follow a smooth, least-cost-first sequence of activities, thus efforts to impute elasticities inherent in NEMS are somewhat artificial.

snapshot for comparison purposes, and cannot be held out as comprehensive. In addition, we do so despite the caution in the preceding footnote.

In Exhibit 7-11, we find the foregoing discussion demonstrated vividly. Implied short-term elasticity is 10.42), mainly because demand evolves only gradually in the low economic growth case. In contrast, long-term elasticity changes drastically to 1.05 as the impact of reductions in demand are reflected in lower Henry Hub prices.

Exhibit 7-11: Gas Production Area Price Elasticities Implied in AEO 2014 Reference and Low Economic Growth Cases

	AEO 2014 Reference Case	AEO 2014 Low Economic Growth Case	Diff - Change in Sensitivity Case	Implied Elasticity
2015-2020				
Total Consumption/year	26.389	26.012	1.427%	
Average Lower 48 Price	4.354	4.348	0.137%	10.42
2020-2030				
Total Consumption/year	28.452	26.946	5.295%	
Average Lower 48 Price	5.305	5.037	5.061%	1.05

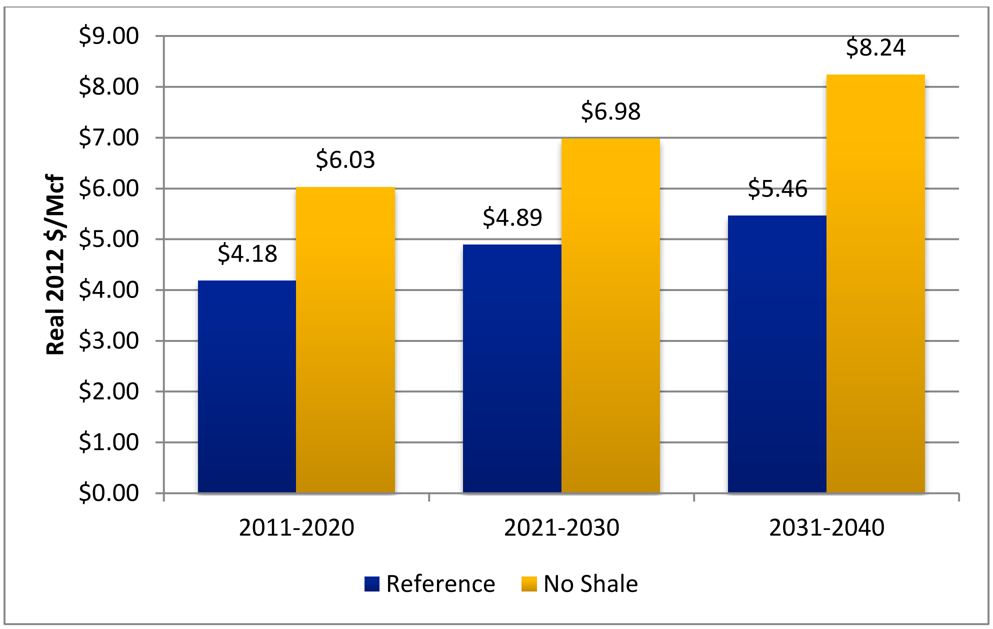
The foregoing analysis continues to have the difficulty plaguing other studies described above, namely, that the NEMS model was only gradually assimilating shale field realities and growth during mid-2013, when EIA was preparing AEO 2014. This concern may explain the rather low 2020-2030 estimate of elasticity we glean from this comparison.

Rice/Baker Studies

As discussed above, focusing specifically on the impact of shale gas, the Rice/Baker team makes use of its World Gas Trade Model, which is essentially the same model methodology employed by the Deloitte MarketPoint team. The Rice/Baker estimates of far greater gas supply price elasticity with shale versus without shale gas, i.e., 1.52 with shale nationally, versus 0.29 without shale – are derived from detailed assessment of field-level economics and emerging rig productivity (Medlock, 2013). EIA's process for reporting drilling productivity grew in part out of this pioneering work. Gas supply price-quantity curves (and, therefore, elasticities) form an inherent component of the Rice/Baker model. Such curves are derived by gleaning information from experienced geologists, field operators, and available local area data. Consequently, the Rice/Baker model comprehends a large number of disaggregated gas supply curves, some field by field. This fine-grained approach facilitates a shale-versus-no-shale analysis by adjusting supply curves for some regions to eliminate the influence of shale gas resources, or removing shale-only curves from the model altogether, depending on the locale. As an illustration, the gas supply curve for Pennsylvania would either include recoverable shale resources of, say, 400 Tcf or it would not, thus leaving only, say, 20 Tcf of recoverable resources. These and other (although not as pronounced) differences in gas supply curves for other locations were developed and incorporated into the Rice/Baker model. Building up regions to the nation as a whole, the Rice/Baker model was used to develop overall elasticities for with-versus-without shale gas scenarios, for the nation as a while. Along with aggregated elasticity measurements, the model results include Henry Hub and regional gas prices at more than 200 locations (hubs, pricing points, and the like), pipeline flows over time, sector-by-sector gas consumption in each of more than a dozen gas demand regions, pipeline gas and LNG imports and exports, and other information consistent with the scenario being examined.

The implications of the Rice/Baker analysis of the impact of shale gas production on Henry Hub prices are shown in Exhibit 7-12. These results illustrate the cost savings to U.S consumers inherent in the shale gas revolution, provided they have access to sufficient pipeline capacity.

Exhibit 7-12: Rice/Baker Estimate of Shale Gas Impact on Projected Henry Hub Prices



AESC 2015 Production Area Gas DRIPE - Conclusions

Based upon our review of the foregoing estimates and our own experience, the TCR team is proposing a production area supply price elasticity of 1.52, drawn from the Rice/Baker studies. That elasticity reflects the impact of Marcellus/Utica shale production, which has a relatively high production area price elasticity that is reasonably expected to last throughout most of the planning horizon. A production area supply price elasticity of 1.52 implies an inverse elasticity of 0.6579 (1/ 1.52) under which a 10% change in gas demand would produce a 6.58% change in the price of gas production. We note that Deloitte MarketPoint and a number of other model-based comprehensive studies (see Exhibit 7-10) produce higher estimates of elasticity than the one used by AESC 2015, thus we deem the 1.52 elasticity as a conservative estimate.

The following example places this elasticity in a New England perspective. If gas fired power plants throughout New England were to reduce gas demand by 100,000 MMBtu/day evenly during the study period (i.e. 0.1 Bcf/day) and if Marcellus/Utica gas production were to remain at 18.4 Bcf/day, the demand reduction would be 0.1 / 18.4 = 0.005435, or about 0.54%.[194] Applying the production area elasticity of 1.52 to that reduction in demand implies that Henry Hub gas prices would decline by 0.54% / 1.52 or about 0.3576%. Applying that decline to the AESC 2015 15 year levelized Henry Hub price of $4.99 per MMBtu (2015$) produces a production area price gas DRIPE effect of $0.0178 per MMBtu ($4.99 * 0.3576%).

The AESC 2015 production area price gas DRIPE is calculated and expressed in a different manner than the AESC 2013 estimate. The AESC 2013 estimate was a "$0.632/MMBtu decrease in Henry Hub gas price for every quad (quadrillion Btu or 10^9 MMBtu) decrease in annual gas consumption."[195] A one quad per year decrease in annual gas consumption is 27.4 times greater than the 100,000 MMBtu/day gas demand reduction example discussed above. Hence, to provide a production area gas DRIPE comparable to a 1 quad decrease in gas demand we multiply the AESC 2015 production area price gas DRIPE estimate of $0.0178 per MMBtu by 27.4 to get an impact of = $0.49/MMBtu for a 1 quad decrease in gas demand. Thus, the AESC 2015 estimate of production area gas DRIPE is approximately 23% less than the AESC 2013 estimate (i.e., 0.49/MMbtu versus 0.63/MMBtu).

7.3.3 New England Basis Gas DRIPE: Assumptions and Methodology

The second component of gas DRIPE is New England basis DRIPE. Much like natural gas, crude oil or agricultural products, some basis differentials are, themselves, commodities that may be traded fluidly in spot and commodity futures markets. Algonquin Citygate basis qualifies in that respect, i.e., Algonquin Citygate basis futures are actively traded on both the New York Mercantile Exchange (NYMEX) and the Inter-Continental Exchange (ICE), the latter with substantial front-month liquidity. As described earlier (see Chapter 2), Algonquin Citygate basis market on ICE (referred to as "ALQ") is a commodity that represents the difference between the wholesale Algonquin Citygate spot gas price and the corresponding price of gas at Henry Hub.

AESC 2013 estimated New England basis using the results of a correlation of daily pipeline nomination quantities and daily basis between Algonquin city-gates and TETCO M-3[196]. The correlation has an R^2 of

[194] Relatively close pricing and correlations among pricing points that lie purely within the supply region per se – Dominion Appalachia and Transco Leidy – suggests that natural gas moves about within the supply region from lower priced points to higher priced points, thus we cannot limit the supply field (the denominator) to volumes on one or another pipeline or within a particular sub-region, especially in a 15-year planning horizon.

[195] _____, AESC 2013, page 7-21.

[196] Ibid. Exhibit 7-21.

0.3525, which indicates that changes in daily nomination quantities do not correlate with changes in daily basis in the manner the regression model implies.

We considered estimating New England basis gas DRIPE from data on Algonquin Citygate basis, in a manner similar to AESC 2013. However, we determined that approach would not provide a reasonable estimate of New England basis gas DRIPE for two main reasons.

First, the attribution of gas basis DRIPE to gas efficiency measures assumes that LDCs will respond to reductions in retail gas use by existing retail customers by releasing temporarily spare pipeline capacity to allow deliveries of gas to gas-fired electric generators. The ASESC 2015 team do not consider this a reasonable assumption other than in the very short term. It is much more likely that LDCs in New England will want to use any pipeline capacity not required to supply existing customers to serve prospective new customers who wish to convert to gas from their existing fuel.

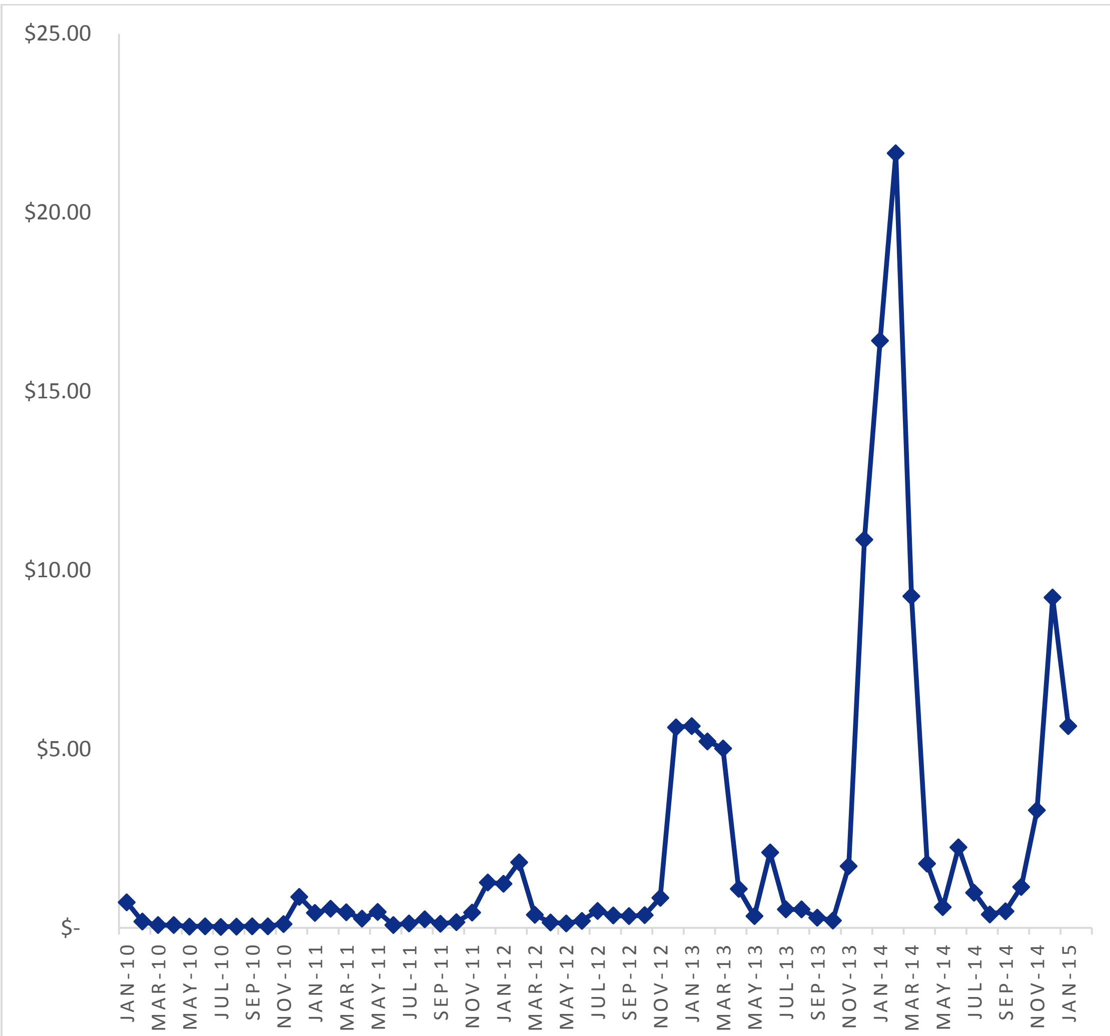
Second, numerous factors drive New England basis, whether referenced to Henry Hub or a Marcellus/Utica gas price index, making it extremely complicated to estimate. Basis on a given day is equal to the value of the marginal source of gas on that day minus the price of gas in the relevant supply region, which is the Henry Hub in this part of our analysis. During winter months the value of the marginal source of gas on a given day will be influenced by:

- The maximum price that marginal generating units are willing to pay for fuel that day. That value will in turn be driven by the market price of electricity expected for the day, the heat rates of their units, their ability to burn a fuel, low sulfur diesel, other than natural gas and the penalty, if any, they face for not generating.
- The price of low sulfur diesel
- The price of the marginal source of gas, which on peak days may be from LNG. (LNG is priced in global gas market competition, its price does not relate to New England so much as to other bidders that may be entirely reliant on its supply, e.g., Japan, South Korea, Taiwan and Spain are largely reliant on global LNG markets, and <u>their</u> alternate fuel is often gas priced to an index of costly liquid fuels.)
- The quantity of gas available from ALG & TGP
- The quantity of gas available from M&NP

Hence, efforts to correlate basis with one pipeline's nominations are problematic. Basis on any day is being driven by numerous factors in addition to pipeline nomination quantities. A correlation of basis with pipeline nomination quantities during winter months especially does not accurately reflect the impacts of these additional factors.

In addition, New England winter gas market conditions have changed dramatically beginning with the winter of 2012/2013, even before the "polar vortex." Falling gas prices in the Marcellus/Utica region coupled with declines in deliveries on M&NP, and costly LNG imports, have all led to dramatic increases in basis in the peak months of December, January and February. For example, Exhibit 7-13 shows how radically winter New England basis has changed since the AESC 2013 and a somewhat earlier study by Concentric[197] (Concentric 2012) were prepared. Not only were the correlations between Algonquin Basis and pipeline nominations presented in those reports clouded by the additional factors discussed above, particularly LNG, but they were prepared before there was a general recognition of the dramatic changes underway in New England winter gas markets. Neither study, however diligent they were, may be used as a foundation to estimate elasticities in the pipeline capacity-starved New England basis markets as we know them now.

Exhibit 7-13: Monthly Index Basis Differential between Algonquin Citygates and Tetco M-3, $/MMBtu



[197] Concentric Energy Advisors, "New England Cost Savings Associated with New Natural Gas Supply and Infrastructure," May 2012.

Consequently, we are proposing a relatively high-level generalized estimate New England basis DRIPE. Using a broad brush, we apply the same basic math described above in order to estimate production area gas DRIPE. Here, instead of referencing supply elasticities with respect to the Marcellus/Utica region's production of 18.4 Bcf/day, we consider the pipeline capacity available to deliver gas into the region from producing areas west of New England, particularly the Marcellus/Utica fields. As developed in Exhibit 4-5 of AESC 2015 Task 3A report, that existing Delivery Capacity equals 2.6 Bcf/day. Using our earlier example: a gas demand reduction of 100,000 MMcf/day (0.1 Bcf/day) amounts to a change of 0.10/2.6= 3.8%. We further assuming basis is highly inelastic in the winter months due to the limited quantity of capacity to deliver gas from the west, for a winter basis elasticity of 1:1, and highly elastic in the summer for a zero impact. The 0.1 Bcf/day reduction in demand in winter would produce a 3.8% reduction in winter month basis. AESC 2015 New England basis DRIPE is less than the 2013 estimates, as shown below.

Exhibit 7-14. Estimate of New England basis DRIPE

Estimate of New England basis DRIPE

Month	Pipeline Capacity able to deliver Marcellus gas into western New England	Reduction in wholesale gas Use	% change	Basis Elasticity	New England basis to HH	Change in New England basis		Three Peak winter Months (D, J, F)			AESC 2013	Aesc 2015 vs AESC 2013
	bcf/Day	bcf/day			$/MMBtu	$/Mmbtu		coefficients			Exhibit 7-23	CHANGE - higher (lower)
								$/MMbtu reduction per reduction of				
								0.1 bcf/day	MMcf/day			
	a	b	c = b / a	d	e	f = e * c * d		g = avg DEC, Jan, Feb	h = g / 100		i	j = h / I - 1
December-13	2.6	0.1	3.8%	1	$ 11.36	$ 0.44						
January-14	2.6	0.1	3.8%	1	$ 17.65	$ 0.68		0.7566	0.00757		0.016	-53%
February-14	2.6	0.1	3.8%	1	$ 30.00	$ 1.15						
December-14	2.6	0.1	3.8%	1	$ 9.75	$ 0.38						
January-15	2.6	0.1	3.8%	1	$ 12.16	$ 0.47		0.4386	0.00439		0.0118	-63%
February-15	2.6	0.1	3.8%	1	$ 12.30	$ 0.47						
December-15	2.8	0.1	3.6%	1	$ 8.55	$ 0.31						
January-16	2.8	0.1	3.6%	1	$ 11.95	$ 0.43		0.3787	0.00379		0.0106	-64%
February-16	2.8	0.1	3.6%	1	$ 11.31	$ 0.40						
December-16	2.8	0.1	3.6%	1	$ 4.47	$ 0.16						
January-17	2.8	0.1	3.6%	1	$ 8.16	$ 0.29		0.2176	0.00218		0.004	-46%
February-17	2.8	0.1	3.6%	1	$ 5.64	$ 0.20						
December-17	3.2	0.1	3.1%	1	$ 4.39	$ 0.14						
January-18	3.2	0.1	3.1%	1	$ 2.50	$ 0.08		0.0953	0.00095		0.003	-68%
February-18	3.2	0.1	3.1%	1	$ 2.25	$ 0.07						
December-18	3.8	0.1	2.6%	1	$ 1.83	$ 0.05						
January-19	3.8	0.1	2.6%	1	$ 2.45	$ 0.06		0.0570	0.00057		0.003	-81%
February-19	3.8	0.1	2.6%	1	$ 2.21	$ 0.06						

7.4 Direct DRIPE Effects from Electric Efficiency

Section 7.2 provides estimates of the effect of reductions in electric energy use from energy efficiency programs on wholesale market prices for energy through May 2018. This section calculates the impact of those DRIPE effects on the retail rates of electric customers by year.

Electric energy DRIPE affects wholesale energy market prices immediately. Prior AESC studies have assumed that those wholesale energy price effects do not flow through to all retail electric customers immediately because most energy purchased for retail load is bought at prices set several months in advance of delivery. While that assumption is correct, it is reasonable to assume that the prices that are set several months in advance are based upon and /or tied to a projection of market prices for the period during which the electricity would be used. Moreover, the exact details of those contract quantities and prices are confidential. For those reasons, and because AESC 2015 is calculating energy DRIPE effects relative to a BAU Case, which is a realistic projection of market prices, we do not reduce the forecast load subject to wholesale energy market prices in each year by assumed levels of hedging.

Exhibit 7-15 presents the energy DRIPE effects by year by state.

Exhibit 7-15. Energy own-price DRIPE effects by year by state

Winter On-Peak						
Intrastate						
Year	**CT**	**MA**	**ME**	**NH**	**RI**	**VT**
2016	$ 6.60	$ 20.45	$ 3.72	$ 3.33	$ 2.43	$ 1.63
2017	$ 6.31	$ 19.57	$ 3.56	$ 3.18	$ 2.33	$ 1.56
2018	$ 3.34	$ 10.35	$ 1.89	$ 1.68	$ 1.23	$ 0.83
Rest-of Pool						
Year	**CT**	**MA**	**ME**	**NH**	**RI**	**VT**
2016	$ 5.83	$ 18.30	$ 3.88	$ 3.61	$ 1.21	$ 1.46
2017	$ 5.58	$ 17.51	$ 3.71	$ 3.46	$ 1.16	$ 1.40
2018	$ 2.95	$ 9.26	$ 1.96	$ 1.83	$ 0.61	$ 0.74

Summer On-Peak						
Intrastate						
Year	**CT**	**MA**	**ME**	**NH**	**RI**	**VT**
2016	$ 2.94	$ 34.19	$ (2.31)	$ 11.53	$ 11.67	$ (1.27)
2017	$ 3.03	$ 35.28	$ (2.38)	$ 11.90	$ 12.05	$ (1.31)
Rest-of Pool						
Year	**CT**	**MA**	**ME**	**NH**	**RI**	**VT**
2016	$ 2.73	$ 29.14	$ (2.75)	$ 4.44	$ 6.39	$ (3.05)
2017	$ 2.82	$ 30.07	$ (2.84)	$ 4.58	$ 6.59	$ (3.15)

Winter Off-Peak						
Intrastate						
Year	**CT**	**MA**	**ME**	**NH**	**RI**	**VT**
2016	**$ 8.79**	**$ 10.20**	**$ 2.27**	**$ 3.59**	**$ 1.01**	**$ 1.34**
2017	**$ 8.40**	**$ 9.75**	**$ 2.17**	**$ 3.44**	**$ 0.96**	**$ 1.28**
2018	**$ 4.39**	**$ 5.09**	**$ 1.13**	**$ 1.79**	**$ 0.50**	**$ 0.67**
Rest-of Pool						
Year	**CT**	**MA**	**ME**	**NH**	**RI**	**VT**
2016	**$ 7.84**	**$ 10.45**	**$ 2.45**	**$ 3.68**	**$ 0.91**	**$ 1.37**
2017	**$ 7.49**	**$ 9.99**	**$ 2.35**	**$ 3.52**	**$ 0.87**	**$ 1.31**
2018	**$ 3.91**	**$ 5.22**	**$ 1.22**	**$ 1.84**	**$ 0.45**	**$ 0.68**

Summer Off-Peak						
Intrastate						
Year	**CT**	**MA**	**ME**	**NH**	**RI**	**VT**
2016	**$ 9.03**	**$ 10.08**	**$ 0.72**	**$ (0.02)**	**$ 0.72**	**$ 0.94**
2017	**$ 10.70**	**$ 11.93**	**$ 0.85**	**$ (0.03)**	**$ 0.85**	**$ 1.12**
Rest-of Pool						
Year	**CT**	**MA**	**ME**	**NH**	**RI**	**VT**
2016	**$ 4.86**	**$ 9.26**	**$ 0.90**	**$ (0.00)**	**$ 0.40**	**$ 0.54**
2017	**$ 5.75**	**$ 10.96**	**$ 1.06**	**$ (0.00)**	**$ 0.48**	**$ 0.64**

7.5 Gas DRIPE and Electric Fuel-Related DRIPE Assumptions and Methodology

This section describes the major assumptions and methods AESC 2015 used to calculate natural gas efficiency direct and cross-fuel DRIPE as well as electric efficiency fuel-related and cross-fuel DRIPE.

Exhibit 7-16 provides an overview of our calculations of these three categories of DRIPE.

Exhibit 7-16. Summary of Gas-Related DRIPE Effects

Efficiency Programs	Value of Usage Reduction	Wholesale Gas Cost Component	Avoided Cost Calculation
Gas	Avoided Cost to retail gas consumers	Supply	Supply price DRIPE * retail gas use subject to wholesale gas supply price
		Pipeline transportation and Storage services	No impact
	Cross-fuel : Avoided Cost to retail electric consumers via reduction in fuel cost to gas-fired electric generation	Supply	Price DRIPE * retail electric use subject to wholesale electric energy market price
		Basis	Price DRIPE * retail electric use subject to wholesale electric energy market price
Electricity	Avoided Cost to retail electric consumers via reduction in fuel cost to gas-fired electric generation	Supply	Price DRIPE * retail electric use subject to wholesale electric energy market price
		Basis	Price DRIPE * retail electric use subject to wholesale electric energy market price
	Cross-fuel : Avoided Cost to retail gas consumers via reduction in gas supply cost	Supply	Supply price DRIPE * retail gas use subject to supply price
		Pipeline transportation and Storage services	No impact

7.5.1 DRIPE Value of Reduction in Retail Gas Use – Assumptions and Method

The gas supply DRIPE effect of reductions in retail gas use is:

- the quantity of retail gas saved (MMBtu), multiplied by
- the gas supply DRIPE from Chapter 6 of $0.49 × 10^{-9}/MMBtu per MMBTU saved, multiplied by
- the quantity of retail gas use (MMBtu) paying a price tied to the wholesale supply price. (AESC 2015 assumes this to be 100 per cent since the details of gas utility hedging arrangements, to the extent they exist, are confidential).

As in AESC we do not calculate a basis DRIPE because only a very small portion of gas delivered to retail gas users in New England is subject to market basis the reduction in retail gas use.

Cross-Fuel

The avoided cost to retail electric consumers from reductions in retail gas use results from the impact of savings from gas efficiency on the fuel cost of gas-fired electric generation. The reductions in retail gas use result in both gas supply DRIPE, ($0.49 × 10^{-9}/MMBtu per MMBTU saved) and gas basis DRIPE. Those two sources of DRIPE result in a lower price for wholesale gas in New England, i.e. the fuel cost of gas-fired electric generating units. Those lower wholesale gas prices will, in turn, tend to reduce wholesale electric energy prices by reducing the production costs of gas-fired units. While generators are free to set their bid prices, the optimal bidding strategy for a gas fired generator that may set the market price is to bid an electric energy price close to its fuel price multiplied by its heat rate.

The cross-fuel gas supply DRIPE effect of reductions in retail gas use is:

- the quantity of retail gas saved (MMBtu), multiplied by
- the gas supply DRIPE from Chapter 6 of $\$0.49 \times 10^{-9}$/MMBtu per MMBTU saved, multiplied by
- the MMBtu required to produce a MWh of electricity. This is 7.2 MMBtu/MWh based on gas units setting the marginal energy price (directly or indirectly) in 85 percent of hours at an annual average heat rate of 8,500 Btu/kWh (i.e. 7.2 MMBTU/MWh = 8.5 MMBtu/MWh $\times$ 0.85), multiplied by
- the quantity of retail electric use (MWh) subject to wholesale energy prices.

Steps two and three reduce to $\$3.54 \times 10^{-9}$/MWh per MMBTU saved, which is the gas supply DRIPE of \$0.49 × 10 9/MMBtu per MMBTU multiplied by the quantity of MMBtu required to produce a MWh of electricity of 7.2 MMBtu/MWh.

The cross-fuel basis DRIPE effect of reductions in retail gas use each year is:

- the quantity of retail gas saved (MMBtu), multiplied by
- the basis DRIPE (\$/MMBtu per Mcf/day saved) from Chapter 6 each year multiplied by
- the MMBtu required to produce a MWh of electricity, i.e., 7.2 MMBtu/MWh, multiplied by
- the quantity of retail electric use (MWh) subject to wholesale energy prices.

7.5.2 Fuel and Cross-Fuel DRIPE Value of Reduction in Retail Electric Use – Assumptions and Method

The gas supply DRIPE effect on energy market prices of reductions in retail electric use is:

- the reduction in electric energy (MWh), multiplied by
- $\$3.54 \times 10^{-9}$/MMBtu per MWh saved, multiplied by
- the MMBtu required to produce a MWh of electricity, 7.2 MMBtu, multiplied by
- the quantity of retail electric use (MWh) subject to wholesale energy prices.

Steps two and three reduce to $\$2.55 \times 10^{-8}$/MWh per MMBTU saved. This is \$3.54 × 10 9/MMBtu per MMBTU multiplied by the quantity of MMBtu required to produce a MWh of electricity of 7.2 MMBtu/MWh.

The basis DRIPE effect of reductions in retail electric use each year is:

- the reduction in electric energy (MWh), multiplied by.
- the basis DRIPE from Chapter 6 each year , expressed as $/TWh per quad saved, multiplied by
- the quantity of MMBtu required to produce a MWh of electricity, i.e., 7.2 MMBtu/MWh, multiplied by
- the quantity of retail electric use (MWh) subject to wholesale energy prices.

Cross-Fuel

The cross-fuel gas supply DRIPE effect of reductions in retail electric use is:

- the reduction in electric energy (MWh), multiplied by
- $2.55 × 10^{-8}/MMBtu per MWh saved, multiplied by
- the quantity of retail gas use (MMBtu) paying a price tied to the wholesale supply price.

7.6 DRIPE Effects from Gas Efficiency on Retail Customers

7.6.1 Gas Efficiency Direct DRIPE

The gas supply DRIPE for each New England state, and the total benefit for all New England gas end-use consumers, is shown in Exhibit 7-17.

Exhibit 7-17. Supply DRIPE Benefit in Annual MMBtu Load Reduction, by State

	CT	MA	ME	NH	RI	VT	New England
Annual Use in 2013 (quads)	0.1232	0.2800	0.0423	0.0243	0.0380	0.0095	0.5172
Gas efficiency supply price DRIPE effect ($ x 10^{-9}/MMBTU per MMBtu saved)	$0.060	$0.137	$0.021	$0.012	$0.019	$0.005	$0.253

The speed at which that supply DRIPE is reflected in retail rates depends upon the extent to which utilities, marketers, and self-supplying customers are hedging their purchases. Since we do not know the extent to which the gas utilities, marketers, and self-supplying customers in each state hedge their purchases, and since the specific details of those hedging arrangements are confidential, AESC 2015 assumes no hedging. Thus 100 per cent of retail gas use is assumed to benefit from gas supply price DRIPE.

AESC 2015 assumes gas supply DRIPE benefits would continue as long as the efficiency measure continues to reduce load. Gas supply DRIPE is measuring the effect of demand on the marginal cost of extraction for a finite resource.

7.6.2 Gas Efficiency Cross-Fuel DRIPE

The gas supply price DRIPE effect on annual average wholesale electric energy prices in New England due to a one MMBtu reduction in annual gas use is $\$3.54 \times 10^{-9}$/MWh per MMBtu saved, as noted above.

The basis DRIPE effect on annual average wholesale electric energy prices in New England due to a reduction in annual gas use in each state would be a function of the reduction by time period, the basis DRIPE coefficients by time period, the MMBtu required to produce a MWh of electricity (i.e., 7.2 MMBtu/MWh), and the MWh of annual electric use paying prices tied to the wholesale energy price.[198]

The basis DRIPE coefficient for the three peak winter months, December through February, from Exhibit 1-1 is presented in column a. The basis DRIPE coefficient for the remaining two months of the gas industry winter, i.e. November and March, is approximately 29 percent of the three peak month value. The resulting basis DRIPE for the five month winter is a weighted average of those two periods, as presented in Exhibit 7-18. AESC 2015 assumes that basis DRIPE will terminate after 2020. The AESC 2015 Base Case assumes that significant additional pipeline capacity will be in service by that time, which will change the New England demand / supply situation substantially relative to current market conditions. In contrast, the AESC 2015 estimate of basis DRIPE for winter months is based on current market conditions in New England. Moreover it is a high level qualitative assumption of elasticity of 1. Thus it is reasonable to assume that basis elasticity will change after 2019.

Exhibit 7-18. Basis DRIPE Coefficients by Time Period, MMBtu per Mcf/Day Saved

Year	Three peak Winter months	Two shoulder Winter months	Gas Industry Winter (Nov - March)	Summer (April - October)
	a	b = a * 29%	c = ((a* 90 days) + (b * 61 days))/ 151 days	d
2016	0.00379	0.0011	0.0024	0.0000
2017	0.00218	0.0006	0.0014	0.0000
2018	0.00095	0.0003	0.0006	0.0000
2019	0.00057	0.0002	0.0004	0.0000
2020	0.00056	0.0002	0.0004	0.0000

The DRIPE coefficients in Exhibit 7-18 are stated in terms of reductions in average daily gas load in each time period in each year. For example, a one MMBtu/day of load reduction throughout the winter is a load reduction of 90 MMBtu. Therefore the DRIPE coefficient for one MMBtu reduction in total for a

[198] Since generation everywhere in ISO-NE serves load throughout New England, the cross-price effect on electric consumers in a state is not dependent on the amount of gas burned for electric generation in that state.

given time period is much lower than the coefficient for a one MMBtu/day reduction during that same time period. Exhibit 7-19 converts the gas basis price effect per MMBtu saved per day into a gas basis price effect per quad saved in each time period.

Exhibit 7-19 Gas Basis Coefficients, $/MMBtu Reduction per Quad Saved

Year	Three peak Winter months	Two shoulder Winter months	Gas Industry Winter (Nov - March)	Baseload
Days per Period	90	61	151	Winter portion
	a = (Basis per MCF per day / # days) * 10^6	a = (Basis per MCF per day / # days) * 10^6	c = ((a* 90 days) + (b * 61 days))/ 151 days	d = c * 151 / 365
2016	$ 42.07	$ 18.12	32.4	$ 13.40
2017	$ 24.17	$ 10.41	18.6	$ 7.70
2018	$ 10.59	$ 4.56	8.2	$ 3.37
2019	$ 6.33	$ 2.73	4.9	$ 2.02
2020	$ 6.22	$ 2.68	4.8	$ 1.98

Exhibit 7-20 summarizes the gas-on-electric cross-fuel basis DRIPE coefficients, stated in dollars per TWh (million MWh) per MMBtu saved.

Exhibit 7-20. Cross-Fuel DRIPE ($/TWh per MMBtu Gas Saved)

Gas Cross DRIPE $/TWh per MMBtu saved					
		Basis		total DRIPE	
	Supply (annual)	Gas Heating (Nov to March)	Gas Baseload (annual)	Gas Heating (Nov to March)	Gas Baseload (annual)
2016	0.00354	0.23408	0.09684	0.23762	0.10038
2017	0.00354	0.13449	0.05564	0.13803	0.05918
2018	0.00354	0.05890	0.02437	0.06244	0.02791
2019	0.00354	0.03521	0.01457	0.03875	0.01811
2020	0.00354	0.03462	0.01432	0.03816	0.01786
2021	0.00354	0.00000	0.00000	0.00354	0.00354
2022	0.00354	0.00000	0.00000	0.00354	0.00354
2023	0.00354	0.00000	0.00000	0.00354	0.00354
2024	0.00354	0.00000	0.00000	0.00354	0.00354
2025	0.00354	0.00000	0.00000	0.00354	0.00354
2026	0.00354	0.00000	0.00000	0.00354	0.00354
2027	0.00354	0.00000	0.00000	0.00354	0.00354
2028	0.00354	0.00000	0.00000	0.00354	0.00354
2029	0.00354	0.00000	0.00000	0.00354	0.00354
2030	0.00354	0.00000	0.00000	0.00354	0.00354

Exhibit 7-21 summarizes the own-state and ISO-wide cross-fuel DRIPE values for gas efficiency installations based upon the coefficients in Exhibit 7-20 and that approximately 50 percent of electric energy usage occurs in the heating season.

Exhibit 7-21. Gas-to-Electric Cross-Fuel Heating DRIPE, $/MMBtu, Gas Efficiency installations

Gas Winter Heating DRIPE

Year	CT	MA	ME	NH	RI	VT	New England
2016	$ 3.11	$ 5.79	$ 1.10	$ 1.16	$ 0.77	$ 0.57	$ 12.49
2017	$ 1.84	$ 3.36	$ 0.64	$ 0.68	$ 0.44	$ 0.33	$ 7.29
2018	$ 0.83	$ 1.51	$ 0.29	$ 0.31	$ 0.20	$ 0.15	$ 3.29
2019	$ 0.51	$ 0.94	$ 0.18	$ 0.19	$ 0.12	$ 0.09	$ 2.04
2020	$ 0.51	$ 0.92	$ 0.17	$ 0.19	$ 0.12	$ 0.09	$ 2.00
2021	$ 0.05	$ 0.09	$ 0.02	$ 0.02	$ 0.01	$ 0.01	$ 0.19
2022	$ 0.05	$ 0.09	$ 0.02	$ 0.02	$ 0.01	$ 0.01	$ 0.18
2023	$ 0.05	$ 0.09	$ 0.02	$ 0.02	$ 0.01	$ 0.01	$ 0.18
2024	$ 0.05	$ 0.09	$ 0.02	$ 0.02	$ 0.01	$ 0.01	$ 0.18
2025	$ 0.05	$ 0.08	$ 0.02	$ 0.02	$ 0.01	$ 0.01	$ 0.18
2026	$ 0.05	$ 0.08	$ 0.02	$ 0.02	$ 0.01	$ 0.01	$ 0.18
2027	$ 0.05	$ 0.08	$ 0.02	$ 0.02	$ 0.01	$ 0.01	$ 0.18
2028	$ 0.05	$ 0.08	$ 0.02	$ 0.02	$ 0.01	$ 0.01	$ 0.18
2029	$ 0.05	$ 0.08	$ 0.02	$ 0.02	$ 0.01	$ 0.01	$ 0.18
2030	$ 0.05	$ 0.08	$ 0.02	$ 0.02	$ 0.01	$ 0.01	$ 0.18

Gas Annual Baseload DRIPE

Year	CT	MA	ME	NH	RI	VT	New England
2016	$ 3.28	$ 6.12	$ 1.16	$ 1.23	$ 0.81	$ 0.60	$ 13.19
2017	$ 1.97	$ 3.60	$ 0.68	$ 0.73	$ 0.48	$ 0.35	$ 7.82
2018	$ 0.93	$ 1.69	$ 0.32	$ 0.35	$ 0.22	$ 0.17	$ 3.68
2019	$ 0.60	$ 1.09	$ 0.21	$ 0.23	$ 0.14	$ 0.11	$ 2.38
2020	$ 0.59	$ 1.08	$ 0.20	$ 0.22	$ 0.14	$ 0.10	$ 2.34
2021	$ 0.12	$ 0.21	$ 0.04	$ 0.04	$ 0.03	$ 0.02	$ 0.46
2022	$ 0.12	$ 0.21	$ 0.04	$ 0.04	$ 0.03	$ 0.02	$ 0.46
2023	$ 0.12	$ 0.21	$ 0.04	$ 0.05	$ 0.03	$ 0.02	$ 0.46
2024	$ 0.12	$ 0.21	$ 0.04	$ 0.05	$ 0.03	$ 0.02	$ 0.46
2025	$ 0.12	$ 0.21	$ 0.04	$ 0.05	$ 0.03	$ 0.02	$ 0.46
2026	$ 0.12	$ 0.21	$ 0.04	$ 0.05	$ 0.03	$ 0.02	$ 0.46
2027	$ 0.12	$ 0.21	$ 0.04	$ 0.05	$ 0.03	$ 0.02	$ 0.46
2028	$ 0.12	$ 0.21	$ 0.04	$ 0.05	$ 0.03	$ 0.02	$ 0.46
2029	$ 0.12	$ 0.21	$ 0.04	$ 0.05	$ 0.03	$ 0.02	$ 0.46
2030	$ 0.12	$ 0.21	$ 0.04	$ 0.05	$ 0.03	$ 0.02	$ 0.46

Exhibit 7-22 provides a comparison of the Gas direct DRIPE and cross-fuel DRIPE 2013 for CT. AESC 2015 results are lower than AESC 2013, primarily due to the lower AESC 2015 estimate of basis DRIPE. The AESC 2015 results for other states are similarly lower than the AESC 2013 results.

Exhibit 7-22. Gas Supply DRIPE and Cross-Fuel DRIPE, AESC 2015 vs AESC 2013, CT, 2016 Installations, 15 Year Levelized (2015$/MMBtu)

CT		Gas Supply DRIPE applicable to every MMBtu Reduction	Gas to Electric DRIPE							
			RESIDENTIAL				COMMERCIAL & INDUSTRIAL			ALL RETAIL END USES
Study	Dollars		Non Heating	Hot Water	Heating	All	Non Heating	Heating	All	
		1	2	3	4	5	6	7	8	9
AESC 2013	2013$	$ 0.07	$ 0.79	$ 1.23	$ 1.37	$ 1.25	$ 0.95	$ 1.23	$ 1.11	$ 1.19
	2015$	$ 0.07	$ 0.82	$ 1.27	$ 1.42	$ 1.30	$ 0.98	$ 1.27	$ 1.15	$ 1.23
AESC 2015	2015$	$ 0.06	$ 0.64	$ 0.57	$ 0.55	$ 0.57	$ 0.61	$ 0.57	$ 0.59	$ 0.58
AESC 2015 vs AESC 2013		-14%	-22%	-55%	-61%	-56%	-38%	-55%	-49%	-53%

7.7 Fuel DRIPE Effects from Electric Gas Efficiency on Retail Customers

7.7.1 Electric Efficiency Own Fuel DRIPE Effects

The gas supply DRIPE effect of a one MWh reduction in annual electric use is $\$2.55 \times 10^{-8}$/ per MWh saved. The basis DRIPE effect of that one MWh reduction is the reduction in electric energy (MWh) multiplied by the basis DRIPE multiplied by 7.2 MMBtu/MWh. Exhibit 7-23 shows the resulting electric efficiency gas supply and basis DRIPE effects by year.

Exhibit 7-23. Annual Electric-Gas-Electric Price Benefit per MWh Saved

	Winter					
	CT	MA	ME	NH	RI	VT
2016	$22.443	$41.851	$7.912	$8.407	$5.542	$4.094
2017	$13.283	$24.268	$4.607	$4.943	$3.211	$2.391
2018	$5.999	$10.945	$2.073	$2.249	$1.443	$1.067
2019	$3.715	$6.770	$1.279	$1.402	$0.889	$0.653
2020	$3.651	$6.649	$1.254	$1.387	$0.868	$0.636
2021	$0.338	$0.616	$0.116	$0.129	$0.080	$0.058
2022	$0.338	$0.615	$0.116	$0.130	$0.080	$0.058
2023	$0.338	$0.615	$0.115	$0.130	$0.079	$0.057
2024	$0.338	$0.614	$0.115	$0.131	$0.079	$0.057
2025	$0.338	$0.613	$0.115	$0.132	$0.078	$0.056
2026	$0.337	$0.612	$0.114	$0.132	$0.077	$0.055
2027	$0.337	$0.611	$0.114	$0.133	$0.077	$0.055
2028	$0.336	$0.610	$0.113	$0.133	$0.076	$0.054
2029	$0.336	$0.609	$0.113	$0.134	$0.076	$0.054
2030	$0.336	$0.608	$0.112	$0.135	$0.075	$0.053
levelized 15	$3.97	$7.31	$1.38	$1.49	$0.96	$0.71
	Summer					
	CT	MA	ME	NH	RI	VT
2016	$14.221	$26.519	$5.013	$5.327	$3.512	$2.594
2017	$8.543	$15.607	$2.963	$3.179	$2.065	$1.538
2018	$4.022	$7.338	$1.390	$1.508	$0.968	$0.715
2019	$2.604	$4.745	$0.896	$0.983	$0.623	$0.458
2020	$2.564	$4.669	$0.880	$0.974	$0.610	$0.447
2021	$0.508	$0.924	$0.174	$0.194	$0.120	$0.088
2022	$0.507	$0.923	$0.173	$0.195	$0.119	$0.087
2023	$0.507	$0.923	$0.173	$0.196	$0.119	$0.086
2024	$0.507	$0.921	$0.172	$0.197	$0.118	$0.085
2025	$0.506	$0.920	$0.172	$0.197	$0.117	$0.084
2026	$0.506	$0.918	$0.171	$0.198	$0.116	$0.083
2027	$0.505	$0.917	$0.171	$0.199	$0.115	$0.082
2028	$0.505	$0.915	$0.170	$0.200	$0.115	$0.081
2029	$0.504	$0.914	$0.169	$0.201	$0.114	$0.080
2030	$0.504	$0.912	$0.169	$0.202	$0.113	$0.080
levelized 15	$2.76	$5.08	$0.96	$1.04	$0.67	$0.49

7.7.2 Electric Efficiency Cross-Fuel DRIPE Effect on Retail Gas Rates

Exhibit 7-24 shows the results of multiplying the estimated supply price reduction per MWh of electric efficiency by the end-use gas consumption in each state and the region to estimate the electric cross-fuel effect on retail gas prices.

Exhibit 7-24. Annual Gas Price Benefit ($ x 10-9/MMBTU per MWh Saved)

	WINTER					
Year	CT	MA	ME	NH	RI	VT
2016	$22.748	$42.547	$8.017	$8.467	$5.636	$4.118
2017	$13.589	$24.964	$4.712	$5.003	$3.306	$2.414
2018	$6.304	$11.641	$2.178	$2.310	$1.538	$1.091
2019	$4.020	$7.466	$1.384	$1.462	$0.983	$0.677
2020	$3.957	$7.345	$1.359	$1.447	$0.963	$0.659
2021	$0.644	$1.312	$0.221	$0.189	$0.174	$0.082
2022	$0.644	$1.311	$0.221	$0.190	$0.174	$0.081
2023	$0.644	$1.311	$0.220	$0.191	$0.174	$0.081
2024	$0.643	$1.310	$0.220	$0.191	$0.173	$0.080
2025	$0.643	$1.309	$0.220	$0.192	$0.172	$0.080
2026	$0.643	$1.308	$0.219	$0.192	$0.172	$0.079
2027	$0.642	$1.307	$0.219	$0.193	$0.171	$0.078
2028	$0.642	$1.306	$0.218	$0.194	$0.171	$0.078
2029	$0.641	$1.305	$0.218	$0.194	$0.170	$0.077
2030	$0.641	$1.304	$0.217	$0.195	$0.170	$0.077
levelized 15	$4.27	$8.01	$1.49	$1.55	$1.06	$0.74

	SUMMER					
	CT	MA	ME	NH	RI	VT
2016	$14.352	$26.817	$5.058	$5.353	$3.552	$2.604
2017	$8.673	$15.905	$3.008	$3.205	$2.106	$1.548
2018	$4.152	$7.636	$1.435	$1.534	$1.008	$0.725
2019	$2.735	$5.043	$0.941	$1.008	$0.663	$0.468
2020	$2.695	$4.967	$0.925	$0.999	$0.650	$0.457
2021	$0.638	$1.222	$0.219	$0.220	$0.160	$0.098
2022	$0.638	$1.221	$0.218	$0.220	$0.160	$0.097
2023	$0.638	$1.221	$0.218	$0.221	$0.159	$0.096
2024	$0.638	$1.220	$0.217	$0.222	$0.158	$0.095
2025	$0.637	$1.218	$0.217	$0.223	$0.157	$0.094
2026	$0.637	$1.217	$0.216	$0.224	$0.157	$0.093
2027	$0.636	$1.215	$0.216	$0.225	$0.156	$0.092
2028	$0.636	$1.213	$0.215	$0.226	$0.155	$0.091
2029	$0.635	$1.212	$0.214	$0.227	$0.154	$0.091
2030	$0.634	$1.210	$0.214	$0.228	$0.154	$0.090
levelized 15	$2.89	$5.38	$1.00	$1.06	$0.71	$0.50

Appendix A: Usage Instructions

Table of Exhibits

1.1 Introduction

This appendix provides instructions on how to apply the Base Case avoided costs of electricity, how to estimate avoided costs of electricity for the High Gas sensitivity case, and how to apply the Base Case avoided costs of natural gas.

1.2 Base Case Avoided Costs of Electricity

Appendix B of AESC 2015 provides detailed projections of avoided electricity costs for each New England state as well as for specific zones within Massachusetts whose energy prices differ from the statewide energy price. Appendix B provides tables in constant 2015$ for the following reporting regions:

- Connecticut
- Massachusetts : Northeast Massachusetts (NEMA), West Central Massachusetts (WCMA), Southeast Massachusetts (SEMA), MA statewide
- Maine
- New Hampshire
- Rhode Island
- Vermont

Appendix B also provides tables in nominal $ for Connecticut.

The projections are provided as two- page tables in Appendix B. The Excel workbooks used to develop these tables are provided to Program Administrators.

The Appendix B tables use the following costing periods:[1]

- Summer On-Peak: The 16-hour block 7 am–11 pm, Monday–Friday (except ISO holidays), in the months of June–September (1,390 Hours, 15.9 percent of 8,760).[2]
- Summer Off-Peak: All other hours–11 pm–7 am, Monday–Friday, weekends, and ISO holidays in the months of June–September (1,530 Hours, 17.5 percent of 8,760).
- Winter On-Peak: The 16-hour block 7 am–11 pm, Monday–Friday (except ISO holidays), in the eight months of January–May and October–December (2,781 Hours, 31.7 percent of 8,760).
- Winter Off-Peak: All other hours–11 pm-7 am, Monday–Friday, all day on weekends, and ISO holidays–in the months of January–May and October–December (3,059 Hours, 34.9 percent of 8,760)

The "all-hours" avoided electricity cost for a given year, or set of years, is equal to the hour-weighted average of avoided costs for each costing period of that year.

All-hours avoided electricity cost = (15.9 percent *summer on-peak) + (17.5 percent *summer off-peak) + (31.7 * winter on-peak) + (34.9 percent * winter off-peak)

Page one of each reporting region table provides the following avoided cost components:

1. Avoided unit cost of electric energy;
2. Avoided unit cost of electric capacity by demand reduction bidding strategy;
3. Intrastate energy DRIPE;
4. Cross-DRIPE; and
5. Avoided non-embedded costs.

Page two of each reporting region table provides:

1. Wholesale avoided costs of electricity (energy and capacity);
2. Avoided REC costs to load;
3. Rest-of-Pool Energy DRIPE values.

Each table provides illustrative levelized values for each category of avoided cost at the bottom of each cost column. These are computed using a real discount rate of 2.43 percent.

[1] AESC 2015 follows the ISO-NE defined on-peak and off-peak hours available at: http://www.iso-ne.com/support/training/glossary/index-p5.html.

[2] ISO-NE holidays are New Year's Day, Memorial Day, July 4, Labor Day, Thanksgiving Day, and Christmas.

1.3 Worksheet Structure and Terminology

For each reporting region/zone there is a two-page table of avoided electricity costs.

1.3.1 Page One—Avoided Cost of Electricity Results

Reading from left to right, the structure of page one of each table is as follows:

User-Defined Inputs

The tables have the following default values for the following three input assumptions:

1. Wholesale Risk Premium – 9 percent[3]
2. ISO Distribution Losses – 8 percent
3. Real Discount Rate – 2.43 percent
4. Percent of Capacity Bid into the FCM – 50 percent

Users may insert their own values for any or all of those input assumptions.

The columns in the tables are labeled a through al. **These column labels do NOT refer to xls cell coordinates.**

Avoided Unit Cost of Electric Energy ($/kWh) (Table columns a – d)

Avoided energy costs are presented by year for each of the four energy costing periods: Winter On-Peak, Winter Off-Peak, Summer-On Peak, and Summer Off-Peak.[4]

The generalized avoided energy cost in each period is calculated as: (modeled avoided wholesale energy cost + avoided renewable energy certificate cost) * (1 + wholesale risk premium).

Avoided Unit Cost of Electric Capacity ($/kW-yr) (Table columns e – g)

This section provides values for a PA to calculate the avoided capacity cost based on a simplified bidding strategy consisting of x percent of demand reductions from measures in each year bid into the FCA for that year and the remaining 1-x percent not bid into any FCA. The default value for x is 50 percent. Users

[3] The wholesale risk premium for Vermont is 11.1 percent per Vermont DPS.

[4] The avoided energy costs are computed for the aggregate load shape in each zone by costing period, and are applicable to DSM programs reducing load roughly in proportion to existing load. Other resources, such as load management and distributed generation, may have very different load shapes and significantly different avoided energy costs. Baseload resources, such as combined-heat-and-power (CHP) systems, would tend to have lower avoided costs per kWh. Peaking resources, such as most non-CHP distributed generation and load management, would tend to have higher avoided costs per kWh.

can insert their own input for that value in the user-defined inputs section of Table One. (See Chapter 5 for a discussion of energy efficiency and the capacity market).

The components of the avoided capacity cost are as follows:

- The Avoided Unit Cost of Capacity of a kW bid into the FCM in column e reflects an 8 percent adjustment to reflect losses from the customer meter to the ISO-NE delivery point.
- The Avoided Unit Cost of Capacity in column f for avoided capacity not bid into an FCA reflects upward adjustments for the wholesale risk premium, the reserve margin in that year, and also a 2.2 percent adjustment to reflect PTF losses. Because FCA auctions are set three years in advance of the actual delivery year, avoided capacity for measures installed in 2016 that is *not* bid into a FCA will not impact ISO-NE's determination of forecasted peak until 2020.
- The Weighted Average *Capacity Value* based on percent bid in column g is the *weighted average* avoided capacity of column e and f reflecting an individual PA's percent of capacity that is bid into the Forward Capacity Market. The column presents a weighted average of 50 percent bid default value that may be changed by PAs to reflect specific bidding strategies.

Under this approach the avoided capacity cost in each year is equal to the Weighted Average *Capacity Value* in column g for the relevant year multiplied by the demand reduction in that year.

Demand-Reduction-Induced Price Effects (Columns h – q)

Each table provides separate projections of intrastate energy DRIPE and capacity DRIPE for efficiency measures implemented in 2016 and in 2017, respectively.

AESC 2015 does not project any difference in electric energy DRIPE for efficiency measures implemented in 2016, 2017 or 2018. For example there are no differences by year due to differences in phase-in or decay. The only difference between the values applicable to reductions from measures of different vintages is the start year. A PA who wishes to evaluate an efficiency measure implemented in 2018 would use the energy DRIPE values for 2018 from columns m through p.

AESC 2015 does not project energy DRIPE from 2019 onward. AESC 2015 projects a zero capacity DRIPE value.

PAs should use energy DRIPE values that reflect the relevant state regulations governing treatment of energy DRIPE. For Massachusetts zones, the energy DRIPE values will be intrastate values only. For the remaining four states, the energy DRIPE values should reflect both intrastate and rest of pool values.

Avoided Non-Embedded Costs $/kWh (Columns r – u)

This section of the worksheet table provides the AESC 2015 estimates of non-embedded values fir CO_2. CO_2 non-embedded values are presented by year for each of the four energy costing periods.

1.3.2 Page Two—Inputs to Avoided Cost Calculations

Reading from left to right, the structure of page two is as follows:

Wholesale Avoided Costs of Electricity Energy, $ per kWh (Table columns v – y)

The wholesale electric energy prices are from the Base Case simulation modelling described in Chapter 5. Users should not normally need to use the input values directly, or modify these values.

Electric Cross DRIPE (Table columns z and aa)

These columns provide AESC 2015 projections of Electric own-fuel and Cross-fuel DRIPE as described in Chapter 7. Values are provided for the winter and the summer. PAs should use these own fuel and cross fuel DRIPE values to the extent allowed by the relevant state regulations governing treatment of energy DRIPE.

PAs would apply the winter values in column z to reductions in load which occur in winter on-peak or winter off-peak periods, and would apply summer values in column aa to z to reductions in load which occur in summer on-peak or winter off-peak periods.

AESC 2015 does not project any difference in electric cross DRIPE for efficiency measures implemented in 2016, 2017 or 2018. For example there are no differences by year due to differences in phase-in or decay. The only difference between the values applicable to reductions from measures of different vintages is the start year. A PA who wishes to evaluate an efficiency measure implemented in 2017 would use the cross DRIPE values starting 2017. A PA who wishes to evaluate an efficiency measure implemented in 2018 would use the cross DRIPE values starting 2018

Capacity, $ per kW-year (Table columns ab and ac)

The wholesale electric capacity prices and reserve margin requirements are from the relevant sections in Chapter 5 sections. Users should not normally need to use the input values directly or modify these values.

Avoided REC Costs to Load $/kWh (Table column ad)

The avoided REC costs are calculated based on REC prices and RPS requirements that are described in detail in Chapter 5. Users should not normally need to use the input values directly or to modify these values.

Rest-of-Pool Energy DRIPE Values $/kWh (Table columns ae – al)

The rest-of-pool energy DRIPE values are calculated based on energy DRIPE factors described in detail in Chapter 7. The Appendix B workbooks present both intrastate and rest of pool energy DRIPE values. Users should not normally need to use the input values directly or modify these values.

1.4 Guide to Applying the Avoided Costs

Users have the ability to specify certain inputs as well as to choose which of the avoided cost components to include in their analyses. .

1.4.1 User-Specified Inputs

The avoided cost results are based upon default values for three inputs that users can specify. They are 1) the wholesale risk premium of 9 percent (11.1 percent for Vermont), 2) the real discount rate of 2.43 percent, and 3) a percentage of capacity bid into the Forward Capacity Market of 50 percent. [5] The Excel workbook is designed to allow Program Administrators to specify their preferred values for those three inputs in the top left section of page one of each worksheet.

If a user wishes to specify a different value for any of the inputs, the user should enter the *new* value directly in the worksheet. The calculations in the worksheet are linked to these values and new avoided costs will be calculated automatically.

Program administrators are responsible for developing and applying estimates of avoided transmission and distribution costs for their own specific system that would be separate inputs to the values in the provided tables. An application of avoided transmission and distribution costs is described in section 1.4.6.

1.4.2 Avoided Costs of Energy

Calculating the quantity reduction benefits of energy reductions in a given year requires an estimate of losses from the ISO delivery points to the end use in addition to an estimate of the reduction at the meter. Each PA should obtain or calculate the losses applicable to its specific system as discussed in section 1.7.1.

These avoided costs should be estimated as follows:

- Reduction in winter peak energy at the end use
  × winter peak energy losses from the ISO delivery points to the end use
  × the *Winter Peak Energy* value for that year by costing period

- Reduction in winter off-peak energy at the end use
  × winter off-peak energy losses from the ISO delivery points to the end use
  × the *Winter Off-Peak Energy* value for that year by costing period

[5] For avoided capacity values, the Appendix B workbook includes ISO-NE distribution loss factor of 8%. This value should not need to be changed.

- Reduction in summer peak energy at the end use
  × summer peak energy losses from the ISO delivery points to the end use
  × the *Summer Peak Energy* value for that year by costing period

- Reduction in summer off-peak energy at the end use
  × summer off-peak energy losses from the ISO delivery points to the end use
  × the *Summer Off-Peak Energy* value for that year by costing period

1.4.3 Capacity Costs Avoided by Reductions in Peak Demand

A PA may achieve avoided capacity costs from reductions in peak demand through a range of approaches. At one extreme the PA could choose to bid 100 percent of the anticipated demand reduction from the program into the relevant FCAs, at the other extreme the PA could choose to bid zero percent of the anticipated reduction into any FCA. The range of approaches between those two extremes vary according to the portion of the reduction in peak demand from efficiency measures the PA chooses to bid into FCAs. These approaches are discussed in Chapter 5 as well as in section 1.9 of this Appendix.

The magnitude of the avoided capacity cost from the reduction in peak demand resulting from a particular measure in a given year will depend upon the approach the PA has taken and/or will take towards bidding the reduction in demand from that measure in that year into the applicable FCAs.

Following are descriptions of how a PA can calculate the avoided cost of reductions in peak demand for the two extreme approaches and the simplified user-specified bid strategy.

Value of 100 Percent Bid of Demand Reduction from First Program Year into the First Relevant FCA (Column e)

A PA will obtain the highest benefit for the reductions in peak demand from an energy efficiency program by bidding the full anticipated reduction into the FCA for the first power year in which that program would produce reductions. Thus, a PA responsible for an efficiency program that is expected to start January 2016 would have had to have bid 100 percent of the anticipated reduction in demand from that program into FCA 7, which was held in 2013 for the power year starting June 1, 2016. There is some financial risk associated with bidding in advance, in particular the potential a regulator may not approve the anticipated program budget and/or the possibility the program may fail to produce the anticipated level of demand reductions.

The benefit of a reduction in peak demand from either an On-Peak or a Seasonal Peak resource in a given year starting 2016 is estimated as the result of:

Average kW reduction at the meter for the relevant period in a given year

× the Avoided Unit Cost of Capacity bid if a kW bid into the FCM for that year.

Value of Zero Percent Bid of Demand Reduction into Any FCA (column f)

For an efficiency program that produces reductions starting in 2016, there is no benefit of a reduction in peak demand until 2020, at which point the annual benefit is calculated as follows:

> kW reduction at the meter during system peak in a given year× summer peak-hour losses from the ISO delivery points to the end use
> × the Avoided Unit Cost of Capacity for that year, which is the FCA price for that year adjusted upward by the reserve margin that ISO-NE requires for that year, distribution losses (user defined), by the PTF losses, and the wholesale risk premium.

Value of 50 Percent Bid of Demand Reduction into FCM (Column g)

The column reflects a 50 percent weighted average of demand reduction into Forward Capacity Market. A PA would therefore obtain 50 percent of the value of the capacity that is bid into the FCM (highest value) as described in section 1.9 and 50 percent of the market capacity value of a reduction in peak load (lowest value) based on the default percentage.

1.4.4 DRIPE

The workbook tables provide electricity DRIPE values by year.

AESC 2015 does not project any difference in electric cross DRIPE for efficiency measures implemented in 2016, 2017 or 2018. For example there are no differences by year due to differences in phase-in or decay. The only difference between the values applicable to reductions from measures of different vintages is the start year.

Avoided Cost of Energy DRIPE

The price benefits of energy reductions are energy DRIPE. A PA can estimate energy DRIPE for a measure as follows:

- Reduction in annual winter on peak energy at the end use
  × winter peak energy losses from ISO delivery to the end use
  × the Winter On-Peak Energy DRIPE;
- Reduction in annual winter off-peak energy at the end use
  × winter off-peak energy losses from ISO delivery to the end use
  × the Winter Off-Peak Energy DRIPE;
- Reduction in annual summer on peak energy at the end use
  × summer peak energy losses from ISO delivery to the end use
  × the Summer On-Peak Energy DRIPE;
- Reduction in annual summer off-peak energy at the end use
  × summer off-peak energy losses from ISO delivery to the end use
  × the Summer Off-Peak Energy DRIPE.

A PA who wishes to evaluate an efficiency measure implemented in 2016 would use the energy DRIPE values starting 2016. A PA who wishes to evaluate an efficiency measure implemented in 2017 would use the energy DRIPE values starting 2017. A PA who wishes to evaluate an efficiency measure implemented in 2018 would use the energy DRIPE values starting 2018

Cross DRIPE

A reduction in the quantity of electricity reduces gas consumption, which reduces electric prices. A PA can estimate the electric-gas-electric DRIPE value of a measure as follows:

- Reduction in summer energy (peak + off-peak periods) at the end use in the year × electric-gas-electric DRIPE for summer in that year
- Reduction in winter energy (peak + off-peak periods) at the end use in the year × electric-gas-electric DRIPE for winter in that year

A PA who wishes to evaluate an efficiency measure implemented in 2016 would use the cross DRIPE values starting 2016. A PA who wishes to evaluate an efficiency measure implemented in 2017 would use the cross DRIPE values starting 2017. A PA who wishes to evaluate an efficiency measure implemented in 2018 would use the cross DRIPE values starting 2018.

If desired, cross DRIPE values for a given season and time-period can be added to energy DRIPE values for the corresponding season and time period to simplify evaluations.

1.4.5 Avoided Non-Embedded Cost of Carbon

The non-embedded carbon costs can be calculated as follows:

- Reduction in winter peak energy at the end use
  × winter peak energy losses from the ISO delivery points to the end use
  × the *CO_2 Externality Winter On Peak Energy* value for that year,
- Reduction in winter off-peak energy at the end use
  × winter off-peak energy losses from the ISO delivery points to the end use
  × the *CO_2 Externality Winter Off-Peak Energy* value for that year,
- Reduction in summer peak energy at the end use
  × summer peak energy losses from the ISO delivery points to the end use
  × the *CO_2 Externality Summer On-Peak Energy* value for that year,
- Reduction in summer off-peak energy at the end use
  × summer off-peak energy losses from the ISO delivery points to the end use
  × the *CO_2 Externality Summer Off-Peak Energy* value for that year

1.4.6 Local T&D Capacity Costs Avoided by Reductions in Peak Demand

Although not part of the provided tables, the benefits of peak demand reductions of avoided local transmission and distribution costs, which should be based upon specific PA information, can be calculated as follows:

- Reduction in the peak demand used in estimating avoided transmission and distribution costs at the end use × the utility-specific estimate of avoided T&D costs in $/kW-year.[6]

1.5 Levelization Calculations

Illustrative levelized costs for each of the direct avoided costs are presented along the bottom of each table. These values are calculated for three periods (2016-2025, 2016-2030, and 2016-2045), using a 2.43 percent real discount rate assumed throughout this project.

For levelization calculations outside the three periods documented in the workbook, the following inputs are required:

- The real discount rate of 2.43 percent or other user specified discount rate
- The number or periods over the levelization time frame. For instance, the period 2014-2023 contains 10 periods
- The avoided costs within the levelization period

The Excel formula used to calculate levelized values in the workbook is:

$$\text{Present Value} = -PMT(Discount\_Rate, Period, (NPV(Discount\_Rate, Annual\_\cos ts\_within\_period)$$

1.6 Converting Constant 2015 Dollars to Nominal Dollars

Unless specifically noted, all dollar values in AESC 2015 are presented in 2015 constant dollars. To convert constant dollars into nominal (current) dollars, a user would follow the formula:

$$\text{Nominal Value} = \frac{\text{Constant Value}_{2015\$}}{Conversion\,Factor\,to\ 2015\$}$$

[6] Most demand-response and load-management programs will not avoid transmission and distribution costs, since they are as likely to shift local loads to new hours as to reduce local peak load.

For instance, in order to convert an AESC 2015 $1 in 2016 into nominal 2016 dollars, one would use the AESC 2015 conversion factor from 2016 to 2015 of 0.983. Inserting the conversion factor into the equation above (Nominal Value_{2016} = ($\$1_{2015\$}$/0.983)) results in a value of $1.02 in nominal dollars.

The AESC 2015 inflator and deflator conversion factors are presented in Appendix E.

1.7 Comparisons to AESC 2015 Reference Case Avoided Costs of Electricity

A PA can prepare a comparison of the 15-year levelized avoided costs of electricity from AESC 2015 for a given reporting location and costing period to the corresponding AESC 2015 results, such as the comparison presented in Exhibit 1-2, as follows:

- Identify the relevant reporting location and costing period
- For the relevant reporting location and costing period, obtain the yearly values of each component from AESC 2013 Appendix B.
- Convert the AESC 2013 yearly values for each component from $2013 to $2015
- Calculate the 15-year levelized values of each AESC 2013 component in 2015$ (AESC 2015 uses a default discount rate of 2.43 percent)
- For the relevant reporting location and costing period, obtain the fifteen year values of each component from AESC 2015 Appendix B.

1.8 Utility-Specific Costs to be Added/Considered by Program Administrators Not Included in Worksheets

This section details additional inputs that are not specifically included in the worksheet and not part of the AESC 2015 scope of work, but should be considered by program administrators.

1.8.1 Losses between the ISO Delivery Point and the End Use

The avoided energy and capacity costs and the estimates of DRIPE include energy and capacity losses on the ISO-administered PTF, from the generator to the delivery points at which the PTF system connects to local non-PTF transmission or to distribution substations.

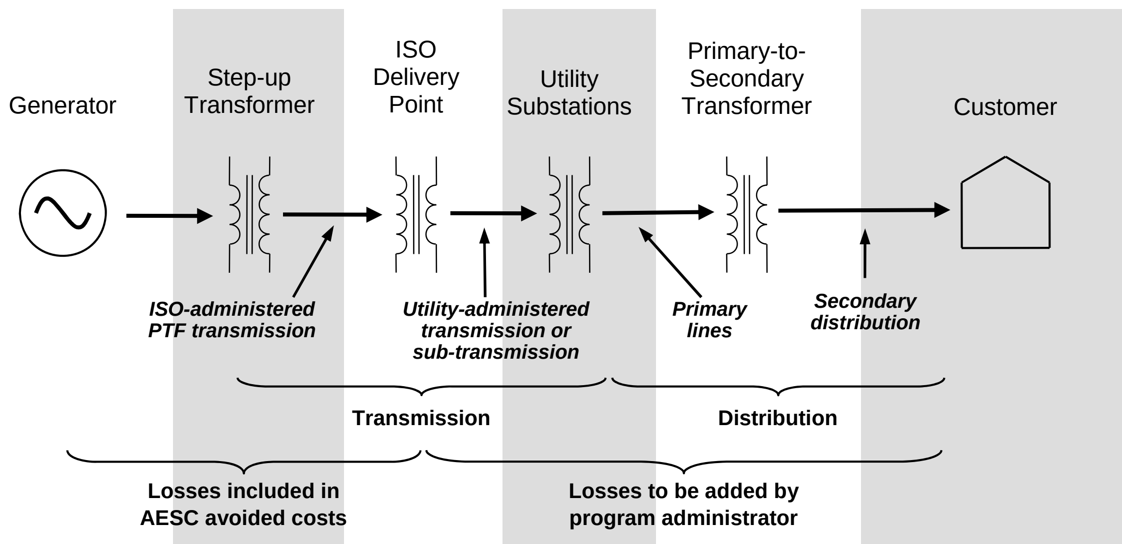
The presented values ***do not*** include the following losses:

- Losses over the non-PTF transmission substations and lines to distribution substations;
- Losses in distribution substations;

- Losses from the distribution substations to the line transformers on primary feeders and laterals;[7]
- Losses from the line transformers over the secondary lines and services to the customer meter;[8]
- Losses from the customer meter to the end use.

Exhibit A - 1 illustrates the sources of losses on transmission and distribution systems highlighted in the list above.

Exhibit A - 1. Delivery System Structure and Losses



In most cases, DSM program administrators measure demand savings from DSM programs at the end use. To be more comprehensive, the program administrator should estimate the losses from delivery points to the end uses. For example, if the energy delivered to the utility at the PTF is *a*, losses are *b*, and the customer received energy is *c*,

- Losses as a fraction of deliveries to the utility are $b \div a$,
- Losses as a fraction of deliveries to customers are $b \div c$.

[7] In some cases, this may involve multiple stages of transformers and distribution, as (for example) power is transformed from 115 kV transmission to 34 kV primary distribution and then to 14 kV primary distribution and then to 4 kV primary distribution, to which the line transformer is connected.

[8] Some customers receive their power from the utility at primary voltage. Since virtually all electricity is used at secondary voltages, these customers generally have line transformers on the customer side of the meter and secondary distribution within the customer facility.

Hence, each kilowatt or kilowatt-hour saved at the end use saves $1 + {}^{b}\!/_{c}$. The program administrator should estimate that ratio and multiply the end-use savings or benefits by that loss ratio. Loss ratios will be generally higher for higher-load periods than lower-load periods, since losses in wires (both within transformers and in lines) vary with the square of the load, for a given voltage and conductor type.

If the change in load does not change the capacity of the transmission and distribution system, then the losses should be computed as marginal losses, which are roughly twice the percentage as average line losses for the same load level.[9] Energy savings and/or growth do not generally result in changing the wire sizes. Hence, for energy avoided costs, losses are estimated on a marginal basis, so *a, b*, and *c* above are increments or derivatives, rather than total load values.

If the change in load results in a proportional change in transmission and distribution capacity, losses should be computed as the average losses for that load level. If the program administrator treats all load-carrying parts of the transmission and distribution as avoidable and varying with peak load, then only average losses should be applied to avoided capacity costs.

1.9 Energy Efficiency Programs and the Capacity Market

An energy efficiency program that produces a reduction in peak demand has the ability to avoid the wholesale capacity cost associated with that reduction. The capacity-cost amount that a particular reduction in peak demand will avoid in a given year will depend upon the approach that the program administrator responsible for that energy efficiency program takes towards bidding all, or some, of that reduction into the applicable FCAs.

A program administrator (PA) can choose an approach that ranges between bidding 100 percent of the anticipated demand reduction from the program into the relevant FCAs to bidding zero percent of the anticipated reduction into any FCA.

- A PA that wishes to bid 100 percent of the anticipated demand reduction from the program into the relevant FCA has to do so when that FCA is conducted, which can be up to three years in advance of the program implementation year. For example, a PA responsible for an efficiency program that will be implemented starting January 2016 would have had to have bid 100 percent of the forecast demand reduction for June 2016 onwards from that program into FCA 7, which was held in 2013. Since a bid is a firm financial commitment, there is an associated financial risk if the PA is unable to actually deliver the full demand reduction for whatever reason. The value of this approach is the compensation paid by ISO-NE, i.e., the quantity of peak reduction each year times the FCA price for the corresponding year.

[9] In this sense, "line losses" does not include the no-load losses that result from eddy currents in the cores of transformers. These are often called "iron" losses (since transformer cores were historically made of iron), in contrast to the load-related "copper" losses of the lines and transformer windings.

- If a PA does not bid any of the anticipated demand reduction into any FCA, the program can still avoid some capacity costs if it has a measure life longer than three years.[10] Under this approach, a PA responsible for an efficiency program starting January 2016 simply implements that program. The customers' contribution to the ISO peak load, whenever that occurs in the summer of 2016, would be lower due to the program. This PA's customers would see some benefit from a lower capacity share starting in June 2017 (the following year). The reduced capacity requirement will reduce the capacity acquired in future FCAs, starting as early as the reconfiguration auctions for the power year starting in June 2017 and affecting all the auctions for the power years from June 2020 onward; the entire region will benefit from the reduction of capacity purchases.

Exhibit A - 2 illustrates the various approaches that a program administrator could choose for avoiding wholesale capacity costs via a hypothetical energy efficiency measure that is implemented in 2012 and produces a 100 kW reduction for a five year period, 2014 to 2018. In this example, the PA considers three approaches.

The first approach is to bid 100 percent of the projected reduction, 100 kW, into each of the relevant FCAs. Under this approach the reduction avoids capacity costs roughly equals to its revenues from the FCM each year, i.e., l to 100 kW times the FCA price in each of the five years, 2014 through 2018.[11] However, the PA would have had to bid that 100-kW reduction, scheduled to start in 2014, into each FCA from FCA 5 onward.

The second approach is to bid none of the projected reductions into any FCA. Under this approach, the reduction avoids capacity costs equal to the value of the reduction in installed capacity it causes in 2018. That value is 100 kW increased by the reserve margin (17.2 percent for illustrative purposes) in 2018 and multiplied by the FCA price in 2018. The avoided capacity cost is limited to the impact in 2018 because ISO-NE sets the ICR to be acquired in each power year three years in advance of that year. Thus, in this approach, ISO-NE would first see the 100 kW reduction as a lower actual peak load in 2014. However, 2018 is the earliest power year for which ISO-NE could reflect the actual reduction in 2014 because, by July 2015 ISO-NE will have forecast peak load for 2018, set the ICR for 2018, and run the FCA for 2018.

The third illustrated approach is to bid 50 percent of the projected reduction, 50 kW, into each of the relevant FCAs.

Other approaches, not illustrated in Exhibit A - 2, would include bidding an increasing percentage of the 2014 load reduction into FCA 5 and future auctions, as the PA becomes more confident in its estimates of the demonstrable savings.

[10] In many cases, the PA is a utility; in other cases it is a state agency or other entity. In any case, the reduction in load benefits the customers served by the PA, whether they pay for generation supply through a utility standard-offer supply, an aggregator, or a competitive supplier.

[11] The price paid to a capacity resource in any year can vary from the price paid by load-serving entities by various factors, including PER deductions, availability penalties, multi-year prices for new resources, local reliability costs, etc.

Exhibit A - 2. Illustration of Alternative Approaches to Capturing Value from Reductions in Peak Demands

Hypothetical measure installed in 2012, reduces peak by 100 kw for 5 years								
ISO-NE sets NICR and Conducts FCA			Example 1—PA bids 100% of expected demand reduction into each corresponding FCA		Example 2—PA bids zero expected demand reduction into each corresponding FCA		Example 3—PA bids 50% of expected demand reduction into each corresponding FCA	
FCA #	**Calendar year**	FCA for power year Starting	Reduction Bid into FCA	Impact of Reduction on NICR set for power year	Reduction Bid into FCA	Impact of Reduction on NICR set for power year	Reduction Bid into FCA	Impact of Reduction on NICR set for power year
			kw	kw	kw	kw	kw	kw
5	2011	6/1/2014	100		0		50	
6	2012	6/1/2015	100		0		50	
7	2013	6/1/2016	100		0		50	
8	2014	6/1/2017	100	0	0	0	50	0
9	2015	6/1/2018	100	0	0	0	50	0
10	2016	6/1/2019	0	0		0	0	0
11	2017	6/1/2020	0	0		0	0	0
12	2018	6/1/2021	0	0		**117**	0	**58.6**

1.10 High Gas Price Sensitivity Case Avoided Cost of Electricity

Chapter 6 provides avoided wholesale electric energy costs for a High Gas Price sensitivity case. Calculating the complete avoided cost of electricity under each of those sensitivity cases is not included in the AESC 2015 scope of work. However, a PA could use the results from those sensitivity cases to develop approximate estimates of the avoided costs of electricity for either or both sensitivity cases.

The estimates developed through th**e** approach described below will be approximate because they will not reflect the changes in various components, relative to Base Case values, that would occur with a change in wholesale electric energy costs. For example, an increase in wholesale electric energy costs under the High Gas Price would cause a decrease in the REC cost component.

A PA could develop an approximate estimate of the 15-year levelized avoided costs of electricity for the High Gas Price sensitivity case for a given reporting location by multiplying the wholesale avoided costs of electric energy for that location, on page two of the relevant Appendix B workbook, in each of the columns v, w, x, and y, by 1+ the percentage increase in electric energy prices in each year under the High Gas Case from column h in Exhibit A-3.

Exhibit A - 3. Avoided electric energy costs by year, WCMA, High Gas Case versus Base Case

Year	Annual Wholesale Gas Price, AGT hub (2015$/MMBtu)				Annual Energy Price, WCMA (2015$/MWh)			
	CASES		High Gas Case - Base Case		CASES		High Gas Case - Base Case	
	Base	High Gas	absolute difference	% change from Base Case	Base	High Gas	absolute difference	% change from Base Case
	a	b	c = b - a	d = c / a	e	f	g = f - e	h = g / e
2015	$ 6.96	$ 6.96	$0.00	0%	$57.59	$57.59	$0.00	0%
2016	$ 6.32	$ 6.32	$0.00	0%	$55.62	$55.62	$0.00	0%
2017	$ 6.33	$ 7.02	$0.69	11%	$54.99	$57.46	$2.48	5%
2018	$ 5.59	$ 6.78	$1.19	21%	$48.83	$60.04	$11.21	23%
2019	$ 5.43	$ 6.59	$1.16	21%	$48.24	$59.37	$11.13	23%
2020	$ 5.13	$ 6.27	$1.15	22%	$47.00	$57.68	$10.68	23%
2021	$ 5.42	$ 6.64	$1.22	22%	$49.42	$61.03	$11.61	23%
2022	$ 5.58	$ 6.85	$1.27	23%	$52.17	$63.88	$11.71	22%
2023	$ 5.72	$ 7.04	$1.32	23%	$54.23	$65.93	$11.70	22%
2024	$ 5.88	$ 7.25	$1.37	23%	$56.11	$68.07	$11.96	21%
2025	$ 5.99	$ 7.41	$1.42	24%	$59.26	$71.81	$12.55	21%
2026	$ 6.12	$ 7.59	$1.47	24%	$61.51	$74.15	$12.64	21%
2027	$ 6.25	$ 7.76	$1.51	24%	$62.52	$75.02	$12.51	20%
2028	$ 6.35	$ 7.91	$1.56	24%	$64.88	$77.63	$12.75	20%
2029	$ 6.54	$ 8.15	$1.61	25%	$68.46	$80.88	$12.42	18%
2030	$ 6.81	$ 8.48	$1.68	25%	$75.24	$87.93	$12.68	17%
15 yrs Levelized (2016-2030)								
	$5.94	$7.14	$1.21	20%	$56.58	$66.83	$10.25	18%
Real Discount Rate						2.43%		

1.11 Guide to Applying Avoided Natural Gas Costs

Appendix C of AESC 2015 provides projections of avoided natural gas costs cost by end use by year as well as projections of natural gas supply and cross-fuel DRIPE by end use by year.

Avoided natural gas costs cost by end use

Exhibits C-1 through C-5 provide projections of avoided natural gas costs cost by end use by year for three sub-regions in New England, i.e. Southern New England (CT, RI, MA), Northern New England (NH, ME) and Vermont. The avoided cost by end use by is the sum of:

- the avoided cost of the gas sent out by the LDC (avoided city-gate cost) and
- the avoidable distribution cost, referred to as the avoidable LDC margin.

The Exhibits report avoided costs for Residential non-heating, water heating, heating and all; Commercial & Industrial non-heating, heating and all and all sectors.

- Non-heating value streams apply to year-round end uses whose gas use is generally constant over the year.
- Heating value streams apply to heating end uses where usage is high during winter months.
- For each program and/or measure, users should choose the appropriate value stream to determine the avoided cost benefit stream in evaluating cost-effectiveness.

Exhibits C-1 through C-5 provide two sets of avoided natural gas costs by end-use for each sub-region, one set assuming no avoided margin and one set assuming some level of avoided margins. PAs need to determine if their LDC does, or does not, have avoidable LDC margins.

Natural Gas Supply and Cross-Fuel DRIPE

Exhibits C-7 through C-13 provide projections of natural gas supply and cross-fuel DRIPE by end use / costing period by year by state, as well as for New England. PAs should use the natural gas supply and cross-fuel DRIPE values that reflect the relevant state regulations governing treatment of energy DRIPE. The values reported by state, Exhibits C-7 through C-12 are intrastate values. The values for New England, C-13, are essentially intrastate plus rest of pool vales.

A program administrator would apply these values regardless of whether or not the program administrator uses avoided costs including or excluding retail margin. If desired, a PA may add the natural gas supply and cross-fuel DRIPE values for a given year and end use / costing period to the avoided natural gas costs from Exhibits C-1 through C-6 for the corresponding year and end use / costing period.

AESC 2015 does not project any difference in natural gas supply or gas Cross-Fuel DRIPE for efficiency measures implemented in 2016, 2017 or 2018. For example there are no differences by year due to differences in phase-in or decay. The only difference between the values applicable to reductions from measures of different vintages is the start year. A PA who wishes to evaluate an efficiency measure implemented in 2016 would use the cross DRIPE values starting 2016. A PA who wishes to evaluate an efficiency measure implemented in 2017 would use the cross DRIPE values starting 2017. A PA who wishes to evaluate an efficiency measure implemented in 2018 would use the cross DRIPE values starting 2018.

The columns in Exhibits C-7 through C-13 are labeled 1 through 9. **These column labels do NOT refer to xls cell columns.**

Column 1 of Exhibits C-7 through C-13 provide gas supply DRIPE. PAs would apply the gas supply value in each year from Column 1 to every MMBtu of gas reduction from efficiency measures over the life of that measure. (As discussed in Chapter 7, a reduction in the quantity of gas used by retail gas customers reduces the demand for gas in producing regions and therefore reduce the market price for that gas supply. As discussed in detail in Chapter 7, we do not expect to see any significant decay in these natural gas supply DRIPE values.)

Columns 2 through 9 of Exhibits C-7 through C-13 provide gas cross-fuel c DRIPE by costing period / load segment. . PAs would apply the gas cross-fuel value in each year from each of these columns to the y MMBtu of gas reduction in the corresponding costing period / load segment in the corresponding year. (A reduction in gas use by retail gas customers reduces the gas production costs and gas basis components of the New England wholesale cost of gas incurred by gas-fired electric generators. These benefits accrue to gas programs for reducing natural gas prices to electric generators as a result of natural gas efficiency.)

Public Estimates of Price Suppression in Wholesale Electricity Markets

Table 1. Reduction in Electricity from Wholesale Markets due to EE/DR & /or DG

Citation	Source	Region	Resource	Estimation Method	Years / Period	Energy Results	Capacity Results
Brattle 2014	Brattle	ISO-NE	DG	simple energy dispatch model; model of capacity market. Without case and with cases of 160 MW; to 1,000 MW	25 (2014 - 2038)	$0.08/MWh for 160 MW, (pg 18)	zero
ACEEE 2013	Synapse	PJM (OH)	EE	Annual energy price elasticity with R2 of 0.36; PJM capacity market curves assuming vertical capacity supply price curve	Energy – 2010 to 2020; Capacity – 2017 to 2020	Yes	Yes
BGE & PEPCO 2012	BGE PEPCO	MD	EE / DR	Energy - PJM Net Benefits Test; Capacity – PJM VRR curves	N/ A	Yes, in hours when prices set by steep section of supply curve	Yes, according to PJM VRR curves
Felder 2011.	Rutgers University	Electricity Journal article					
Brattle Group 2007	The Brattle Group	PJM	Demand response	“Dayzer” simulation of energy market; 3% reduction in top 25 hours.	1(2005)	Yes	No estimate

Table 2. Addition of Clean Supply Resources to Wholesale Markets

Citation	Source	Region	Resource	Estimation Method	Years / Period	Energy Results	Capacity Results
TCR 2014 b	TCR	ISO-NE	Offshore wind	Market simulation.	1	Yes	No estimate
TCR 2014 a (Stony Brook University)	TCR	NYISO	Offshore wind	Market simulation.	1	Yes	Yes
B&V 2013	Black & Veatch	ISO-NE	RE	Market simulation. Without, 1200 MW Hydro, 2400 MW, 3600 MW	12 (2018-2029)	minimal	zero
OH PUC 2013.	Ohio PUC	PJM (OH)	Renewable	Market simulation via PROMOD IV; w/o & with	1 (2014)	Yes	No estimate
CRA 2012	Charles River	ISO-NE	Cape Wind	GE MAPS;468 MW; without & with	25 (2014 – 2038)	$1.86/MWh	Zero
CRA 2010	Charles River	ISO-NE	Northern Pass	GE MAPS; 1,200 MW @ 85% cf is 8.9 Tcf, without & with	10 (2014 – 2025)	$1.86/MWh	zero
RIEDC 2010	Levitan Associates .	ISO NE (RI)	Wind	dispatch model; without and with BIWF Deepwater.	20 (2013 – 2032)	Yes	No
PJM 2009	PJM	PJM	Wind	PROMOD; without & with 15,000 MW wind capacity in PJM west	1 (2013)	Yes	No estimate
TPH 2009	Tudor Pickering Holt	ERCOT	Wind	Illustrations using Summer supply stack	1 (2013)	Yes	N / A
NYSERDA 2009	Summit Blue Consulting	NYISO	RE	Regression analysis of annual electric energy prices as function of load, natural gas prices, reserve margin and RPS requirements	1 (2010)	yes	None

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Revision: 4/3/2015

Table One: Avoided Cost of Electricity (2015 $) Results : CT Connecticut

State CT

User-defined Inputs	
Wholesale Risk Premium (WRP)	9.00%
Distribution Losses	8.00%
Real Discount Rate	2.43%
Pcnt of Capacity Bid into FCM (%Bid)	50.00%

	Avoided Unit Cost of Electric Energy[1]				Avoided Unit Cost of Electric Capacity[2]			DRIPE: 2016 vintage measures Intrastate					DRIPE: 2017 vintage measures Intrastate					Avoided Non-Embedded Costs			
								Energy				Capacity (See note 2)	Energy				Capacity (See note 2)				
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	kW sold into FCA (PA to determine quantity)[3]	kW purchased from FCA (PA to determine quantity)	Weighted Average Avoided Cost Based on Percent Capacity Bid	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kW-yr	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh
Period:	a	b	c	d	e=ab*1.08	f=ab*(1+ac)*(1+WRP) *(1+Dist Loss) *(1+PTF Loss)	g=(e*%Bid)+(f*(1 +%Bid))	h	i	j	k	l	m	n	o	p	q	r	s	t	u
2015	0.0890	0.0799	0.0522	0.0424														0.0478	0.0472	0.0509	0.0487
2016	0.0822	0.0769	0.0608	0.0433	41.2	*0.0*	20.6	0.0066	0.0088	0.0029	0.0090							0.0473	0.0467	0.0504	0.0482
2017	0.0795	0.0744	0.0629	0.0499	123.7	*0.0*	61.8	0.0063	0.0084	0.0030	0.0107		0.0063	0.0084	0.0030	0.0107		0.0469	0.0464	0.0500	0.0479
2018	0.0691	0.0641	0.0622	0.0532	143.6	*0.0*	71.8	0.0033	0.0044	0.0000	0.0000		0.0033	0.0044	0.0000	0.0000		0.0466	0.0461	0.0497	0.0476
2019	0.0686	0.0636	0.0622	0.0529	133.2	*0.0*	66.6											0.0462	0.0457	0.0492	0.0472
2020	0.0673	0.0619	0.0627	0.0516	146.6	191.1	168.9											0.0458	0.0452	0.0488	0.0467
2021	0.0686	0.0635	0.0648	0.0539	149.7	195.1	172.4											0.0446	0.0440	0.0475	0.0455
2022	0.0744	0.0688	0.0700	0.0584	151.1	196.9	174.0											0.0433	0.0428	0.0462	0.0442
2023	0.0753	0.0700	0.0736	0.0605	148.7	193.9	171.3											0.0421	0.0416	0.0449	0.0430
2024	0.0771	0.0719	0.0732	0.0625	151.8	197.9	174.8											0.0409	0.0404	0.0436	0.0418
2025	0.0805	0.0732	0.0787	0.0644	155.0	202.0	178.5											0.0397	0.0392	0.0423	0.0405
2026	0.0815	0.0750	0.0821	0.0657	155.6	202.8	179.2											0.0385	0.0380	0.0410	0.0393
2027	0.0821	0.0763	0.0789	0.0669	154.2	200.9	177.5											0.0373	0.0369	0.0397	0.0381
2028	0.0832	0.0780	0.0831	0.0692	157.9	205.8	181.8											0.0361	0.0357	0.0385	0.0368
2029	0.0879	0.0829	0.0870	0.0727	164.0	213.8	188.9											0.0349	0.0345	0.0372	0.0356
2030	0.0950	0.0858	0.1037	0.0775	165.8	216.1	191.0											0.0337	0.0333	0.0359	0.0344
2031	0.0981	0.0890	0.1082	0.0806	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2032	0.1014	0.0922	0.1129	0.0838	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2033	0.1049	0.0955	0.1178	0.0872	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2034	0.1084	0.0990	0.1230	0.0906	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2035	0.1121	0.1027	0.1284	0.0943	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2036	0.1159	0.1065	0.1340	0.0981	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2037	0.1198	0.1104	0.1399	0.1021	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2038	0.1239	0.1145	0.1461	0.1063	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2039	0.1282	0.1188	0.1526	0.1106	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2040	0.1326	0.1232	0.1594	0.1151	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2041	0.1372	0.1279	0.1665	0.1199	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2042	0.1419	0.1327	0.1740	0.1248	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2043	0.1468	0.1377	0.1818	0.1300	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2044	0.1519	0.1429	0.1899	0.1354	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2045	0.1572	0.1483	0.1985	0.1411	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
Levelized Costs																					
10 years (2016-2025)	0.0742	0.0688	0.0667	0.0547	132.9	111.9	122.4	0.0018	0.0024	0.0007	0.0022	0.0000	0.0011	0.0014	0.0003	0.0012	0.0000	0.045	0.044	0.047	0.045
15 years (2016-2030)	0.0776	0.0720	0.0726	0.0593	140.7	140.1	140.4	0.0013	0.0017	0.0005	0.0015	0.0000	0.0008	0.0010	0.0002	0.0008	0.0000	0.042	0.042	0.045	0.043
30 years (2016-2045)	0.0965	0.0893	0.1028	0.0785	148.1	167.6	157.8	0.0007	0.0010	0.0003	0.0009	0.0000	0.0004	0.0006	0.0001	0.0005	0.0000	0.039	0.038	0.041	0.039

NOTES:

General — All Avoided Costs are in Year 2015 Dollars

ISO NE periods: Summer is June through September, Winter is all other months. Peak hours are: Monday through Friday 7 AM - 11 PM; Off-Peak Hours are all other hours

1 Avoided cost of electric energy = (wholesale energy avoided cost + REC cost to load) * risk premium, e.g. A = (v+ad) * (1+Wholesale Risk Premium)

2 Absolute value of avoided capacity costs and capacity DRIPE each year is function of quantity of kW reduction in year, PA strategy re bidding that reduction into applicable FCAs, and unit values in columns e and f. □

3 Proceeds from selling into the FCM also include the ISO-NE loss factor of 8%

4 PTF loss = 2.20%

5 Electric Cross -DRIPE is electric owen fuel DRIPE + Electric Cross-DRIPE

Revision: 4/3/2015

Table Two: Inputs to Avoided Cost Calculations

Zone: CT

	Wholesale Avoided Costs of Electricity								Avoided REC Costs to Load	DRIPE: 2016 vintage measures Rest-of-Pool				DRIPE: 2017 vintage measures Rest-of-Pool			
	Energy				Electric Cross DRIPE (5)		Capacity			Energy				Energy			
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter	Summer	FCA Price	Reserve Margin	REC Costs	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	%	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh
Period:	v	w	x	y	z	aa	ab	ac	ad	ae	af	ag	ah	ai	aj	ak	al
2015	0.0732	0.0649	0.0395	0.0305			39.7	17.0%	0.0084								
2016	0.0666	0.0618	0.0470	0.0309	0.0227	0.0144	38.2	17.0%	0.0088	0.0058	0.0078	0.0027	0.0049				
2017	0.0637	0.0591	0.0486	0.0366	0.0136	0.0087	114.5	17.0%	0.0092	0.0056	0.0075	0.0028	0.0058	0.0056	0.0075	0.0028	0.0058
2018	0.0539	0.0493	0.0476	0.0393	0.0063	0.0042	132.9	17.0%	0.0095	0.0030	0.0039	0.0000	0.0000	0.0030	0.0039	0.0000	0.0000
2019	0.0532	0.0486	0.0473	0.0388	0.0040	0.0027	123.3	17.0%	0.0097								
2020	0.0518	0.0469	0.0476	0.0375	0.0040	0.0027	135.8	17.0%	0.0099								
2021	0.0539	0.0492	0.0504	0.0404	0.0006	0.0006	138.6	17.0%	0.0090								
2022	0.0571	0.0519	0.0531	0.0424	0.0006	0.0006	139.9	17.0%	0.0112								
2023	0.0585	0.0537	0.0569	0.0450	0.0006	0.0006	137.7	17.0%	0.0106								
2024	0.0606	0.0558	0.0571	0.0472	0.0006	0.0006	140.6	17.0%	0.0101								
2025	0.0645	0.0578	0.0628	0.0497	0.0006	0.0006	143.5	17.0%	0.0094								
2026	0.0660	0.0601	0.0666	0.0515	0.0006	0.0006	144.1	17.0%	0.0087								
2027	0.0672	0.0619	0.0643	0.0533	0.0006	0.0006	142.7	17.0%	0.0081								
2028	0.0688	0.0641	0.0688	0.0560	0.0006	0.0006	146.2	17.0%	0.0075								
2029	0.0727	0.0680	0.0718	0.0587	0.0006	0.0006	151.9	17.0%	0.0080								
2030	0.0796	0.0712	0.0876	0.0636	0.0006	0.0006	153.5	17.0%	0.0075								
2031	0.0825	0.0741	0.0918	0.0664	0.0006	0.0006	147.0	17.0%	0.0075								
2032	0.0856	0.0771	0.0961	0.0694	0.0006	0.0006	147.0	17.0%	0.0075								
2033	0.0887	0.0802	0.1006	0.0725	0.0006	0.0006	147.0	17.0%	0.0075								
2034	0.0920	0.0834	0.1053	0.0757	0.0006	0.0006	147.0	17.0%	0.0075								
2035	0.0954	0.0868	0.1103	0.0791	0.0006	0.0006	147.0	17.0%	0.0074								
2036	0.0989	0.0903	0.1155	0.0826	0.0006	0.0006	147.0	17.0%	0.0074								
2037	0.1025	0.0939	0.1209	0.0862	0.0006	0.0006	147.0	17.0%	0.0074								
2038	0.1063	0.0977	0.1266	0.0901	0.0006	0.0006	147.0	17.0%	0.0074								
2039	0.1102	0.1016	0.1326	0.0941	0.0006	0.0006	147.0	17.0%	0.0074								
2040	0.1143	0.1057	0.1389	0.0983	0.0006	0.0006	147.0	17.0%	0.0074								
2041	0.1185	0.1099	0.1454	0.1026	0.0006	0.0006	147.0	17.0%	0.0074								
2042	0.1228	0.1144	0.1522	0.1072	0.0006	0.0006	147.0	17.0%	0.0074								
2043	0.1273	0.1190	0.1594	0.1119	0.0006	0.0006	147.0	17.0%	0.0073								
2044	0.1320	0.1238	0.1669	0.1169	0.0006	0.0006	147.0	17.0%	0.0073								
2045	0.1369	0.1287	0.1748	0.1221	0.0006	0.0006	147.0	17.0%	0.0073								
Levelized Costs																	
10 years (2016-2025)	0.0584	0.0534	0.0515	0.0404	0.0058	0.0038	123.0		0.0097	0.0016	0.0021	0.0006	0.0012	0.0009	0.0013	0.0003	0.0006
15 years (2016-2030)	0.0620	0.0568	0.0574	0.0452	0.0043	0.0029	130.2		0.0092	0.0011	0.0015	0.0004	0.0008	0.0007	0.0009	0.0002	0.0005
30 years (2016-2045)	0.0800	0.0735	0.0858	0.0635	0.0028	0.0020	137.1		0.0085	0.0007	0.0009	0.0003	0.0005	0.0004	0.0005	0.0001	0.0003

NOTES: General — All Avoided Costs are in Year 2015 Dollars
periods:

Revision: 4/3/2015

Table One: Avoided Cost of Electricity (2015 $) Results :

MA-NEMA
NEMA (Northeast Massachusetts)

State MA

User-defined Inputs	
Wholesale Risk Premium (WRP)	9.00%
Distribution Losses	8.00%
Real Discount Rate	2.43%
Pcnt of Capacity Bid into FCM (%Bid)	50.00%

	Avoided Unit Cost of Electric Energy[1]				Avoided Unit Cost of Electric Capacity[2]			DRIPE: 2016 vintage measures Intrastate					DRIPE: 2017 vintage measures Intrastate					Avoided Non-Embedded Costs			
								Energy				Capacity (See note 2)	Energy				Capacity (See note 2)				
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	kW sold into FCA (PA to determine quantity)[3]	kW purchased from FCA (PA to determine quantity)	Weighted Average Avoided Cost Based on Percent Capacity Bid	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kW-yr	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh
Period:	a	b	c	d	e=ab*1.08	f=ab*(1+ac)*(1+WRP) *(1+Dist Loss) *(1+PTF Loss)	g=(e*%Bid)+(f*(1 +%Bid))	h	i	j	k	l	m	n	o	p	q	r	s	t	u
2015	0.0875	0.0780	0.0521	0.0406														0.0478	0.0472	0.0509	0.0487
2016	0.0811	0.0753	0.0611	0.0416	127.7	*0.0*	63.8	0.0205	0.0102	0.0342	0.0101							0.0473	0.0467	0.0504	0.0482
2017	0.0779	0.0722	0.0625	0.0476	185.4	*0.0*	92.7	0.0196	0.0097	0.0353	0.0119		0.0196	0.0097	0.0353	0.0119		0.0469	0.0464	0.0500	0.0479
2018	0.0672	0.0616	0.0610	0.0507	143.6	*0.0*	71.8	0.0104	0.0051	0.0000	0.0000		0.0104	0.0051	0.0000	0.0000		0.0466	0.0461	0.0497	0.0476
2019	0.0662	0.0606	0.0605	0.0501	133.2	*0.0*	66.6											0.0462	0.0457	0.0492	0.0472
2020	0.0646	0.0586	0.0605	0.0481	146.6	191.1	168.9											0.0458	0.0452	0.0488	0.0467
2021	0.0689	0.0632	0.0659	0.0535	149.7	195.1	172.4											0.0446	0.0440	0.0475	0.0455
2022	0.0726	0.0664	0.0689	0.0560	151.1	196.9	174.0											0.0433	0.0428	0.0462	0.0442
2023	0.0742	0.0686	0.0732	0.0591	148.7	193.9	171.3											0.0421	0.0416	0.0449	0.0430
2024	0.0770	0.0715	0.0739	0.0620	151.8	197.9	174.8											0.0409	0.0404	0.0436	0.0418
2025	0.0817	0.0738	0.0798	0.0641	155.0	202.0	178.5											0.0397	0.0392	0.0423	0.0405
2026	0.0830	0.0761	0.0843	0.0669	155.6	202.8	179.2											0.0385	0.0380	0.0410	0.0393
2027	0.0842	0.0781	0.0818	0.0687	154.2	200.9	177.5											0.0373	0.0369	0.0397	0.0381
2028	0.0871	0.0817	0.0880	0.0726	157.9	205.8	181.8											0.0361	0.0357	0.0385	0.0368
2029	0.0912	0.0859	0.0912	0.0753	164.0	213.8	188.9											0.0349	0.0345	0.0372	0.0356
2030	0.0986	0.0893	0.1087	0.0807	165.8	216.1	191.0											0.0337	0.0333	0.0359	0.0344
2031	0.1018	0.0924	0.1132	0.0837	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2032	0.1051	0.0956	0.1180	0.0868	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2033	0.1085	0.0990	0.1229	0.0901	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2034	0.1121	0.1025	0.1281	0.0935	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2035	0.1158	0.1062	0.1335	0.0971	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2036	0.1196	0.1100	0.1391	0.1008	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2037	0.1235	0.1139	0.1450	0.1047	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2038	0.1276	0.1180	0.1512	0.1087	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2039	0.1318	0.1223	0.1577	0.1129	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2040	0.1362	0.1267	0.1645	0.1173	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2041	0.1408	0.1314	0.1716	0.1219	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2042	0.1455	0.1362	0.1790	0.1267	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2043	0.1504	0.1412	0.1867	0.1317	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2044	0.1555	0.1464	0.1949	0.1369	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2045	0.1607	0.1518	0.2034	0.1424	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
Levelized Costs																					
10 years (2016-2025)	0.0731	0.0671	0.0663	0.0528	149.2	111.9	130.5	0.0055	0.0027	0.0076	0.0024	0.0000	0.0033	0.0016	0.0039	0.0013	0.0000	0.045	0.044	0.047	0.045
15 years (2016-2030)	0.0777	0.0715	0.0734	0.0587	152.2	140.1	146.1	0.0039	0.0019	0.0054	0.0017	0.0000	0.0023	0.0012	0.0028	0.0009	0.0000	0.042	0.042	0.045	0.043
30 years (2016-2045)	0.0980	0.0905	0.1053	0.0792	154.9	167.6	161.2	0.0023	0.0011	0.0032	0.0010	0.0000	0.0014	0.0007	0.0016	0.0006	0.0000	0.039	0.038	0.041	0.039

NOTES:

General — All Avoided Costs are in Year 2015 Dollars

ISO NE periods: Summer is June through September, Winter is all other months. Peak hours are: Monday through Friday 7 AM - 11 PM; Off-Peak Hours are all other hours

1. Avoided cost of electric energy = (wholesale energy avoided cost + REC cost to load) * risk premium, e.g. A = (v+ad) * (1+Wholesale Risk Premium)
2. Absolute value of avoided capacity costs and capacity DRIPE each year is function of quantity of kW reduction in year, PA strategy re bidding that reduction into applicable FCAs, and unit values in columns e and f. □
3. Proceeds from selling into the FCM also include the ISO-NE loss factor of 8%
4. PTF loss = 2.20%
5. Electric Cross -DRIPE is electric owen fuel DRIPE + Electric Cross-DRIPE

Revision: 4/3/2015

Table Two: Inputs to Avoided Cost Calculations

Zone: MA-NEMA

	Wholesale Avoided Costs of Electricity								Avoided REC Costs to Load	DRIPE: 2016 vintage measures Rest-of-Pool				DRIPE: 2017 vintage measures Rest-of-Pool			
	Energy				Electric Cross DRIPE (5)		Capacity			Energy				Energy			
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter	Summer	FCA Price	Reserve Margin	REC Costs	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	%	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh
Period:	v	w	x	y	z	aa	ab	ac	ad	ae	af	ag	ah	ai	aj	ak	al
2015	0.0736	0.0649	0.0412	0.0306			39.7	17.0%	0.0067								
2016	0.0672	0.0618	0.0488	0.0309	0.0425	0.0268	118.2	17.0%	0.0072	0.0183	0.0105	0.0291	0.0093				
2017	0.0642	0.0591	0.0501	0.0365	0.0250	0.0159	171.7	17.0%	0.0072	0.0175	0.0100	0.0301	0.0110	0.0175	0.0100	0.0301	0.0110
2018	0.0546	0.0494	0.0488	0.0394	0.0116	0.0076	132.9	17.0%	0.0071	0.0093	0.0052	0.0000	0.0000	0.0093	0.0052	0.0000	0.0000
2019	0.0537	0.0486	0.0485	0.0390	0.0075	0.0050	123.3	17.0%	0.0070								
2020	0.0524	0.0469	0.0487	0.0373	0.0073	0.0050	135.8	17.0%	0.0069								
2021	0.0545	0.0492	0.0517	0.0403	0.0013	0.0012	138.6	17.0%	0.0088								
2022	0.0577	0.0520	0.0542	0.0424	0.0013	0.0012	139.9	17.0%	0.0090								
2023	0.0588	0.0537	0.0579	0.0450	0.0013	0.0012	137.7	17.0%	0.0093								
2024	0.0609	0.0559	0.0581	0.0472	0.0013	0.0012	140.6	17.0%	0.0097								
2025	0.0651	0.0578	0.0633	0.0490	0.0013	0.0012	143.5	17.0%	0.0099								
2026	0.0663	0.0601	0.0675	0.0516	0.0013	0.0012	144.1	17.0%	0.0098								
2027	0.0675	0.0619	0.0653	0.0533	0.0013	0.0012	142.7	17.0%	0.0098								
2028	0.0690	0.0641	0.0698	0.0558	0.0013	0.0012	146.2	17.0%	0.0109								
2029	0.0729	0.0680	0.0729	0.0583	0.0013	0.0012	151.9	17.0%	0.0108								
2030	0.0798	0.0712	0.0891	0.0633	0.0013	0.0012	153.5	17.0%	0.0107								
2031	0.0827	0.0741	0.0932	0.0661	0.0013	0.0012	147.0	17.0%	0.0107								
2032	0.0857	0.0770	0.0975	0.0690	0.0013	0.0012	147.0	17.0%	0.0107								
2033	0.0889	0.0801	0.1020	0.0720	0.0013	0.0012	147.0	17.0%	0.0107								
2034	0.0921	0.0833	0.1068	0.0751	0.0013	0.0012	147.0	17.0%	0.0107								
2035	0.0955	0.0867	0.1117	0.0784	0.0013	0.0012	147.0	17.0%	0.0107								
2036	0.0990	0.0902	0.1169	0.0818	0.0013	0.0012	147.0	17.0%	0.0107								
2037	0.1026	0.0938	0.1223	0.0853	0.0013	0.0012	147.0	17.0%	0.0107								
2038	0.1063	0.0976	0.1280	0.0890	0.0013	0.0012	147.0	17.0%	0.0107								
2039	0.1102	0.1015	0.1339	0.0929	0.0013	0.0012	147.0	17.0%	0.0107								
2040	0.1143	0.1055	0.1402	0.0969	0.0013	0.0012	147.0	17.0%	0.0107								
2041	0.1184	0.1098	0.1467	0.1011	0.0013	0.0012	147.0	17.0%	0.0107								
2042	0.1228	0.1142	0.1535	0.1055	0.0013	0.0012	147.0	17.0%	0.0107								
2043	0.1272	0.1188	0.1606	0.1101	0.0013	0.0012	147.0	17.0%	0.0107								
2044	0.1319	0.1235	0.1680	0.1149	0.0013	0.0012	147.0	17.0%	0.0108								
2045	0.1367	0.1285	0.1758	0.1199	0.0013	0.0012	147.0	17.0%	0.0108								
Levelized Costs																	
10 years (2016-2025)	0.0589	0.0535	0.0527	0.0404	0.0108	0.0071	138.1		0.0081	0.0049	0.0028	0.0065	0.0022	0.0030	0.0017	0.0033	0.0012
15 years (2016-2030)	0.0625	0.0568	0.0586	0.0451	0.0080	0.0054	140.9		0.0088	0.0035	0.0020	0.0046	0.0016	0.0021	0.0012	0.0024	0.0009
30 years (2016-2045)	0.0803	0.0734	0.0870	0.0630	0.0053	0.0037	143.4		0.0096	0.0020	0.0012	0.0027	0.0009	0.0012	0.0007	0.0014	0.0005

NOTES: General All Avoided Costs are in Year 2015 Dollars
periods:

Revision: 4/3/2015

Table One: Avoided Cost of Electricity (2015 $) Results :

MA-SEMA

SEMA (Southeast Massachusetts)

State MA

User-defined Inputs	
Wholesale Risk Premium (WRP)	9.00%
Distribution Losses	8.00%
Real Discount Rate	2.43%
Pcnt of Capacity Bid into FCM (%Bid)	50.00%

	Avoided Unit Cost of Electric Energy[1]				Avoided Unit Cost of Electric Capacity[2]			DRIPE: 2016 vintage measures Intrastate					DRIPE: 2017 vintage measures Intrastate					Avoided Non-Embedded Costs			
								Energy				Capacity (See note 2)	Energy				Capacity (See note 2)				
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	kW sold into FCA (PA to determine quantity)[3]	kW purchased from FCA (PA to determine quantity)	Weighted Average Avoided Cost Based on Percent Capacity Bid	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kW-yr	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh
Period:	a	b	c	d	e=ab*1.08	f=ab*(1+ac)*(1+WRP) *(1+Dist Loss) *(1+PTF Loss)	g=(e*%Bid)+(f*(1 +%Bid))	h	i	j	k	l	m	n	o	p	q	r	s	t	u
2015	0.0870	0.0780	0.0498	0.0401														0.0478	0.0472	0.0509	0.0487
2016	0.0803	0.0752	0.0587	0.0410	41.2	*0.0*	20.6	0.0205	0.0102	0.0342	0.0101							0.0473	0.0467	0.0504	0.0482
2017	0.0770	0.0721	0.0604	0.0472	123.7	*0.0*	61.8	0.0196	0.0097	0.0353	0.0119		0.0196	0.0097	0.0353	0.0119		0.0469	0.0464	0.0500	0.0479
2018	0.0663	0.0615	0.0593	0.0505	200.9	*0.0*	100.4	0.0104	0.0051	0.0000	0.0000		0.0104	0.0051	0.0000	0.0000		0.0466	0.0461	0.0497	0.0476
2019	0.0654	0.0606	0.0589	0.0499	174.1	*0.0*	87.0											0.0462	0.0457	0.0492	0.0472
2020	0.0638	0.0585	0.0590	0.0478	146.6	191.1	168.9											0.0458	0.0452	0.0488	0.0467
2021	0.0682	0.0631	0.0641	0.0531	149.7	195.1	172.4											0.0446	0.0440	0.0475	0.0455
2022	0.0719	0.0664	0.0673	0.0558	151.1	196.9	174.0											0.0433	0.0428	0.0462	0.0442
2023	0.0738	0.0686	0.0719	0.0589	148.7	193.9	171.3											0.0421	0.0416	0.0449	0.0430
2024	0.0766	0.0714	0.0725	0.0617	151.8	197.9	174.8											0.0409	0.0404	0.0436	0.0418
2025	0.0810	0.0737	0.0783	0.0638	155.0	202.0	178.5											0.0397	0.0392	0.0423	0.0405
2026	0.0824	0.0761	0.0830	0.0666	155.6	202.8	179.2											0.0385	0.0380	0.0410	0.0393
2027	0.0838	0.0781	0.0805	0.0685	154.2	200.9	177.5											0.0373	0.0369	0.0397	0.0381
2028	0.0868	0.0817	0.0866	0.0724	157.9	205.8	181.8											0.0361	0.0357	0.0385	0.0368
2029	0.0909	0.0859	0.0898	0.0751	164.0	213.8	188.9											0.0349	0.0345	0.0372	0.0356
2030	0.0983	0.0892	0.1067	0.0803	165.8	216.1	191.0											0.0337	0.0333	0.0359	0.0344
2031	0.1015	0.0924	0.1112	0.0834	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2032	0.1048	0.0956	0.1159	0.0865	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2033	0.1083	0.0990	0.1209	0.0898	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2034	0.1119	0.1025	0.1260	0.0932	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2035	0.1156	0.1062	0.1314	0.0968	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2036	0.1194	0.1100	0.1371	0.1005	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2037	0.1234	0.1140	0.1430	0.1044	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2038	0.1275	0.1181	0.1492	0.1085	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2039	0.1318	0.1224	0.1557	0.1128	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2040	0.1362	0.1268	0.1625	0.1172	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2041	0.1408	0.1315	0.1696	0.1218	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2042	0.1455	0.1363	0.1771	0.1267	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2043	0.1505	0.1413	0.1849	0.1317	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2044	0.1556	0.1465	0.1931	0.1370	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2045	0.1609	0.1519	0.2017	0.1425	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
Levelized Costs																					
10 years (2016-2025)	0.0724	0.0671	0.0646	0.0525	143.2	111.9	127.5	0.0055	0.0027	0.0076	0.0024	0.0000	0.0033	0.0016	0.0039	0.0013	0.0000	0.045	0.044	0.047	0.045
15 years (2016-2030)	0.0770	0.0715	0.0718	0.0584	147.9	140.1	144.0	0.0039	0.0019	0.0054	0.0017	0.0000	0.0023	0.0012	0.0028	0.0009	0.0000	0.042	0.042	0.045	0.043
30 years (2016-2045)	0.0976	0.0905	0.1036	0.0789	152.4	167.6	160.0	0.0023	0.0011	0.0032	0.0010	0.0000	0.0014	0.0007	0.0016	0.0006	0.0000	0.039	0.038	0.041	0.039

NOTES:

General — All Avoided Costs are in Year 2015 Dollars

ISO NE periods: Summer is June through September, Winter is all other months. Peak hours are: Monday through Friday 7 AM - 11 PM; Off-Peak Hours are all other hours

1. Avoided cost of electric energy = (wholesale energy avoided cost + REC cost to load) * risk premium, e.g. A = (v+ad) * (1+Wholesale Risk Premium)
2. Absolute value of avoided capacity costs and capacity DRIPE each year is function of quantity of kW reduction in year, PA strategy re bidding that reduction into applicable FCAs, and unit values in columns e and f. □
3. Proceeds from selling into the FCM also include the ISO-NE loss factor of 8%
4. PTF loss = 2.20%
5. Electric Cross -DRIPE is electric owen fuel DRIPE + Electric Cross-DRIPE

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Table Two: Inputs to Avoided Cost Calculations

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Zone: MA-SEMA

	Wholesale Avoided Costs of Electricity								Avoided REC Costs to Load	DRIPE: 2016 vintage measures Rest-of-Pool				DRIPE: 2017 vintage measures Rest-of-Pool			
	Energy				Electric Cross DRIPE (5)		Capacity			Energy				Energy			
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter	Summer	FCA Price	Reserve Margin	REC Costs	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	%	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh
Period:	v	w	x	y	z	aa	ab	ac	ad	ae	af	ag	ah	ai	aj	ak	al
2015	0.0732	0.0649	0.0391	0.0302			39.7	17.0%	0.0067								
2016	0.0664	0.0617	0.0466	0.0304	0.0425	0.0268	38.2	17.0%	0.0072	0.0183	0.0105	0.0291	0.0093				
2017	0.0635	0.0590	0.0482	0.0361	0.0250	0.0159	114.5	17.0%	0.0072	0.0175	0.0100	0.0301	0.0110	0.0175	0.0100	0.0301	0.0110
2018	0.0537	0.0493	0.0473	0.0392	0.0116	0.0076	186.0	17.0%	0.0071	0.0093	0.0052	0.0000	0.0000	0.0093	0.0052	0.0000	0.0000
2019	0.0530	0.0486	0.0471	0.0388	0.0075	0.0050	161.2	17.0%	0.0070								
2020	0.0517	0.0469	0.0473	0.0370	0.0073	0.0050	135.8	17.0%	0.0069								
2021	0.0538	0.0492	0.0501	0.0400	0.0013	0.0012	138.6	17.0%	0.0088								
2022	0.0570	0.0519	0.0528	0.0422	0.0013	0.0012	139.9	17.0%	0.0090								
2023	0.0584	0.0537	0.0567	0.0447	0.0013	0.0012	137.7	17.0%	0.0093								
2024	0.0606	0.0558	0.0568	0.0469	0.0013	0.0012	140.6	17.0%	0.0097								
2025	0.0644	0.0578	0.0620	0.0487	0.0013	0.0012	143.5	17.0%	0.0099								
2026	0.0658	0.0600	0.0663	0.0513	0.0013	0.0012	144.1	17.0%	0.0098								
2027	0.0672	0.0619	0.0641	0.0531	0.0013	0.0012	142.7	17.0%	0.0098								
2028	0.0687	0.0640	0.0685	0.0555	0.0013	0.0012	146.2	17.0%	0.0109								
2029	0.0726	0.0680	0.0716	0.0582	0.0013	0.0012	151.9	17.0%	0.0108								
2030	0.0795	0.0712	0.0872	0.0630	0.0013	0.0012	153.5	17.0%	0.0107								
2031	0.0824	0.0740	0.0914	0.0658	0.0013	0.0012	147.0	17.0%	0.0107								
2032	0.0855	0.0770	0.0957	0.0687	0.0013	0.0012	147.0	17.0%	0.0107								
2033	0.0886	0.0801	0.1002	0.0717	0.0013	0.0012	147.0	17.0%	0.0107								
2034	0.0919	0.0833	0.1049	0.0748	0.0013	0.0012	147.0	17.0%	0.0107								
2035	0.0953	0.0867	0.1099	0.0781	0.0013	0.0012	147.0	17.0%	0.0107								
2036	0.0988	0.0902	0.1151	0.0815	0.0013	0.0012	147.0	17.0%	0.0107								
2037	0.1025	0.0938	0.1205	0.0851	0.0013	0.0012	147.0	17.0%	0.0107								
2038	0.1062	0.0976	0.1262	0.0888	0.0013	0.0012	147.0	17.0%	0.0107								
2039	0.1101	0.1015	0.1321	0.0927	0.0013	0.0012	147.0	17.0%	0.0107								
2040	0.1142	0.1056	0.1384	0.0968	0.0013	0.0012	147.0	17.0%	0.0107								
2041	0.1184	0.1099	0.1449	0.1010	0.0013	0.0012	147.0	17.0%	0.0107								
2042	0.1228	0.1143	0.1517	0.1054	0.0013	0.0012	147.0	17.0%	0.0107								
2043	0.1273	0.1189	0.1589	0.1101	0.0013	0.0012	147.0	17.0%	0.0107								
2044	0.1320	0.1237	0.1664	0.1149	0.0013	0.0012	147.0	17.0%	0.0108								
2045	0.1369	0.1286	0.1743	0.1199	0.0013	0.0012	147.0	17.0%	0.0108								
Levelized Costs																	
10 years (2016-2025)	0.0583	0.0534	0.0512	0.0401	0.0108	0.0071	132.6		0.0081	0.0049	0.0028	0.0065	0.0022	0.0030	0.0017	0.0033	0.0012
15 years (2016-2030)	0.0619	0.0568	0.0571	0.0448	0.0080	0.0054	137.0		0.0088	0.0035	0.0020	0.0046	0.0016	0.0021	0.0012	0.0024	0.0009
30 years (2016-2045)	0.0799	0.0734	0.0854	0.0628	0.0053	0.0037	141.1		0.0096	0.0020	0.0012	0.0027	0.0009	0.0012	0.0007	0.0014	0.0005

NOTES: General All Avoided Costs are in Year 2015 Dollars
periods:

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Table One: Avoided Cost of Electricity (2015 $) Results :

MA-WCMA

WCMA (West-Central Massachusetts)

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State MA

User-defined Inputs	
Wholesale Risk Premium (WRP)	9.00%
Distribution Losses	8.00%
Real Discount Rate	2.43%
Pcnt of Capacity Bid into FCM (%Bid)	50.00%

	Avoided Unit Cost of Electric Energy[1]				Avoided Unit Cost of Electric Capacity[2]			DRIPE: 2016 vintage measures Intrastate					DRIPE: 2017 vintage measures Intrastate					Avoided Non-Embedded Costs			
								Energy				Capacity (See note 2)	Energy				Capacity (See note 2)				
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	kW sold into FCA (PA to determine quantity)[3]	kW purchased from FCA (PA to determine quantity)	Weighted Average Avoided Cost Based on Percent Capacity Bid	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kW-yr	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh
Period:	a	b	c	d	e=ab*1.08	f=ab*(1+ac)*(1+WRP) *(1+Dist Loss) *(1+PTF Loss)	g=(e*%Bid)+(f*(1 +%Bid))	h	i	j	k	l	m	n	o	p	q	r	s	t	u
2015	0.0872	0.0780	0.0507	0.0404														0.0478	0.0472	0.0509	0.0487
2016	0.0806	0.0752	0.0596	0.0415	41.2	*0.0*	20.6	0.0205	0.0102	0.0342	0.0101							0.0473	0.0467	0.0504	0.0482
2017	0.0774	0.0722	0.0612	0.0476	123.7	*0.0*	61.8	0.0196	0.0097	0.0353	0.0119		0.0196	0.0097	0.0353	0.0119		0.0469	0.0464	0.0500	0.0479
2018	0.0666	0.0615	0.0599	0.0506	143.6	*0.0*	71.8	0.0104	0.0051	0.0000	0.0000		0.0104	0.0051	0.0000	0.0000		0.0466	0.0461	0.0497	0.0476
2019	0.0657	0.0606	0.0595	0.0500	133.2	*0.0*	66.6											0.0462	0.0457	0.0492	0.0472
2020	0.0641	0.0586	0.0596	0.0482	146.6	191.1	168.9											0.0458	0.0452	0.0488	0.0467
2021	0.0684	0.0632	0.0648	0.0534	149.7	195.1	172.4											0.0446	0.0440	0.0475	0.0455
2022	0.0721	0.0664	0.0679	0.0559	151.1	196.9	174.0											0.0433	0.0428	0.0462	0.0442
2023	0.0739	0.0686	0.0724	0.0591	148.7	193.9	171.3											0.0421	0.0416	0.0449	0.0430
2024	0.0767	0.0715	0.0730	0.0620	151.8	197.9	174.8											0.0409	0.0404	0.0436	0.0418
2025	0.0811	0.0737	0.0791	0.0644	155.0	202.0	178.5											0.0397	0.0392	0.0423	0.0405
2026	0.0827	0.0762	0.0835	0.0668	155.6	202.8	179.2											0.0385	0.0380	0.0410	0.0393
2027	0.0840	0.0781	0.0810	0.0687	154.2	200.9	177.5											0.0373	0.0369	0.0397	0.0381
2028	0.0869	0.0817	0.0871	0.0727	157.9	205.8	181.8											0.0361	0.0357	0.0385	0.0368
2029	0.0910	0.0859	0.0903	0.0755	164.0	213.8	188.9											0.0349	0.0345	0.0372	0.0356
2030	0.0985	0.0893	0.1075	0.0808	165.8	216.1	191.0											0.0337	0.0333	0.0359	0.0344
2031	0.1017	0.0924	0.1120	0.0838	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2032	0.1050	0.0957	0.1168	0.0870	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2033	0.1084	0.0990	0.1217	0.0903	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2034	0.1120	0.1026	0.1269	0.0938	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2035	0.1157	0.1062	0.1323	0.0974	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2036	0.1195	0.1100	0.1380	0.1012	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2037	0.1234	0.1140	0.1439	0.1051	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2038	0.1276	0.1181	0.1501	0.1093	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2039	0.1318	0.1224	0.1566	0.1136	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2040	0.1362	0.1269	0.1634	0.1180	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2041	0.1408	0.1315	0.1706	0.1227	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2042	0.1456	0.1363	0.1780	0.1276	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2043	0.1505	0.1413	0.1858	0.1327	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2044	0.1556	0.1466	0.1940	0.1381	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2045	0.1609	0.1520	0.2026	0.1436	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
Levelized Costs																					
10 years (2016-2025)	0.0726	0.0671	0.0653	0.0528	132.9	111.9	122.4	0.0055	0.0027	0.0076	0.0024	0.0000	0.0033	0.0016	0.0039	0.0013	0.0000	0.045	0.044	0.047	0.045
15 years (2016-2030)	0.0773	0.0715	0.0724	0.0587	140.7	140.1	140.4	0.0039	0.0019	0.0054	0.0017	0.0000	0.0023	0.0012	0.0028	0.0009	0.0000	0.042	0.042	0.045	0.043
30 years (2016-2045)	0.0977	0.0905	0.1043	0.0794	148.1	167.6	157.8	0.0023	0.0011	0.0032	0.0010	0.0000	0.0014	0.0007	0.0016	0.0006	0.0000	0.039	0.038	0.041	0.039

NOTES:

General All Avoided Costs are in Year 2015 Dollars

ISO NE periods: Summer is June through September, Winter is all other months. Peak hours are: Monday through Friday 7 AM - 11 PM; Off-Peak Hours are all other hours

1 Avoided cost of electric energy = (wholesale energy avoided cost + REC cost to load) * risk premium, e.g. A = (v+ad) * (1+Wholesale Risk Premium)

2 Absolute value of avoided capacity costs and capacity DRIPE each year is function of quantity of kW reduction in year, PA strategy re bidding that reduction into applicable FCAs, and unit values in columns e and f. □

3 Proceeds from selling into the FCM also include the ISO-NE loss factor of 8%

4 PTF loss = 2.20%

5 Electric Cross -DRIPE is electric owen fuel DRIPE + Electric Cross-DRIPE

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Table Two: Inputs to Avoided Cost Calculations

Zone: MA-WCMA

	Wholesale Avoided Costs of Electricity								Avoided REC Costs to Load	DRIPE: 2016 vintage measures Rest-of-Pool				DRIPE: 2017 vintage measures Rest-of-Pool			
	Energy				Electric Cross DRIPE (5)		Capacity			Energy				Energy			
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter	Summer	FCA Price	Reserve Margin	REC Costs	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	%	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh
Period:	v	w	x	y	z	aa	ab	ac	ad	ae	af	ag	ah	ai	aj	ak	al
2015	0.0733	0.0649	0.0398	0.0304			39.7	17.0%	0.0067								
2016	0.0667	0.0618	0.0474	0.0308	0.0425	0.0268	38.2	17.0%	0.0072	0.0183	0.0105	0.0291	0.0093				
2017	0.0638	0.0590	0.0489	0.0365	0.0250	0.0159	114.5	17.0%	0.0072	0.0175	0.0100	0.0301	0.0110	0.0175	0.0100	0.0301	0.0110
2018	0.0540	0.0493	0.0479	0.0393	0.0116	0.0076	132.9	17.0%	0.0071	0.0093	0.0052	0.0000	0.0000	0.0093	0.0052	0.0000	0.0000
2019	0.0533	0.0486	0.0476	0.0389	0.0075	0.0050	123.3	17.0%	0.0070								
2020	0.0519	0.0469	0.0479	0.0373	0.0073	0.0050	135.8	17.0%	0.0069								
2021	0.0540	0.0492	0.0507	0.0402	0.0013	0.0012	138.6	17.0%	0.0088								
2022	0.0572	0.0519	0.0533	0.0424	0.0013	0.0012	139.9	17.0%	0.0090								
2023	0.0586	0.0537	0.0571	0.0449	0.0013	0.0012	137.7	17.0%	0.0093								
2024	0.0607	0.0558	0.0573	0.0471	0.0013	0.0012	140.6	17.0%	0.0097								
2025	0.0646	0.0578	0.0627	0.0492	0.0013	0.0012	143.5	17.0%	0.0099								
2026	0.0660	0.0601	0.0668	0.0515	0.0013	0.0012	144.1	17.0%	0.0098								
2027	0.0673	0.0619	0.0645	0.0532	0.0013	0.0012	142.7	17.0%	0.0098								
2028	0.0689	0.0641	0.0690	0.0558	0.0013	0.0012	146.2	17.0%	0.0109								
2029	0.0727	0.0680	0.0721	0.0585	0.0013	0.0012	151.9	17.0%	0.0108								
2030	0.0796	0.0712	0.0880	0.0634	0.0013	0.0012	153.5	17.0%	0.0107								
2031	0.0826	0.0741	0.0921	0.0662	0.0013	0.0012	147.0	17.0%	0.0107								
2032	0.0856	0.0771	0.0964	0.0691	0.0013	0.0012	147.0	17.0%	0.0107								
2033	0.0887	0.0802	0.1009	0.0722	0.0013	0.0012	147.0	17.0%	0.0107								
2034	0.0920	0.0834	0.1057	0.0753	0.0013	0.0012	147.0	17.0%	0.0107								
2035	0.0954	0.0867	0.1107	0.0786	0.0013	0.0012	147.0	17.0%	0.0107								
2036	0.0989	0.0902	0.1158	0.0821	0.0013	0.0012	147.0	17.0%	0.0107								
2037	0.1025	0.0939	0.1213	0.0857	0.0013	0.0012	147.0	17.0%	0.0107								
2038	0.1063	0.0976	0.1270	0.0895	0.0013	0.0012	147.0	17.0%	0.0107								
2039	0.1102	0.1016	0.1330	0.0934	0.0013	0.0012	147.0	17.0%	0.0107								
2040	0.1143	0.1057	0.1392	0.0976	0.0013	0.0012	147.0	17.0%	0.0107								
2041	0.1185	0.1099	0.1457	0.1019	0.0013	0.0012	147.0	17.0%	0.0107								
2042	0.1228	0.1143	0.1526	0.1063	0.0013	0.0012	147.0	17.0%	0.0107								
2043	0.1273	0.1189	0.1598	0.1110	0.0013	0.0012	147.0	17.0%	0.0107								
2044	0.1320	0.1237	0.1673	0.1159	0.0013	0.0012	147.0	17.0%	0.0108								
2045	0.1369	0.1287	0.1751	0.1210	0.0013	0.0012	147.0	17.0%	0.0108								
Levelized Costs																	
10 years (2016-2025)	0.0585	0.0534	0.0518	0.0403	0.0108	0.0071	123.0		0.0081	0.0049	0.0028	0.0065	0.0022	0.0030	0.0017	0.0033	0.0012
15 years (2016-2030)	0.0621	0.0568	0.0577	0.0450	0.0080	0.0054	130.2		0.0088	0.0035	0.0020	0.0046	0.0016	0.0021	0.0012	0.0024	0.0009
30 years (2016-2045)	0.0801	0.0735	0.0861	0.0632	0.0053	0.0037	137.1		0.0096	0.0020	0.0012	0.0027	0.0009	0.0012	0.0007	0.0014	0.0005

NOTES: General All Avoided Costs are in Year 2015 Dollars
periods:

Revision: 4/3/2015

Table One: Avoided Cost of Electricity (2015 $) Results :

MA
Massachusetts

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State MA

User-defined Inputs	
Wholesale Risk Premium (WRP)	9.00%
Distribution Losses	8.00%
Real Discount Rate	2.43%
Pcnt of Capacity Bid into FCM (%Bid)	50.00%

	Avoided Unit Cost of Electric Energy[1]				Avoided Unit Cost of Electric Capacity[2]			DRIPE: 2016 vintage measures Intrastate					DRIPE: 2017 vintage measures Intrastate					Avoided Non-Embedded Costs			
								Energy				Capacity (See note 2)	Energy				Capacity (See note 2)				
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	kW sold into FCA (PA to determine quantity)[3]	kW purchased from FCA (PA to determine quantity)	Weighted Average Avoided Cost Based on Percent Capacity Bid	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kW-yr	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh
Period:	a	b	c	d	e=ab*1.08	f=ab*(1+ac)*(1+WRP)*(1+Dist Loss)*(1+PTF Loss)	g=(e*%Bid)+(f*(1+%Bid))	h	i	j	k	l	m	n	o	p	q	r	s	t	u
2015	0.0873	0.0780	0.0511	0.0404														0.0478	0.0472	0.0509	0.0487
2016	0.0807	0.0752	0.0600	0.0414	79.0	*0.0*	39.5	0.0205	0.0102	0.0342	0.0101							0.0473	0.0467	0.0504	0.0482
2017	0.0775	0.0722	0.0615	0.0475	150.7	*0.0*	75.4	0.0196	0.0097	0.0353	0.0119		0.0196	0.0097	0.0353	0.0119		0.0469	0.0464	0.0500	0.0479
2018	0.0668	0.0615	0.0602	0.0506	159.5	*0.0*	79.8	0.0104	0.0051	0.0000	0.0000		0.0104	0.0051	0.0000	0.0000		0.0466	0.0461	0.0497	0.0476
2019	0.0658	0.0606	0.0598	0.0500	144.6	*0.0*	72.3											0.0462	0.0457	0.0492	0.0472
2020	0.0642	0.0586	0.0598	0.0481	146.6	191.1	168.9											0.0458	0.0452	0.0488	0.0467
2021	0.0686	0.0632	0.0651	0.0534	149.7	195.1	172.4											0.0446	0.0440	0.0475	0.0455
2022	0.0723	0.0664	0.0682	0.0559	151.1	196.9	174.0											0.0433	0.0428	0.0462	0.0442
2023	0.0740	0.0686	0.0726	0.0590	148.7	193.9	171.3											0.0421	0.0416	0.0449	0.0430
2024	0.0768	0.0715	0.0733	0.0619	151.8	197.9	174.8											0.0409	0.0404	0.0436	0.0418
2025	0.0813	0.0737	0.0792	0.0641	155.0	202.0	178.5											0.0397	0.0392	0.0423	0.0405
2026	0.0827	0.0761	0.0837	0.0668	155.6	202.8	179.2											0.0385	0.0380	0.0410	0.0393
2027	0.0840	0.0781	0.0812	0.0686	154.2	200.9	177.5											0.0373	0.0369	0.0397	0.0381
2028	0.0870	0.0817	0.0873	0.0726	157.9	205.8	181.8											0.0361	0.0357	0.0385	0.0368
2029	0.0911	0.0859	0.0905	0.0753	164.0	213.8	188.9											0.0349	0.0345	0.0372	0.0356
2030	0.0985	0.0893	0.1078	0.0806	165.8	216.1	191.0											0.0337	0.0333	0.0359	0.0344
2031	0.1017	0.0924	0.1123	0.0836	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2032	0.1050	0.0956	0.1171	0.0868	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2033	0.1084	0.0990	0.1220	0.0901	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2034	0.1120	0.1025	0.1271	0.0935	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2035	0.1157	0.1062	0.1326	0.0971	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2036	0.1195	0.1100	0.1382	0.1008	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2037	0.1235	0.1139	0.1441	0.1047	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2038	0.1276	0.1181	0.1503	0.1088	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2039	0.1318	0.1223	0.1568	0.1131	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2040	0.1362	0.1268	0.1636	0.1175	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2041	0.1408	0.1314	0.1707	0.1221	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2042	0.1455	0.1362	0.1782	0.1269	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2043	0.1505	0.1413	0.1860	0.1320	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2044	0.1556	0.1465	0.1941	0.1373	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2045	0.1608	0.1519	0.2027	0.1427	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
Levelized Costs																					
10 years (2016-2025)	0.0728	0.0671	0.0655	0.0527	142.9	111.9	127.4	0.0055	0.0027	0.0076	0.0024	0.0000	0.0033	0.0016	0.0039	0.0013	0.0000	0.045	0.044	0.047	0.045
15 years (2016-2030)	0.0774	0.0715	0.0727	0.0586	147.7	140.1	143.9	0.0039	0.0019	0.0054	0.0017	0.0000	0.0023	0.0012	0.0028	0.0009	0.0000	0.042	0.042	0.045	0.043
30 years (2016-2045)	0.0978	0.0905	0.1045	0.0791	152.2	167.6	159.9	0.0023	0.0011	0.0032	0.0010	0.0000	0.0014	0.0007	0.0016	0.0006	0.0000	0.039	0.038	0.041	0.039

NOTES:

General All Avoided Costs are in Year 2015 Dollars

ISO NE periods: Summer is June through September, Winter is all other months. Peak hours are: Monday through Friday 7 AM - 11 PM; Off-Peak Hours are all other hours

1 Avoided cost of electric energy = (wholesale energy avoided cost + REC cost to load) * risk premium, e.g. A = (v+ad) * (1+Wholesale Risk Premium)

2 Absolute value of avoided capacity costs and capacity DRIPE each year is function of quantity of kW reduction in year, PA strategy re bidding that reduction into applicable FCAs, and unit values in columns e and f. □

3 Proceeds from selling into the FCM also include the ISO-NE loss factor of 8%

4 PTF loss = 2.20%

5 Electric Cross -DRIPE is electric owen fuel DRIPE + Electric Cross-DRIPE

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Table Two: Inputs to Avoided Cost Calculations

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Zone: MA

	Wholesale Avoided Costs of Electricity								Avoided REC Costs to Load	DRIPE: 2016 vintage measures Rest-of-Pool				DRIPE: 2017 vintage measures Rest-of-Pool			
	Energy				Electric Cross DRIPE (5)		Capacity			Energy				Energy			
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter	Summer	FCA Price	Reserve Margin	REC Costs	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	%	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh
Period:	v	w	x	y	z	aa	ab	ac	ad	ae	af	ag	ah	ai	aj	ak	al
2015	0.0734	0.0649	0.0402	0.0304			39.7	17.0%	0.0067								
2016	0.0668	0.0618	0.0478	0.0307	0.0425	0.0268	73.1	17.0%	0.0072	0.0183	0.0105	0.0291	0.0093				
2017	0.0639	0.0590	0.0492	0.0364	0.0250	0.0159	139.6	17.0%	0.0072	0.0175	0.0100	0.0301	0.0110	0.0175	0.0100	0.0301	0.0110
2018	0.0542	0.0493	0.0481	0.0393	0.0116	0.0076	147.7	17.0%	0.0071	0.0093	0.0052	0.0000	0.0000	0.0093	0.0052	0.0000	0.0000
2019	0.0534	0.0486	0.0478	0.0389	0.0075	0.0050	133.9	17.0%	0.0070								
2020	0.0521	0.0469	0.0481	0.0372	0.0073	0.0050	135.8	17.0%	0.0069								
2021	0.0542	0.0492	0.0509	0.0402	0.0013	0.0012	138.6	17.0%	0.0088								
2022	0.0574	0.0520	0.0536	0.0423	0.0013	0.0012	139.9	17.0%	0.0090								
2023	0.0586	0.0537	0.0573	0.0449	0.0013	0.0012	137.7	17.0%	0.0093								
2024	0.0608	0.0558	0.0575	0.0471	0.0013	0.0012	140.6	17.0%	0.0097								
2025	0.0648	0.0578	0.0628	0.0490	0.0013	0.0012	143.5	17.0%	0.0099								
2026	0.0661	0.0600	0.0670	0.0515	0.0013	0.0012	144.1	17.0%	0.0098								
2027	0.0673	0.0619	0.0647	0.0532	0.0013	0.0012	142.7	17.0%	0.0098								
2028	0.0689	0.0641	0.0692	0.0557	0.0013	0.0012	146.2	17.0%	0.0109								
2029	0.0728	0.0680	0.0723	0.0583	0.0013	0.0012	151.9	17.0%	0.0108								
2030	0.0797	0.0712	0.0882	0.0633	0.0013	0.0012	153.5	17.0%	0.0107								
2031	0.0826	0.0741	0.0924	0.0660	0.0013	0.0012	147.0	17.0%	0.0107								
2032	0.0856	0.0770	0.0967	0.0689	0.0013	0.0012	147.0	17.0%	0.0107								
2033	0.0888	0.0801	0.1012	0.0719	0.0013	0.0012	147.0	17.0%	0.0107								
2034	0.0920	0.0834	0.1059	0.0751	0.0013	0.0012	147.0	17.0%	0.0107								
2035	0.0954	0.0867	0.1109	0.0784	0.0013	0.0012	147.0	17.0%	0.0107								
2036	0.0989	0.0902	0.1161	0.0818	0.0013	0.0012	147.0	17.0%	0.0107								
2037	0.1025	0.0938	0.1215	0.0854	0.0013	0.0012	147.0	17.0%	0.0107								
2038	0.1063	0.0976	0.1272	0.0891	0.0013	0.0012	147.0	17.0%	0.0107								
2039	0.1102	0.1015	0.1331	0.0930	0.0013	0.0012	147.0	17.0%	0.0107								
2040	0.1142	0.1056	0.1394	0.0971	0.0013	0.0012	147.0	17.0%	0.0107								
2041	0.1184	0.1098	0.1459	0.1013	0.0013	0.0012	147.0	17.0%	0.0107								
2042	0.1228	0.1143	0.1527	0.1057	0.0013	0.0012	147.0	17.0%	0.0107								
2043	0.1273	0.1188	0.1599	0.1103	0.0013	0.0012	147.0	17.0%	0.0107								
2044	0.1320	0.1236	0.1673	0.1152	0.0013	0.0012	147.0	17.0%	0.0108								
2045	0.1368	0.1286	0.1752	0.1202	0.0013	0.0012	147.0	17.0%	0.0108								
Levelized Costs																	
10 years (2016-2025)	0.0586	0.0535	0.0520	0.0403	0.0108	0.0071	132.3		0.0081	0.0049	0.0028	0.0065	0.0022	0.0030	0.0017	0.0033	0.0012
15 years (2016-2030)	0.0622	0.0568	0.0579	0.0450	0.0080	0.0054	136.8		0.0088	0.0035	0.0020	0.0046	0.0016	0.0021	0.0012	0.0024	0.0009
30 years (2016-2045)	0.0801	0.0734	0.0863	0.0630	0.0053	0.0037	141.0		0.0096	0.0020	0.0012	0.0027	0.0009	0.0012	0.0007	0.0014	0.0005

NOTES: General — All Avoided Costs are in Year 2015 Dollars
periods:

Revision: 4/3/2015

Table One: Avoided Cost of Electricity (2015 $) Results : ME Maine

State ME

User-defined Inputs	
Wholesale Risk Premium (WRP)	9.00%
Distribution Losses	8.00%
Real Discount Rate	2.43%
Pcnt of Capacity Bid into FCM (%Bid)	50.00%

	Avoided Unit Cost of Electric Energy[1]				Avoided Unit Cost of Electric Capacity[2]			DRIPE: 2016 vintage measures Intrastate					DRIPE: 2017 vintage measures Intrastate					Avoided Non-Embedded Costs			
								Energy				Capacity (See note 2)	Energy				Capacity (See note 2)				
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	kW sold into FCA (PA to determine quantity)[3]	kW purchased from FCA (PA to determine quantity)	Weighted Average Avoided Cost Based on Percent Capacity Bid	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kW-yr	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh
Period:	a	b	c	d	e=ab*1.08	f=ab*(1+ac)*(1+WRP) *(1+Dist Loss) *(1+PTF Loss)	g=(e*%Bid)+(f*(1 +%Bid))	h	i	j	k	l	m	n	o	p	q	r	s	t	u
2015	0.0802	0.0712	0.0431	0.0333														0.0478	0.0472	0.0509	0.0487
2016	0.0727	0.0678	0.0514	0.0338	41.2	*0.0*	20.6	0.0037	0.0023	-0.0023	0.0007							0.0473	0.0467	0.0504	0.0482
2017	0.0694	0.0647	0.0531	0.0399	123.7	*0.0*	61.8	0.0036	0.0022	-0.0024	0.0008		0.0036	0.0022	-0.0024	0.0008		0.0469	0.0464	0.0500	0.0479
2018	0.0593	0.0545	0.0524	0.0435	143.6	*0.0*	71.8	0.0019	0.0011	0.0000	0.0000		0.0019	0.0011	0.0000	0.0000		0.0466	0.0461	0.0497	0.0476
2019	0.0586	0.0538	0.0522	0.0432	133.2	*0.0*	66.6											0.0462	0.0457	0.0492	0.0472
2020	0.0570	0.0519	0.0526	0.0413	146.6	191.1	168.9											0.0458	0.0452	0.0488	0.0467
2021	0.0588	0.0539	0.0551	0.0441	149.7	195.1	172.4											0.0446	0.0440	0.0475	0.0455
2022	0.0618	0.0562	0.0577	0.0460	151.1	196.9	174.0											0.0433	0.0428	0.0462	0.0442
2023	0.0632	0.0578	0.0616	0.0485	148.7	193.9	171.3											0.0421	0.0416	0.0449	0.0430
2024	0.0651	0.0599	0.0616	0.0507	151.8	197.9	174.8											0.0409	0.0404	0.0436	0.0418
2025	0.0679	0.0617	0.0666	0.0525	155.0	202.0	178.5											0.0397	0.0392	0.0423	0.0405
2026	0.0704	0.0639	0.0720	0.0553	155.6	202.8	179.2											0.0385	0.0380	0.0410	0.0393
2027	0.0720	0.0658	0.0693	0.0570	154.2	200.9	177.5											0.0373	0.0369	0.0397	0.0381
2028	0.0736	0.0679	0.0737	0.0595	157.9	205.8	181.8											0.0361	0.0357	0.0385	0.0368
2029	0.0772	0.0718	0.0766	0.0622	164.0	213.8	188.9											0.0349	0.0345	0.0372	0.0356
2030	0.0845	0.0752	0.0944	0.0675	165.8	216.1	191.0											0.0337	0.0333	0.0359	0.0344
2031	0.0874	0.0779	0.0986	0.0703	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2032	0.0904	0.0808	0.1030	0.0732	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2033	0.0935	0.0838	0.1076	0.0763	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2034	0.0968	0.0869	0.1124	0.0794	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2035	0.1001	0.0901	0.1174	0.0828	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2036	0.1036	0.0935	0.1226	0.0862	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2037	0.1072	0.0969	0.1281	0.0898	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2038	0.1109	0.1005	0.1338	0.0935	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2039	0.1147	0.1042	0.1398	0.0974	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2040	0.1187	0.1081	0.1460	0.1014	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2041	0.1228	0.1121	0.1525	0.1057	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2042	0.1270	0.1163	0.1593	0.1101	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2043	0.1314	0.1206	0.1665	0.1146	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2044	0.1359	0.1250	0.1739	0.1194	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2045	0.1407	0.1297	0.1817	0.1244	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
Levelized Costs																					
10 years (2016-2025)	0.0634	0.0583	0.0561	0.0440	132.9	111.9	122.4	0.0010	0.0006	-0.0005	0.0002	0.0000	0.0006	0.0004	-0.0003	0.0001	0.0000	0.045	0.044	0.047	0.045
15 years (2016-2030)	0.0669	0.0614	0.0622	0.0488	140.7	140.1	140.4	0.0007	0.0004	-0.0004	0.0001	0.0000	0.0004	0.0003	-0.0002	0.0001	0.0000	0.042	0.042	0.045	0.043
30 years (2016-2045)	0.0848	0.0773	0.0916	0.0670	148.1	167.6	157.8	0.0004	0.0003	-0.0002	0.0001	0.0000	0.0002	0.0002	-0.0001	0.0000	0.0000	0.039	0.038	0.041	0.039

NOTES:

General All Avoided Costs are in Year 2015 Dollars
ISO NE periods: Summer is June through September, Winter is all other months. Peak hours are: Monday through Friday 7 AM - 11 PM; Off-Peak Hours are all other hours

1 Avoided cost of electric energy = (wholesale energy avoided cost + REC cost to load) * risk premium, e.g. A = (v+ad) * (1+Wholesale Risk Premium)

2 Absolute value of avoided capacity costs and capacity DRIPE each year is function of quantity of kW reduction in year, PA strategy re bidding that reduction into applicable FCAs, and unit values in columns e and f.

3 Proceeds from selling into the FCM also include the ISO-NE loss factor of 8%

4 PTF loss = 2.20%

5 Electric Cross -DRIPE is electric owen fuel DRIPE + Electric Cross-DRIPE

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Table Two: Inputs to Avoided Cost Calculations

Zone: ME

	Wholesale Avoided Costs of Electricity								Avoided REC Costs to Load	DRIPE: 2016 vintage measures Rest-of-Pool				DRIPE: 2017 vintage measures Rest-of-Pool			
	Energy				Electric Cross DRIPE (5)		Capacity			Energy				Energy			
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter	Summer	FCA Price	Reserve Margin	REC Costs	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	%	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh
Period:	v	w	x	y	z	aa	ab	ac	ad	ae	af	ag	ah	ai	aj	ak	al
2015	0.0731	0.0648	0.0391	0.0301			39.7	17.0%	0.0005								
2016	0.0661	0.0616	0.0466	0.0303	0.0080	0.0051	38.2	17.0%	0.0006	0.0039	0.0025	-0.0028	0.0009				
2017	0.0631	0.0588	0.0482	0.0360	0.0047	0.0030	114.5	17.0%	0.0006	0.0037	0.0023	-0.0028	0.0011	0.0037	0.0023	-0.0028	0.0011
2018	0.0536	0.0493	0.0473	0.0392	0.0022	0.0014	132.9	17.0%	0.0007	0.0020	0.0012	0.0000	0.0000	0.0020	0.0012	0.0000	0.0000
2019	0.0528	0.0485	0.0470	0.0387	0.0014	0.0009	123.3	17.0%	0.0009								
2020	0.0513	0.0467	0.0472	0.0369	0.0014	0.0009	135.8	17.0%	0.0010								
2021	0.0532	0.0488	0.0499	0.0398	0.0002	0.0002	138.6	17.0%	0.0007								
2022	0.0564	0.0512	0.0526	0.0418	0.0002	0.0002	139.9	17.0%	0.0004								
2023	0.0577	0.0528	0.0562	0.0442	0.0002	0.0002	137.7	17.0%	0.0003								
2024	0.0594	0.0547	0.0562	0.0462	0.0002	0.0002	140.6	17.0%	0.0003								
2025	0.0620	0.0563	0.0608	0.0479	0.0002	0.0002	143.5	17.0%	0.0003								
2026	0.0643	0.0583	0.0657	0.0504	0.0002	0.0002	144.1	17.0%	0.0003								
2027	0.0658	0.0600	0.0632	0.0520	0.0002	0.0002	142.7	17.0%	0.0003								
2028	0.0672	0.0620	0.0673	0.0543	0.0002	0.0002	146.2	17.0%	0.0003								
2029	0.0705	0.0656	0.0699	0.0567	0.0002	0.0002	151.9	17.0%	0.0003								
2030	0.0772	0.0686	0.0863	0.0616	0.0002	0.0002	153.5	17.0%	0.0003								
2031	0.0799	0.0712	0.0901	0.0642	0.0002	0.0002	147.0	17.0%	0.0003								
2032	0.0826	0.0738	0.0942	0.0669	0.0002	0.0002	147.0	17.0%	0.0003								
2033	0.0855	0.0766	0.0984	0.0697	0.0002	0.0002	147.0	17.0%	0.0003								
2034	0.0885	0.0794	0.1028	0.0726	0.0002	0.0002	147.0	17.0%	0.0003								
2035	0.0915	0.0824	0.1074	0.0756	0.0002	0.0002	147.0	17.0%	0.0003								
2036	0.0947	0.0854	0.1122	0.0788	0.0002	0.0002	147.0	17.0%	0.0003								
2037	0.0980	0.0886	0.1172	0.0820	0.0002	0.0002	147.0	17.0%	0.0003								
2038	0.1014	0.0919	0.1224	0.0855	0.0002	0.0002	147.0	17.0%	0.0003								
2039	0.1049	0.0953	0.1279	0.0890	0.0002	0.0002	147.0	17.0%	0.0003								
2040	0.1086	0.0989	0.1336	0.0928	0.0002	0.0002	147.0	17.0%	0.0003								
2041	0.1123	0.1025	0.1396	0.0966	0.0002	0.0002	147.0	17.0%	0.0003								
2042	0.1162	0.1064	0.1459	0.1007	0.0002	0.0002	147.0	17.0%	0.0003								
2043	0.1202	0.1103	0.1524	0.1049	0.0002	0.0002	147.0	17.0%	0.0003								
2044	0.1244	0.1144	0.1592	0.1092	0.0002	0.0002	147.0	17.0%	0.0003								
2045	0.1287	0.1187	0.1663	0.1138	0.0002	0.0002	147.0	17.0%	0.0003								
Levelized Costs																	
10 years (2016-2025)	0.0576	0.0529	0.0509	0.0398	0.0020	0.0013	123.0		0.0006	0.0010	0.0007	-0.0006	0.0002	0.0006	0.0004	-0.0003	0.0001
15 years (2016-2030)	0.0609	0.0558	0.0566	0.0442	0.0015	0.0010	130.2		0.0005	0.0007	0.0005	-0.0004	0.0002	0.0004	0.0003	-0.0002	0.0001
30 years (2016-2045)	0.0774	0.0705	0.0836	0.0611	0.0010	0.0007	137.1		0.0004	0.0004	0.0003	-0.0003	0.0001	0.0003	0.0002	-0.0001	0.0000

NOTES: General All Avoided Costs are in Year 2015 Dollars
periods:

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Table One: Avoided Cost of Electricity (2015 $) Results :

NH
New Hampshire

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State NH

User-defined Inputs	
Wholesale Risk Premium (WRP)	9.00%
Distribution Losses	8.00%
Real Discount Rate	2.43%
Pcnt of Capacity Bid into FCM (%Bid)	50.00%

	Avoided Unit Cost of Electric Energy[1]				Avoided Unit Cost of Electric Capacity[2]			DRIPE: 2016 vintage measures Intrastate					DRIPE: 2017 vintage measures Intrastate					Avoided Non-Embedded Costs			
								Energy				Capacity (See note 2)	Energy				Capacity (See note 2)				
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	kW sold into FCA (PA to determine quantity)[3]	kW purchased from FCA (PA to determine quantity)	Weighted Average Avoided Cost Based on Percent Capacity Bid	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kW-yr	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh
Period:	a	b	c	d	e=ab*1.08	f=ab*(1+ac)*(1+WRP) *(1+Dist Loss) *(1+PTF Loss)	g=(e*%Bid)+(f*(1+%Bid))	h	i	j	k	l	m	n	o	p	q	r	s	t	u
2015	0.0878	0.0788	0.0509	0.0410														0.0478	0.0472	0.0509	0.0487
2016	0.0804	0.0753	0.0593	0.0414	41.2	*0.0*	20.6	0.0033	0.0036	0.0115	0.0000							0.0473	0.0467	0.0504	0.0482
2017	0.0773	0.0726	0.0612	0.0478	123.7	*0.0*	61.8	0.0032	0.0034	0.0119	0.0000		0.0032	0.0034	0.0119	0.0000		0.0469	0.0464	0.0500	0.0479
2018	0.0663	0.0614	0.0595	0.0504	143.6	*0.0*	71.8	0.0017	0.0018	0.0000	0.0000		0.0017	0.0018	0.0000	0.0000		0.0466	0.0461	0.0497	0.0476
2019	0.0656	0.0607	0.0594	0.0502	133.2	*0.0*	66.6											0.0462	0.0457	0.0492	0.0472
2020	0.0641	0.0590	0.0598	0.0484	146.6	191.1	168.9											0.0458	0.0452	0.0488	0.0467
2021	0.0678	0.0630	0.0642	0.0531	149.7	195.1	172.4											0.0446	0.0440	0.0475	0.0455
2022	0.0716	0.0662	0.0673	0.0557	151.1	196.9	174.0											0.0433	0.0428	0.0462	0.0442
2023	0.0733	0.0682	0.0716	0.0585	148.7	193.9	171.3											0.0421	0.0416	0.0449	0.0430
2024	0.0755	0.0706	0.0718	0.0610	151.8	197.9	174.8											0.0409	0.0404	0.0436	0.0418
2025	0.0787	0.0727	0.0773	0.0631	155.0	202.0	178.5											0.0397	0.0392	0.0423	0.0405
2026	0.0809	0.0748	0.0819	0.0654	155.6	202.8	179.2											0.0385	0.0380	0.0410	0.0393
2027	0.0822	0.0765	0.0789	0.0669	154.2	200.9	177.5											0.0373	0.0369	0.0397	0.0381
2028	0.0835	0.0785	0.0832	0.0691	157.9	205.8	181.8											0.0361	0.0357	0.0385	0.0368
2029	0.0878	0.0832	0.0868	0.0724	164.0	213.8	188.9											0.0349	0.0345	0.0372	0.0356
2030	0.0950	0.0863	0.1041	0.0775	165.8	216.1	191.0											0.0337	0.0333	0.0359	0.0344
2031	0.0983	0.0895	0.1086	0.0806	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2032	0.1016	0.0928	0.1132	0.0837	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2033	0.1051	0.0962	0.1181	0.0870	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2034	0.1087	0.0998	0.1232	0.0905	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2035	0.1124	0.1035	0.1286	0.0941	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2036	0.1163	0.1074	0.1342	0.0978	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2037	0.1203	0.1114	0.1400	0.1017	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2038	0.1244	0.1156	0.1462	0.1058	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2039	0.1288	0.1199	0.1526	0.1101	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2040	0.1332	0.1245	0.1593	0.1145	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2041	0.1379	0.1292	0.1663	0.1192	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2042	0.1427	0.1341	0.1737	0.1240	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2043	0.1477	0.1392	0.1814	0.1291	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2044	0.1529	0.1445	0.1894	0.1343	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2045	0.1583	0.1501	0.1978	0.1398	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
Levelized Costs																					
10 years (2016-2025)	0.0721	0.0670	0.0647	0.0525	132.9	111.9	122.4	0.0009	0.0010	0.0026	0.0000	0.0000	0.0005	0.0006	0.0013	0.0000	0.0000	0.045	0.044	0.047	0.045
15 years (2016-2030)	0.0761	0.0707	0.0712	0.0577	140.7	140.1	140.4	0.0006	0.0007	0.0018	0.0000	0.0000	0.0004	0.0004	0.0009	0.0000	0.0000	0.042	0.042	0.045	0.043
30 years (2016-2045)	0.0958	0.0890	0.1019	0.0774	148.1	167.6	157.8	0.0004	0.0004	0.0011	0.0000	0.0000	0.0002	0.0002	0.0005	0.0000	0.0000	0.039	0.038	0.041	0.039

NOTES:

General All Avoided Costs are in Year 2015 Dollars

ISO NE periods: Summer is June through September, Winter is all other months. Peak hours are: Monday through Friday 7 AM - 11 PM; Off-Peak Hours are all other hours

1 Avoided cost of electric energy = (wholesale energy avoided cost + REC cost to load) * risk premium, e.g. A = (v+ad) * (1+Wholesale Risk Premium)

2 Absolute value of avoided capacity costs and capacity DRIPE each year is function of quantity of kW reduction in year, PA strategy re bidding that reduction into applicable FCAs, and unit values in columns e and f. □

3 Proceeds from selling into the FCM also include the ISO-NE loss factor of 8%

4 PTF loss = 2.20%

5 Electric Cross -DRIPE is electric owen fuel DRIPE + Electric Cross-DRIPE

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Table Two: Inputs to Avoided Cost Calculations

Zone: NH

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	Wholesale Avoided Costs of Electricity								Avoided REC Costs to Load	DRIPE: 2016 vintage measures Rest-of-Pool				DRIPE: 2017 vintage measures Rest-of-Pool			
	Energy				Electric Cross DRIPE (5)		Capacity			Energy				Energy			
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter	Summer	FCA Price	Reserve Margin	REC Costs	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	%	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh
Period:	v	w	x	y	z	aa	ab	ac	ad	ae	af	ag	ah	ai	aj	ak	al
2015	0.0731	0.0648	0.0393	0.0302			39.7	17.0%	0.0074								
2016	0.0663	0.0616	0.0469	0.0305	0.0085	0.0054	38.2	17.0%	0.0075	0.0036	0.0037	0.0044	0.0000				
2017	0.0633	0.0589	0.0484	0.0362	0.0050	0.0032	114.5	17.0%	0.0077	0.0035	0.0035	0.0046	0.0000	0.0035	0.0035	0.0046	0.0000
2018	0.0538	0.0493	0.0475	0.0392	0.0023	0.0015	132.9	17.0%	0.0071	0.0018	0.0018	0.0000	0.0000	0.0018	0.0018	0.0000	0.0000
2019	0.0529	0.0485	0.0472	0.0388	0.0015	0.0010	123.3	17.0%	0.0072								
2020	0.0515	0.0468	0.0475	0.0371	0.0014	0.0010	135.8	17.0%	0.0073								
2021	0.0535	0.0491	0.0502	0.0401	0.0002	0.0002	138.6	17.0%	0.0087								
2022	0.0569	0.0520	0.0530	0.0423	0.0002	0.0002	139.9	17.0%	0.0088								
2023	0.0583	0.0537	0.0568	0.0448	0.0002	0.0002	137.7	17.0%	0.0089								
2024	0.0603	0.0558	0.0569	0.0470	0.0002	0.0002	140.6	17.0%	0.0090								
2025	0.0632	0.0577	0.0619	0.0488	0.0002	0.0002	143.5	17.0%	0.0090								
2026	0.0656	0.0600	0.0665	0.0514	0.0002	0.0002	144.1	17.0%	0.0086								
2027	0.0672	0.0620	0.0642	0.0531	0.0002	0.0002	142.7	17.0%	0.0082								
2028	0.0688	0.0642	0.0685	0.0556	0.0002	0.0002	146.2	17.0%	0.0078								
2029	0.0723	0.0681	0.0714	0.0582	0.0002	0.0002	151.9	17.0%	0.0082								
2030	0.0793	0.0713	0.0876	0.0633	0.0002	0.0002	153.5	17.0%	0.0079								
2031	0.0823	0.0742	0.0917	0.0660	0.0002	0.0002	147.0	17.0%	0.0079								
2032	0.0853	0.0772	0.0960	0.0689	0.0002	0.0002	147.0	17.0%	0.0079								
2033	0.0885	0.0804	0.1005	0.0719	0.0002	0.0002	147.0	17.0%	0.0079								
2034	0.0918	0.0836	0.1052	0.0751	0.0002	0.0002	147.0	17.0%	0.0079								
2035	0.0952	0.0870	0.1101	0.0784	0.0002	0.0002	147.0	17.0%	0.0079								
2036	0.0987	0.0906	0.1152	0.0818	0.0002	0.0002	147.0	17.0%	0.0079								
2037	0.1024	0.0943	0.1205	0.0854	0.0002	0.0002	147.0	17.0%	0.0079								
2038	0.1062	0.0981	0.1262	0.0891	0.0002	0.0002	147.0	17.0%	0.0079								
2039	0.1102	0.1021	0.1320	0.0930	0.0002	0.0002	147.0	17.0%	0.0079								
2040	0.1143	0.1062	0.1382	0.0971	0.0002	0.0002	147.0	17.0%	0.0079								
2041	0.1185	0.1106	0.1446	0.1014	0.0002	0.0002	147.0	17.0%	0.0080								
2042	0.1230	0.1151	0.1514	0.1058	0.0002	0.0002	147.0	17.0%	0.0080								
2043	0.1275	0.1197	0.1584	0.1104	0.0002	0.0002	147.0	17.0%	0.0080								
2044	0.1323	0.1246	0.1658	0.1153	0.0002	0.0002	147.0	17.0%	0.0080								
2045	0.1372	0.1297	0.1735	0.1203	0.0002	0.0002	147.0	17.0%	0.0080								
Levelized Costs																	
10 years (2016-2025)	0.0580	0.0534	0.0513	0.0401	0.0021	0.0014	123.0		0.0081	0.0010	0.0010	0.0010	0.0000	0.0006	0.0006	0.0005	0.0000
15 years (2016-2030)	0.0617	0.0568	0.0572	0.0449	0.0016	0.0011	130.2		0.0081	0.0007	0.0007	0.0007	0.0000	0.0004	0.0004	0.0004	0.0000
30 years (2016-2045)	0.0798	0.0736	0.0855	0.0630	0.0010	0.0007	137.1		0.0080	0.0004	0.0004	0.0004	0.0000	0.0002	0.0002	0.0002	0.0000

NOTES: General — All Avoided Costs are in Year 2015 Dollars
periods:

Revision: 4/3/2015

Table One: Avoided Cost of Electricity (2015 $) Results :

RI
Rhode Island

State RI

User-defined Inputs	
Wholesale Risk Premium (WRP)	9.00%
Distribution Losses	8.00%
Real Discount Rate	2.43%
Pcnt of Capacity Bid into FCM (%Bid)	50.00%

	Avoided Unit Cost of Electric Energy[1]				Avoided Unit Cost of Electric Capacity[2]			DRIPE: 2016 vintage measures Intrastate					DRIPE: 2017 vintage measures Intrastate					Avoided Non-Embedded Costs			
								Energy				Capacity (See note 2)	Energy				Capacity (See note 2)				
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	kW sold into FCA (PA to determine quantity)[3]	kW purchased from FCA (PA to determine quantity)	Weighted Average Avoided Cost Based on Percent Capacity Bid	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kW-yr	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh
Period:	a	b	c	d	e=ab*1.08	f=ab*(1+ac)*(1+WRP) *(1+Dist Loss) *(1+PTF Loss)	g=(e*%Bid)+(f*(1 +%Bid))	h	i	j	k	l	m	n	o	p	q	r	s	t	u
2015	0.0839	0.0748	0.0471	0.0371														0.0478	0.0472	0.0509	0.0487
2016	0.0771	0.0720	0.0558	0.0379	41.2	*0.0*	20.6	0.0000	0.0000	0.0000	0.0000							0.0473	0.0467	0.0504	0.0482
2017	0.0746	0.0696	0.0582	0.0447	123.7	*0.0*	61.8	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000	0.0000	0.0000		0.0469	0.0464	0.0500	0.0479
2018	0.0645	0.0596	0.0577	0.0486	143.6	*0.0*	71.8	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000	0.0000	0.0000		0.0466	0.0461	0.0497	0.0476
2019	0.0642	0.0593	0.0579	0.0486	133.2	*0.0*	66.6											0.0462	0.0457	0.0492	0.0472
2020	0.0625	0.0571	0.0579	0.0464	146.6	191.1	168.9											0.0458	0.0452	0.0488	0.0467
2021	0.0660	0.0608	0.0621	0.0508	149.7	195.1	172.4											0.0446	0.0440	0.0475	0.0455
2022	0.0691	0.0635	0.0647	0.0529	151.1	196.9	174.0											0.0433	0.0428	0.0462	0.0442
2023	0.0702	0.0649	0.0684	0.0552	148.7	193.9	171.3											0.0421	0.0416	0.0449	0.0430
2024	0.0722	0.0670	0.0683	0.0573	151.8	197.9	174.8											0.0409	0.0404	0.0436	0.0418
2025	0.0760	0.0687	0.0735	0.0588	155.0	202.0	178.5											0.0397	0.0392	0.0423	0.0405
2026	0.0771	0.0707	0.0778	0.0613	155.6	202.8	179.2											0.0385	0.0380	0.0410	0.0393
2027	0.0781	0.0723	0.0749	0.0627	154.2	200.9	177.5											0.0373	0.0369	0.0397	0.0381
2028	0.0794	0.0743	0.0794	0.0650	157.9	205.8	181.8											0.0361	0.0357	0.0385	0.0368
2029	0.0840	0.0790	0.0831	0.0682	164.0	213.8	188.9											0.0349	0.0345	0.0372	0.0356
2030	0.0912	0.0821	0.1000	0.0732	165.8	216.1	191.0											0.0337	0.0333	0.0359	0.0344
2031	0.0944	0.0852	0.1045	0.0762	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2032	0.0977	0.0885	0.1092	0.0794	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2033	0.1012	0.0918	0.1141	0.0827	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2034	0.1047	0.0954	0.1193	0.0861	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2035	0.1084	0.0990	0.1247	0.0897	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2036	0.1122	0.1028	0.1303	0.0934	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2037	0.1162	0.1068	0.1363	0.0973	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2038	0.1203	0.1109	0.1425	0.1013	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2039	0.1246	0.1152	0.1490	0.1056	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2040	0.1290	0.1196	0.1558	0.1100	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2041	0.1336	0.1242	0.1629	0.1146	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2042	0.1384	0.1291	0.1704	0.1195	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2043	0.1433	0.1341	0.1782	0.1245	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2044	0.1484	0.1393	0.1864	0.1297	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2045	0.1537	0.1447	0.1949	0.1352	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
Levelized Costs																					
10 years (2016-2025)	0.0696	0.0642	0.0621	0.0497	132.9	111.9	122.4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.045	0.044	0.047	0.045
15 years (2016-2030)	0.0732	0.0676	0.0682	0.0545	140.7	140.1	140.4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.042	0.042	0.045	0.043
30 years (2016-2045)	0.0924	0.0852	0.0987	0.0737	148.1	167.6	157.8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.039	0.038	0.041	0.039

NOTES:

General All Avoided Costs are in Year 2015 Dollars

ISO NE periods: Summer is June through September, Winter is all other months. Peak hours are: Monday through Friday 7 AM - 11 PM; Off-Peak Hours are all other hours

1 Avoided cost of electric energy = (wholesale energy avoided cost + REC cost to load) * risk premium, e.g. A = (v+ad) * (1+Wholesale Risk Premium)

2 Absolute value of avoided capacity costs and capacity DRIPE each year is function of quantity of kW reduction in year, PA strategy re bidding that reduction into applicable FCAs, and unit values in columns e and f.

3 Proceeds from selling into the FCM also include the ISO-NE loss factor of 8%

4 PTF loss = 2.20%

5 Electric Cross -DRIPE is electric owen fuel DRIPE + Electric Cross-DRIPE

Revision: 4/3/2015

Table Two: Inputs to Avoided Cost Calculations

Zone: RI

	Wholesale Avoided Costs of Electricity								Avoided REC Costs to Load	DRIPE: 2016 vintage measures Rest-of-Pool				DRIPE: 2017 vintage measures Rest-of-Pool			
	Energy				Electric Cross DRIPE (5)		Capacity			Energy				Energy			
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter	Summer	FCA Price	Reserve Margin	REC Costs	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	%	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh
Period:	v	w	x	y	z	aa	ab	ac	ad	ae	af	ag	ah	ai	aj	ak	al
2015	0.0732	0.0649	0.0394	0.0302			39.7	17.0%	0.0038								
2016	0.0665	0.0617	0.0470	0.0305	0.0056	0.0036	38.2	17.0%	0.0043	0.0012	0.0009	0.0064	0.0004				
2017	0.0636	0.0590	0.0486	0.0361	0.0033	0.0021	114.5	17.0%	0.0048	0.0012	0.0009	0.0066	0.0005	0.0012	0.0009	0.0066	0.0005
2018	0.0539	0.0493	0.0476	0.0392	0.0015	0.0010	132.9	17.0%	0.0053	0.0006	0.0005	0.0000	0.0000	0.0006	0.0005	0.0000	0.0000
2019	0.0531	0.0486	0.0473	0.0388	0.0010	0.0007	123.3	17.0%	0.0058								
2020	0.0518	0.0469	0.0476	0.0371	0.0010	0.0007	135.8	17.0%	0.0055								
2021	0.0539	0.0492	0.0504	0.0400	0.0002	0.0002	138.6	17.0%	0.0066								
2022	0.0571	0.0519	0.0531	0.0422	0.0002	0.0002	139.9	17.0%	0.0063								
2023	0.0585	0.0537	0.0569	0.0447	0.0002	0.0002	137.7	17.0%	0.0059								
2024	0.0606	0.0558	0.0570	0.0470	0.0002	0.0002	140.6	17.0%	0.0056								
2025	0.0645	0.0578	0.0622	0.0487	0.0002	0.0002	143.5	17.0%	0.0052								
2026	0.0659	0.0600	0.0666	0.0514	0.0002	0.0002	144.1	17.0%	0.0048								
2027	0.0672	0.0619	0.0643	0.0531	0.0002	0.0002	142.7	17.0%	0.0045								
2028	0.0688	0.0640	0.0688	0.0556	0.0002	0.0002	146.2	17.0%	0.0041								
2029	0.0727	0.0680	0.0718	0.0582	0.0002	0.0002	151.9	17.0%	0.0044								
2030	0.0796	0.0712	0.0876	0.0631	0.0002	0.0002	153.5	17.0%	0.0041								
2031	0.0825	0.0740	0.0917	0.0658	0.0002	0.0002	147.0	17.0%	0.0041								
2032	0.0855	0.0770	0.0960	0.0687	0.0002	0.0002	147.0	17.0%	0.0041								
2033	0.0887	0.0801	0.1005	0.0717	0.0002	0.0002	147.0	17.0%	0.0041								
2034	0.0920	0.0833	0.1053	0.0749	0.0002	0.0002	147.0	17.0%	0.0041								
2035	0.0953	0.0867	0.1102	0.0781	0.0002	0.0002	147.0	17.0%	0.0041								
2036	0.0988	0.0902	0.1154	0.0816	0.0002	0.0002	147.0	17.0%	0.0041								
2037	0.1025	0.0938	0.1209	0.0851	0.0002	0.0002	147.0	17.0%	0.0041								
2038	0.1063	0.0976	0.1266	0.0888	0.0002	0.0002	147.0	17.0%	0.0041								
2039	0.1102	0.1015	0.1325	0.0927	0.0002	0.0002	147.0	17.0%	0.0041								
2040	0.1142	0.1056	0.1388	0.0968	0.0002	0.0002	147.0	17.0%	0.0041								
2041	0.1184	0.1099	0.1453	0.1010	0.0002	0.0002	147.0	17.0%	0.0041								
2042	0.1228	0.1143	0.1522	0.1055	0.0002	0.0002	147.0	17.0%	0.0041								
2043	0.1273	0.1189	0.1593	0.1101	0.0002	0.0002	147.0	17.0%	0.0041								
2044	0.1320	0.1237	0.1669	0.1149	0.0002	0.0002	147.0	17.0%	0.0041								
2045	0.1369	0.1286	0.1747	0.1199	0.0002	0.0002	147.0	17.0%	0.0041								
Levelized Costs																	
10 years (2016-2025)	0.0584	0.0534	0.0515	0.0401	0.0014	0.0009	123.0		0.0055	0.0003	0.0002	0.0014	0.0001	0.0002	0.0001	0.0007	0.0001
15 years (2016-2030)	0.0620	0.0568	0.0574	0.0448	0.0011	0.0007	130.2		0.0052	0.0002	0.0002	0.0010	0.0001	0.0001	0.0001	0.0005	0.0000
30 years (2016-2045)	0.0800	0.0734	0.0858	0.0628	0.0007	0.0005	137.1		0.0048	0.0001	0.0001	0.0006	0.0000	0.0001	0.0001	0.0003	0.0000

NOTES: General All Avoided Costs are in Year 2015 Dollars
periods:

Revision: 4/3/2015

Table One: Avoided Cost of Electricity (2015 $) Results : VT Vermont

Page One of Two

State VT

User-defined Inputs	
Wholesale Risk Premium (WRP)	9.00%
Distribution Losses	8.00%
Real Discount Rate	2.43%
Pcnt of Capacity Bid into FCM (%Bid)	50.00%

	Avoided Unit Cost of Electric Energy[1]				Avoided Unit Cost of Electric Capacity[2]			DRIPE: 2016 vintage measures Intrastate					DRIPE: 2017 vintage measures Intrastate					Avoided Non-Embedded Costs			
								Energy				Capacity (See note 2)	Energy				Capacity (See note 2)				
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	kW sold into FCA (PA to determine quantity)[3]	kW purchased from FCA (PA to determine quantity)	Weighted Average Avoided Cost Based on Percent Capacity Bid	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kW-yr	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh
Period:	a	b	c	d	e=ab*1.08	f=ab*(1+ac)*(1+WRP) *(1+Dist Loss) *(1+PTF Loss)	g=(e*%Bid)+(f*(1 +%Bid))	h	i	j	k	l	m	n	o	p	q	r	s	t	u
2015	0.0798	0.0707	0.0432	0.0332														0.0478	0.0472	0.0509	0.0487
2016	0.0725	0.0672	0.0514	0.0337	41.2	*0.0*	20.6	0.0024	0.0010	0.0115	0.0007							0.0473	0.0467	0.0504	0.0482
2017	0.0692	0.0642	0.0531	0.0400	123.7	*0.0*	61.8	0.0023	0.0010	0.0119	0.0009		0.0023	0.0010	0.0119	0.0009		0.0469	0.0464	0.0500	0.0479
2018	0.0587	0.0538	0.0520	0.0428	143.6	*0.0*	71.8	0.0012	0.0005	0.0000	0.0000		0.0012	0.0005	0.0000	0.0000		0.0466	0.0461	0.0497	0.0476
2019	0.0579	0.0529	0.0517	0.0424	133.2	*0.0*	66.6											0.0462	0.0457	0.0492	0.0472
2020	0.0563	0.0510	0.0520	0.0409	146.6	191.1	168.9											0.0458	0.0452	0.0488	0.0467
2021	0.0585	0.0536	0.0550	0.0440	149.7	195.1	172.4											0.0446	0.0440	0.0475	0.0455
2022	0.0622	0.0566	0.0580	0.0463	151.1	196.9	174.0											0.0433	0.0428	0.0462	0.0442
2023	0.0637	0.0585	0.0621	0.0490	148.7	193.9	171.3											0.0421	0.0416	0.0449	0.0430
2024	0.0658	0.0608	0.0622	0.0515	151.8	197.9	174.8											0.0409	0.0404	0.0436	0.0418
2025	0.0692	0.0629	0.0684	0.0541	155.0	202.0	178.5											0.0397	0.0392	0.0423	0.0405
2026	0.0717	0.0655	0.0727	0.0563	155.6	202.8	179.2											0.0385	0.0380	0.0410	0.0393
2027	0.0733	0.0675	0.0702	0.0581	154.2	200.9	177.5											0.0373	0.0369	0.0397	0.0381
2028	0.0751	0.0700	0.0750	0.0610	157.9	205.8	181.8											0.0361	0.0357	0.0385	0.0368
2029	0.0789	0.0742	0.0782	0.0639	164.0	213.8	188.9											0.0349	0.0345	0.0372	0.0356
2030	0.0865	0.0777	0.0958	0.0695	165.8	216.1	191.0											0.0337	0.0333	0.0359	0.0344
2031	0.0897	0.0809	0.1002	0.0725	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2032	0.0930	0.0841	0.1049	0.0758	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2033	0.0965	0.0875	0.1098	0.0791	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2034	0.1001	0.0911	0.1150	0.0826	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2035	0.1038	0.0948	0.1204	0.0863	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2036	0.1077	0.0986	0.1260	0.0901	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2037	0.1117	0.1026	0.1319	0.0941	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2038	0.1158	0.1068	0.1380	0.0982	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2039	0.1201	0.1111	0.1445	0.1026	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2040	0.1246	0.1156	0.1513	0.1071	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2041	0.1292	0.1203	0.1583	0.1119	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2042	0.1340	0.1252	0.1657	0.1168	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2043	0.1390	0.1303	0.1735	0.1220	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2044	0.1442	0.1356	0.1816	0.1274	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
2045	0.1495	0.1411	0.1901	0.1330	158.7	206.9	182.8											0.0337	0.0333	0.0359	0.0344
Levelized Costs																					
10 years (2016-2025)	0.0634	0.0582	0.0562	0.0441	132.9	111.9	122.4	0.0007	0.0003	0.0026	0.0002	0.0000	0.0004	0.0002	0.0013	0.0001	0.0000	0.045	0.044	0.047	0.045
15 years (2016-2030)	0.0674	0.0619	0.0627	0.0492	140.7	140.1	140.4	0.0005	0.0002	0.0018	0.0001	0.0000	0.0003	0.0001	0.0009	0.0001	0.0000	0.042	0.042	0.045	0.043
30 years (2016-2045)	0.0871	0.0802	0.0936	0.0693	148.1	167.6	157.8	0.0003	0.0001	0.0011	0.0001	0.0000	0.0002	0.0001	0.0005	0.0000	0.0000	0.039	0.038	0.041	0.039

NOTES:

General All Avoided Costs are in Year 2015 Dollars
ISO NE periods: Summer is June through September, Winter is all other months. Peak hours are: Monday through Friday 7 AM - 11 PM; Off-Peak Hours are all other hours

1 Avoided cost of electric energy = (wholesale energy avoided cost + REC cost to load) * risk premium, e.g. A = (v+ad) * (1+Wholesale Risk Premium)
2 Absolute value of avoided capacity costs and capacity DRIPE each year is function of quantity of kW reduction in year, PA strategy re bidding that reduction into applicable FCAs, and unit values in columns e and f. □
3 Proceeds from selling into the FCM also include the ISO-NE loss factor of 8%
4 PTF loss = 2.20%
5 Electric Cross -DRIPE is electric owen fuel DRIPE + Electric Cross-DRIPE

Revision: 4/3/2015

Table Two: Inputs to Avoided Cost Calculations

Zone: VT

	Wholesale Avoided Costs of Electricity								Avoided REC Costs to Load	DRIPE: 2016 vintage measures Rest-of-Pool				DRIPE: 2017 vintage measures Rest-of-Pool			
	Energy				Electric Cross DRIPE (5)		Capacity			Energy				Energy			
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter	Summer	FCA Price	Reserve Margin	REC Costs	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	%	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh
Period:	v	w	x	y	z	aa	ab	ac	ad	ae	af	ag	ah	ai	aj	ak	al
2015	0.0732	0.0649	0.0396	0.0305			39.7	17.0%	0.0000								
2016	0.0665	0.0617	0.0472	0.0310	0.0041	0.0026	38.2	17.0%	0.0000	0.0016	0.0013	-0.0031	0.0005				
2017	0.0635	0.0589	0.0487	0.0367	0.0024	0.0015	114.5	17.0%	0.0000	0.0016	0.0013	-0.0031	0.0006	0.0016	0.0013	-0.0031	0.0006
2018	0.0539	0.0493	0.0477	0.0393	0.0011	0.0007	132.9	17.0%	0.0000	0.0008	0.0007	0.0000	0.0000	0.0008	0.0007	0.0000	0.0000
2019	0.0531	0.0485	0.0474	0.0389	0.0007	0.0005	123.3	17.0%	0.0000								
2020	0.0516	0.0468	0.0477	0.0375	0.0007	0.0005	135.8	17.0%	0.0000								
2021	0.0537	0.0492	0.0505	0.0404	0.0001	0.0001	138.6	17.0%	0.0000								
2022	0.0570	0.0520	0.0532	0.0424	0.0001	0.0001	139.9	17.0%	0.0000								
2023	0.0584	0.0537	0.0570	0.0450	0.0001	0.0001	137.7	17.0%	0.0000								
2024	0.0603	0.0558	0.0571	0.0472	0.0001	0.0001	140.6	17.0%	0.0000								
2025	0.0635	0.0577	0.0627	0.0496	0.0001	0.0001	143.5	17.0%	0.0000								
2026	0.0658	0.0601	0.0667	0.0516	0.0001	0.0001	144.1	17.0%	0.0000								
2027	0.0673	0.0620	0.0644	0.0533	0.0001	0.0001	142.7	17.0%	0.0000								
2028	0.0689	0.0642	0.0688	0.0560	0.0001	0.0001	146.2	17.0%	0.0000								
2029	0.0724	0.0681	0.0717	0.0587	0.0001	0.0001	151.9	17.0%	0.0000								
2030	0.0794	0.0713	0.0879	0.0637	0.0001	0.0001	153.5	17.0%	0.0000								
2031	0.0823	0.0742	0.0920	0.0666	0.0001	0.0001	147.0	17.0%	0.0000								
2032	0.0854	0.0772	0.0963	0.0695	0.0001	0.0001	147.0	17.0%	0.0000								
2033	0.0885	0.0803	0.1008	0.0726	0.0001	0.0001	147.0	17.0%	0.0000								
2034	0.0918	0.0836	0.1055	0.0758	0.0001	0.0001	147.0	17.0%	0.0000								
2035	0.0952	0.0870	0.1104	0.0792	0.0001	0.0001	147.0	17.0%	0.0000								
2036	0.0988	0.0905	0.1156	0.0827	0.0001	0.0001	147.0	17.0%	0.0000								
2037	0.1024	0.0942	0.1210	0.0863	0.0001	0.0001	147.0	17.0%	0.0000								
2038	0.1063	0.0980	0.1266	0.0901	0.0001	0.0001	147.0	17.0%	0.0000								
2039	0.1102	0.1020	0.1326	0.0941	0.0001	0.0001	147.0	17.0%	0.0000								
2040	0.1143	0.1061	0.1388	0.0983	0.0001	0.0001	147.0	17.0%	0.0000								
2041	0.1185	0.1104	0.1453	0.1026	0.0001	0.0001	147.0	17.0%	0.0000								
2042	0.1229	0.1149	0.1521	0.1072	0.0001	0.0001	147.0	17.0%	0.0000								
2043	0.1275	0.1195	0.1592	0.1119	0.0001	0.0001	147.0	17.0%	0.0000								
2044	0.1323	0.1244	0.1666	0.1169	0.0001	0.0001	147.0	17.0%	0.0000								
2045	0.1372	0.1294	0.1744	0.1221	0.0001	0.0001	147.0	17.0%	0.0000								
Levelized Costs																	
10 years (2016-2025)	0.0582	0.0534	0.0516	0.0405	0.0010	0.0007	123.0		0.0000	0.0004	0.0004	-0.0007	0.0001	0.0003	0.0002	-0.0004	0.0001
15 years (2016-2030)	0.0618	0.0568	0.0575	0.0452	0.0007	0.0005	130.2		0.0000	0.0003	0.0003	-0.0005	0.0001	0.0002	0.0002	-0.0002	0.0000
30 years (2016-2045)	0.0799	0.0736	0.0859	0.0636	0.0005	0.0003	137.1		0.0000	0.0002	0.0001	-0.0003	0.0001	0.0001	0.0001	-0.0001	0.0000

NOTES: General — All Avoided Costs are in Year 2015 Dollars
periods:

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Table One: Avoided Cost of Electricity (Nominal $) Results : CT Connecticut

State CT

User-defined Inputs	
Wholesale Risk Premium (WRP)	9.00%
Distribution Losses	8.00%
Nominal Discount Rate	4.36%
Pcnt of Capacity Bid into FCM (%Bid)	50.00%

	Avoided Unit Cost of Electric Energy[1]				Avoided Unit Cost of Electric Capacity[2]			DRIPE: 2016 vintage measures Intrastate					DRIPE: 2016 vintage measures Intrastate					Avoided Non-Embedded Costs			
								Energy				Capacity (See note 2)	Energy				Capacity (See note 2)				
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	kW sold into FCA (PA to determine quantity)[3]	kW purchased from FCA (PA to determine quantity)	Weighted Average Avoided Cost Based on Percent Capacity Bid	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Value	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kW-yr	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	$/kWh	$/kWh	$/kWh	$/kWh
Period:	a	b	c	d	e=ab*1.08	f=ab*(1+ac)*(1+WRP) *(1+Dist Loss) *(1+PTF Loss)	g=(e*%Bid)+(f*(1+ %Bid))	h	i	j	k	l	m	n	o	p	q	r	s	t	u
2015	0.0890	0.0799	0.0522	0.0424														0.0478	0.0472	0.0509	0.0487
2016	0.0836	0.0782	0.0618	0.0440	41.9	0.0	21.0	0.0067	0.0089	0.0030	0.0092							0.0481	0.0475	0.0512	0.0490
2017	0.0824	0.0771	0.0652	0.0517	128.2	0.0	64.1	0.0065	0.0087	0.0031	0.0111		0.0065	0.0087	0.0031	0.0111		0.0486	0.0481	0.0518	0.0496
2018	0.0730	0.0678	0.0658	0.0562	151.8	0.0	75.9	0.0035	0.0046	0.0000	0.0000		0.0035	0.0046	0.0000	0.0000		0.0493	0.0487	0.0525	0.0503
2019	0.0740	0.0686	0.0671	0.0571	143.6	0.0	71.8											0.0498	0.0492	0.0531	0.0508
2020	0.0740	0.0680	0.0689	0.0568	161.2	210.2	185.7											0.0503	0.0497	0.0536	0.0514
2021	0.0770	0.0712	0.0727	0.0604	167.9	218.9	193.4											0.0500	0.0494	0.0533	0.0510
2022	0.0852	0.0787	0.0801	0.0668	172.9	225.3	199.1											0.0496	0.0490	0.0529	0.0506
2023	0.0878	0.0817	0.0858	0.0706	173.6	226.3	199.9											0.0492	0.0486	0.0524	0.0502
2024	0.0918	0.0856	0.0872	0.0744	180.7	235.6	208.1											0.0487	0.0481	0.0519	0.0497
2025	0.0977	0.0888	0.0955	0.0781	188.0	245.0	216.5											0.0482	0.0476	0.0513	0.0492
2026	0.1007	0.0927	0.1014	0.0812	192.3	250.6	221.4											0.0476	0.0470	0.0507	0.0486
2027	0.1034	0.0960	0.0994	0.0842	194.1	252.9	223.5											0.0469	0.0464	0.0500	0.0479
2028	0.1067	0.1000	0.1066	0.0887	202.5	263.9	233.2											0.0463	0.0457	0.0493	0.0472
2029	0.1149	0.1083	0.1137	0.0950	214.3	279.3	246.8											0.0456	0.0450	0.0486	0.0465
2030	0.1264	0.1143	0.1381	0.1032	220.7	287.7	254.2											0.0448	0.0443	0.0477	0.0457
2031	0.1330	0.1205	0.1466	0.1092	215.1	280.3	247.7											0.0456	0.0451	0.0486	0.0465
2032	0.1399	0.1271	0.1557	0.1156	218.9	285.3	252.1											0.0464	0.0459	0.0495	0.0474
2033	0.1472	0.1341	0.1653	0.1223	222.8	290.4	256.6											0.0472	0.0467	0.0503	0.0482
2034	0.1548	0.1415	0.1756	0.1295	226.8	295.6	261.2											0.0481	0.0475	0.0512	0.0491
2035	0.1629	0.1493	0.1866	0.1371	230.8	300.8	265.8											0.0489	0.0484	0.0522	0.0499
2036	0.1715	0.1576	0.1983	0.1452	234.9	306.2	270.5											0.0498	0.0492	0.0531	0.0508
2037	0.1805	0.1663	0.2107	0.1538	239.1	311.6	275.4											0.0507	0.0501	0.0540	0.0517
2038	0.1900	0.1756	0.2240	0.1629	243.3	317.2	280.3											0.0516	0.0510	0.0550	0.0527
2039	0.2000	0.1854	0.2381	0.1726	247.7	322.8	285.2											0.0525	0.0519	0.0560	0.0536
2040	0.2105	0.1957	0.2531	0.1829	252.1	328.6	290.3											0.0534	0.0528	0.0570	0.0545
2041	0.2217	0.2067	0.2691	0.1938	256.6	334.4	295.5											0.0544	0.0538	0.0580	0.0555
2042	0.2334	0.2182	0.2862	0.2054	261.1	340.4	300.7											0.0554	0.0547	0.0590	0.0565
2043	0.2458	0.2305	0.3043	0.2177	265.8	346.4	306.1											0.0564	0.0557	0.0601	0.0575
2044	0.2589	0.2435	0.3237	0.2308	270.5	352.6	311.5											0.0574	0.0567	0.0611	0.0585
2045	0.2726	0.2572	0.3443	0.2447	275.3	358.9	317.1											0.0584	0.0577	0.0622	0.0596
Levelized Costs																					
10 years (2016-2025)	0.0744	0.0690	0.0669	0.0548	133.2	112.4	122.8	0.0018	0.0023	0.0007	0.0022	0.0000	0.0011	0.0014	0.0003	0.0012	0.0000	0.0446	0.0441	0.0475	0.0455
15 years (2016-2030)	0.0779	0.0722	0.0729	0.0595	141.2	140.8	141.0	0.0012	0.0017	0.0005	0.0015	0.0000	0.0008	0.0010	0.0002	0.0009	0.0000	0.0422	0.0417	0.0450	0.0430
30 years (2016-2045)	0.0965	0.0894	0.1028	0.0785	148.3	167.8	158.1	0.0007	0.0010	0.0003	0.0009	0.0000	0.0005	0.0006	0.0001	0.0005	0.0000	0.0387	0.0382	0.0412	0.0395

NOTES:

General: All Avoided Costs are in Year 2015 Dollars
ISO NE periods: Summer is June through September, Winter is all other months. Peak hours are: Monday through Friday 7 AM - 11 PM; Off-Peak Hours are all other hours

1. Avoided cost of electric energy = (wholesale energy avoided cost + REC cost to load) * risk premium, e.g. A = (v+ad) * (1+Wholesale Risk Premium)
2. Absolute value of avoided capacity costs and capacity DRIPE each year is function of quantity of kW reduction in year, PA strategy re bidding that reduction into applicable FCAs, and unit values in columns e and f.
3. Proceeds from selling into the FCM also include the ISO-NE loss factor of 8%
4. PTF loss = 2.20%
5. Electric Cross -DRIPE is electric owen fuel DRIPE + Electric Cross-DRIPE

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Table Two: Inputs to Avoided Cost Calculations

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Zone: CT

	Wholesale Avoided Costs of Electricity									DRIPE: 2016 vintage measures				DRIPE: 2017 vintage measures			
										Rest-of-Pool				Rest-of-Pool			
	Energy				Electric Cross DRIPE (5)		Capacity		Avoided REC Costs to Load	Energy				Energy			
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter	Summer	FCA Price	Reserve Margin	REC Costs	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
Units:	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kW-yr	%	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh	$/kWh
Period:	v	w	x	y	z	aa	ab	ac	ad	ae	af	ag	ah	ai	aj	ak	al
2015	0.0732	0.0649	0.0395	0.0305			39.7	17.0%	0.0084								
2016	0.0677	0.0628	0.0478	0.0315	0.0231	0.0146	38.8	17.0%	0.0089	0.0059	0.0080	0.0028	0.0049				
2017	0.0661	0.0612	0.0503	0.0380	0.0141	0.0090	118.7	17.0%	0.0095	0.0058	0.0078	0.0029	0.0060	0.0095	0.0058	0.0078	0.0029
2018	0.0569	0.0521	0.0503	0.0415	0.0067	0.0044	140.5	17.0%	0.0100	0.0031	0.0041	0.0000	0.0000	0.0100	0.0031	0.0041	0.0000
2019	0.0574	0.0524	0.0510	0.0419	0.0043	0.0029	132.9	17.0%	0.0105								
2020	0.0570	0.0515	0.0524	0.0412	0.0044	0.0030	149.3	17.0%	0.0109								
2021	0.0605	0.0552	0.0565	0.0453	0.0007	0.0007	155.5	17.0%	0.0102								
2022	0.0654	0.0594	0.0607	0.0485	0.0007	0.0007	160.1	17.0%	0.0128								
2023	0.0683	0.0626	0.0664	0.0525	0.0008	0.0007	160.7	17.0%	0.0123								
2024	0.0722	0.0665	0.0679	0.0562	0.0008	0.0008	167.3	17.0%	0.0120								
2025	0.0782	0.0701	0.0762	0.0602	0.0008	0.0008	174.0	17.0%	0.0114								
2026	0.0816	0.0742	0.0823	0.0637	0.0008	0.0008	178.0	17.0%	0.0108								
2027	0.0846	0.0779	0.0810	0.0670	0.0008	0.0008	179.7	17.0%	0.0102								
2028	0.0883	0.0822	0.0882	0.0718	0.0008	0.0008	187.5	17.0%	0.0096								
2029	0.0949	0.0889	0.0938	0.0767	0.0008	0.0008	198.4	17.0%	0.0105								
2030	0.1060	0.0948	0.1166	0.0847	0.0009	0.0008	204.4	17.0%	0.0100								
2031	0.1118	0.1004	0.1243	0.0900	0.0009	0.0009	199.1	17.0%	0.0102								
2032	0.1180	0.1063	0.1325	0.0957	0.0009	0.0009	202.7	17.0%	0.0103								
2033	0.1245	0.1125	0.1412	0.1017	0.0009	0.0009	206.3	17.0%	0.0105								
2034	0.1314	0.1191	0.1505	0.1081	0.0009	0.0009	210.0	17.0%	0.0107								
2035	0.1387	0.1261	0.1604	0.1149	0.0009	0.0009	213.7	17.0%	0.0108								
2036	0.1463	0.1336	0.1709	0.1222	0.0009	0.0009	217.5	17.0%	0.0110								
2037	0.1544	0.1414	0.1822	0.1299	0.0010	0.0010	221.4	17.0%	0.0112								
2038	0.1629	0.1497	0.1941	0.1381	0.0010	0.0010	225.3	17.0%	0.0114								
2039	0.1719	0.1585	0.2069	0.1468	0.0010	0.0010	229.3	17.0%	0.0115								
2040	0.1814	0.1678	0.2205	0.1560	0.0010	0.0010	233.4	17.0%	0.0117								
2041	0.1915	0.1777	0.2350	0.1659	0.0010	0.0010	237.6	17.0%	0.0119								
2042	0.2021	0.1881	0.2504	0.1763	0.0011	0.0010	241.8	17.0%	0.0121								
2043	0.2132	0.1992	0.2669	0.1874	0.0011	0.0011	246.1	17.0%	0.0123								
2044	0.2250	0.2109	0.2845	0.1992	0.0011	0.0011	250.5	17.0%	0.0125								
2045	0.2374	0.2233	0.3032	0.2118	0.0011	0.0011	254.9	17.0%	0.0127								
Levelized Costs																	
10 years (2016-2025)	0.0585	0.0536	0.0516	0.0405	0.0058	0.0038	123.3		0.0097	0.0016	0.0021	0.0006	0.0012	0.0021	0.0010	0.0013	0.0003
15 years (2016-2030)	0.0622	0.0570	0.0576	0.0453	0.0043	0.0029	130.7		0.0092	0.0011	0.0015	0.0004	0.0008	0.0015	0.0007	0.0009	0.0002
30 years (2016-2045)	0.0801	0.0735	0.0858	0.0636	0.0028	0.0020	137.3		0.0085	0.0006	0.0009	0.0003	0.0005	0.0009	0.0004	0.0005	0.0001

NOTES: General
All Avoided Costs are in Nominal Dollars
ISO NE
Real Discount Rate : 2.43%

Exhibit C-1

Avoided Cost of Gas to Retail Customers by End Use - Southern New England (CT, MA, RI)

Avoidable Retail Margin (2015$/MMBtu) - NONE

		RESIDENTIAL				COMMERCIAL & INDUSTRIAL			
Year		Non Heating	Hot Water	Heating	All	Non Heating	Heating	All	ALL RETAIL END USES
2015		4.45	4.90	5.06	4.94	4.61	4.92	4.78	4.87
2016		4.66	5.16	5.33	5.19	4.85	5.17	5.03	5.12
2017		5.36	6.02	6.24	6.07	5.60	6.02	5.85	5.96
2018		5.84	6.47	6.68	6.51	6.07	6.48	6.30	6.42
2019		5.89	6.40	6.57	6.44	6.08	6.42	6.27	6.36
2020		5.53	6.02	6.19	6.05	5.72	6.03	5.89	5.98
2021		5.83	6.34	6.51	6.37	6.02	6.35	6.20	6.30
2022		5.91	6.41	6.58	6.45	6.10	6.42	6.28	6.38
2023		6.00	6.50	6.67	6.53	6.19	6.51	6.37	6.45
2024		6.19	6.70	6.87	6.74	6.38	6.71	6.56	6.65
2025		6.31	6.80	6.97	6.83	6.50	6.81	6.68	6.76
2026		6.41	6.92	7.09	6.95	6.60	6.93	6.78	6.87
2027		6.49	7.00	7.17	7.03	6.68	7.01	6.86	6.95
2028		6.60	7.10	7.27	7.14	6.79	7.11	6.97	7.07
2029		6.80	7.30	7.46	7.34	6.99	7.30	7.17	7.26
2030		7.08	7.58	7.74	7.61	7.27	7.58	7.45	7.54
2031		7.21	7.71	7.88	7.75	7.40	7.72	7.58	7.68
2032		7.36	7.85	8.02	7.89	7.54	7.86	7.72	7.82
2033		7.50	7.99	8.16	8.03	7.69	8.00	7.87	7.96
2034		7.65	8.14	8.30	8.18	7.83	8.14	8.01	8.11
2035		7.80	8.28	8.44	8.33	7.98	8.29	8.16	8.25
2036		7.95	8.43	8.59	8.48	8.13	8.44	8.31	8.40
2037		8.10	8.58	8.74	8.63	8.29	8.59	8.46	8.56
2038		8.26	8.74	8.90	8.78	8.45	8.74	8.62	8.71
2039		8.42	8.89	9.05	8.94	8.61	8.90	8.78	8.87
2040		8.59	9.05	9.21	9.10	8.77	9.06	8.94	9.03
2041		8.76	9.22	9.37	9.27	8.94	9.22	9.11	9.20
2042		8.93	9.38	9.54	9.43	9.11	9.39	9.27	9.36
2043		9.10	9.55	9.70	9.60	9.28	9.55	9.45	9.54
2044		9.28	9.72	9.87	9.78	9.45	9.73	9.62	9.71
2045		9.46	9.90	10.05	9.95	9.63	9.90	9.80	9.89
LEVELIZED									
2016-2025	(a)	5.72	6.26	6.44	6.29	5.92	6.27	6.12	6.21
2016-2030		6.00	6.53	6.70	6.56	6.20	6.54	6.39	6.48
2016-2045	(b)	6.91	7.42	7.59	7.46	7.10	7.42	7.29	7.38

(a) Real discount rate: 2.43%

(b) Values 2031-2045 extrapolated per Compound Annual Growth Rate (2021-2030)

Exhibit C-2

Avoided Cost of Gas to Retail Customers by End Use - Southern New England (CT, MA, RI)
Avoidable Retail Margin (2015$/MMBtu) - SOME

		RESIDENTIAL				COMMERCIAL & INDUSTRIAL			
Year		Non Heating	Hot Water	Heating	All	Non Heating	Heating	All	ALL RETAIL END USES
2015		5.06	6.27	6.68	6.51	5.23	6.06	5.76	6.42
2016		5.28	6.53	6.95	6.76	5.46	6.31	6.01	6.62
2017		5.98	7.38	7.85	7.64	6.21	7.17	6.82	6.62
2018		6.45	7.84	8.30	8.08	6.68	7.62	7.28	6.72
2019		6.50	7.77	8.19	8.01	6.69	7.56	7.25	6.96
2020		6.14	7.39	7.81	7.63	6.33	7.17	6.87	7.25
2021		6.45	7.71	8.13	7.94	6.63	7.49	7.18	7.59
2022		6.53	7.78	8.20	8.02	6.71	7.56	7.26	7.84
2023		6.62	7.87	8.28	8.10	6.80	7.65	7.35	7.99
2024		6.81	8.07	8.49	8.31	6.99	7.85	7.54	8.19
2025		6.92	8.17	8.59	8.41	7.11	7.96	7.66	8.31
2026		7.03	8.28	8.70	8.52	7.21	8.07	7.76	8.45
2027		7.11	8.36	8.78	8.60	7.29	8.15	7.84	8.63
2028		7.22	8.47	8.89	8.72	7.41	8.25	7.95	8.76
2029		7.41	8.67	9.08	8.91	7.60	8.45	8.15	8.88
2030		7.69	8.94	9.36	9.19	7.88	8.73	8.43	8.98
2031		7.83	9.08	9.49	9.32	8.02	8.86	8.56	9.13
2032		7.97	9.21	9.63	9.46	8.15	9.00	8.70	9.28
2033		8.11	9.35	9.77	9.60	8.30	9.13	8.84	9.44
2034		8.26	9.49	9.91	9.74	8.44	9.28	8.98	9.60
2035		8.40	9.63	10.05	9.88	8.59	9.42	9.13	9.76
2036		8.55	9.78	10.19	10.03	8.74	9.56	9.27	9.93
2037		8.71	9.93	10.33	10.17	8.89	9.71	9.42	10.10
2038		8.86	10.08	10.48	10.32	9.04	9.86	9.58	10.27
2039		9.02	10.23	10.63	10.47	9.20	10.01	9.73	10.44
2040		9.18	10.38	10.78	10.63	9.36	10.16	9.89	10.62
2041		9.34	10.54	10.94	10.78	9.52	10.32	10.05	10.80
2042		9.51	10.69	11.09	10.94	9.69	10.48	10.21	10.99
2043		9.68	10.85	11.25	11.10	9.85	10.64	10.37	11.17
2044		9.85	11.02	11.41	11.27	10.02	10.80	10.54	11.36
2045		10.03	11.18	11.57	11.43	10.20	10.97	10.71	11.55
LEVELIZED									
2016-2025	(a)	6.34	7.63	8.06	7.87	6.54	7.41	7.10	7.36
2016-2030		6.62	7.89	8.32	8.13	6.81	7.68	7.37	7.77
2016-2045	(b)	7.52	8.77	9.19	9.01	7.71	8.56	8.26	8.77

(a) Real discount rate: 2.43%
(b) Values 2031-2045 extrapolated per Compound Annual Growth Rate (2021-2030)

Exhibit C-3

Avoided Cost of Gas to Retail Customers by End Use - Northern New England (NH, ME)
Avoidable Retail Margin (2015$/MMBtu) - NONE

Year		RESIDENTIAL				COMMERCIAL & INDUSTRIAL			ALL
		Non Heating	Hot Water	Heating	All	Non Heating	Heating	All	RETAIL END USES
2015		4.12	5.54	6.01	5.63	4.65	5.55	5.15	5.41
2016		4.64	5.30	5.52	5.34	4.88	5.31	5.13	5.24
2017		5.70	6.16	6.31	6.19	5.87	6.16	6.04	6.12
2018		5.98	6.76	7.02	6.82	6.28	6.77	6.55	6.69
2019		5.86	7.80	8.44	7.93	6.58	7.83	7.28	7.63
2020		5.48	7.41	8.06	7.54	6.20	7.45	6.90	7.25
2021		5.78	7.75	8.41	7.88	6.52	7.78	7.24	7.58
2022		5.87	7.85	8.51	7.98	6.61	7.88	7.33	7.67
2023		5.95	7.93	8.60	8.07	6.69	7.96	7.40	7.76
2024		6.14	8.16	8.84	8.30	6.90	8.19	7.62	7.98
2025		6.24	8.27	8.95	8.41	7.00	8.30	7.73	8.09
2026		6.35	8.40	9.08	8.53	7.11	8.43	7.85	8.22
2027		6.44	8.49	9.17	8.63	7.21	8.52	7.95	8.32
2028		6.54	8.60	9.29	8.74	7.31	8.63	8.05	8.42
2029		6.73	8.79	9.48	8.93	7.51	8.82	8.24	8.61
2030		7.01	9.07	9.76	9.21	7.78	9.10	8.52	8.89
2031		7.15	9.22	9.90	9.35	7.92	9.25	8.66	9.03
2032		7.29	9.36	10.05	9.50	8.07	9.39	8.81	9.18
2033		7.43	9.51	10.20	9.65	8.21	9.54	8.95	9.33
2034		7.58	9.66	10.36	9.80	8.36	9.69	9.10	9.48
2035		7.73	9.82	10.51	9.96	8.51	9.84	9.25	9.63
2036		7.88	9.97	10.67	10.11	8.66	10.00	9.40	9.78
2037		8.03	10.13	10.83	10.27	8.81	10.16	9.56	9.94
2038		8.19	10.29	10.99	10.43	8.97	10.32	9.72	10.10
2039		8.35	10.45	11.16	10.60	9.13	10.48	9.88	10.26
2040		8.51	10.62	11.33	10.76	9.30	10.65	10.04	10.43
2041		8.68	10.79	11.50	10.93	9.46	10.81	10.21	10.59
2042		8.85	10.96	11.67	11.10	9.63	10.99	10.37	10.76
2043		9.02	11.13	11.84	11.28	9.81	11.16	10.55	10.94
2044		9.20	11.31	12.02	11.46	9.98	11.33	10.72	11.11
2045		9.38	11.49	12.20	11.64	10.16	11.51	10.90	11.29
LEVELIZED									
2016-2025	(a)	5.74	7.28	7.79	7.39	6.32	7.31	6.87	7.15
2016-2030		6.00	7.69	8.25	7.80	6.63	7.71	7.24	7.54
2016-2045	(b)	6.88	8.74	9.36	8.86	7.57	8.76	8.24	8.57

(a) Real discount rate: 2.43%
(b) Values 2031-2045 extrapolated per Compound Annual Growth Rate (2021-2030)

Exhibit C-4

Avoided Cost of Gas by Retail End Use - Northern New England (NH, ME)

Avoidable Retail Margin (2015$/MMBtu) - SOME

		RESIDENTIAL				COMMERCIAL & INDUSTRIAL			
Year		Non Heating	Hot Water	Heating	All	Non Heating	Heating	All	ALL RETAIL END USES
2015		4.65	6.71	7.39	6.97	5.13	6.45	5.92	5.95
2016		5.17	6.47	6.90	6.68	5.36	6.20	5.89	6.15
2017		6.22	7.33	7.69	7.54	6.35	7.06	6.80	6.15
2018		6.51	7.93	8.40	8.16	6.76	7.67	7.32	6.25
2019		6.38	8.97	9.83	9.27	7.06	8.73	8.05	6.49
2020		6.01	8.58	9.44	8.89	6.68	8.34	7.66	6.78
2021		6.31	8.92	9.79	9.22	7.00	8.68	8.00	7.12
2022		6.40	9.02	9.89	9.33	7.09	8.77	8.09	7.37
2023		6.47	9.10	9.98	9.41	7.17	8.86	8.17	7.52
2024		6.66	9.33	10.22	9.64	7.38	9.09	8.39	7.72
2025		6.77	9.44	10.33	9.75	7.48	9.20	8.50	7.84
2026		6.87	9.57	10.46	9.88	7.59	9.32	8.61	7.98
2027		6.96	9.66	10.56	9.98	7.69	9.41	8.71	8.16
2028		7.07	9.77	10.67	10.08	7.79	9.53	8.82	8.29
2029		7.26	9.96	10.86	10.27	7.98	9.72	9.01	8.41
2030		7.54	10.24	11.14	10.55	8.26	10.00	9.29	8.51
2031		7.68	10.38	11.29	10.70	8.40	10.14	9.43	8.66
2032		7.81	10.53	11.43	10.84	8.54	10.29	9.57	8.82
2033		7.96	10.68	11.58	10.99	8.69	10.43	9.72	8.98
2034		8.10	10.82	11.73	11.14	8.83	10.58	9.86	9.14
2035		8.25	10.97	11.89	11.29	8.98	10.73	10.01	9.30
2036		8.39	11.13	12.04	11.44	9.13	10.88	10.16	9.47
2037		8.55	11.28	12.20	11.60	9.28	11.04	10.31	9.64
2038		8.70	11.44	12.36	11.75	9.44	11.20	10.47	9.81
2039		8.86	11.60	12.52	11.91	9.60	11.36	10.63	9.99
2040		9.02	11.76	12.68	12.08	9.76	11.52	10.79	10.17
2041		9.18	11.92	12.84	12.24	9.92	11.68	10.95	10.35
2042		9.35	12.09	13.01	12.40	10.09	11.85	11.11	10.54
2043		9.51	12.26	13.18	12.57	10.26	12.02	11.28	10.73
2044		9.69	12.43	13.35	12.74	10.43	12.19	11.45	10.92
2045		9.86	12.60	13.53	12.92	10.61	12.36	11.62	11.12
LEVELIZED									
2016-2025	(a)	6.27	8.45	9.18	8.73	6.80	8.20	7.64	6.90
2016-2030		6.52	8.86	9.64	9.15	7.11	8.61	8.01	7.30
2016-2045	(b)	7.40	9.90	10.73	10.20	8.05	9.65	9.00	8.31

(a) Real discount rate: 2.43%
(b) Values 2031-2045 extrapolated per Compound Annual Growth Rate (2021-2030)

Exhibit C-5
Avoided Cost of Gas by Retail End Use - Vermont (VT)
Avoidable Retail Margin (2015$/MMBtu) - NONE

	Design day	Peak Days	Remaining winter	Shoulder / summer
Days	1	9	141	214
Year				
2015	$ 521.44	$ 15.66	$ 5.74	$ 4.55
2016	$ 521.65	$ 16.65	$ 6.05	$ 4.73
2017	$ 522.54	$ 18.45	$ 6.94	$ 5.64
2018	$ 522.41	$ 19.70	$ 6.77	$ 6.05
2019	$ 522.84	$ 20.19	$ 7.29	$ 5.91
2020	$ 522.49	$ 20.70	$ 6.91	$ 5.61
2021	$ 522.83	$ 21.24	$ 7.30	$ 5.91
2022	$ 522.98	$ 21.79	$ 7.43	$ 6.08
2023	$ 523.10	$ 22.37	$ 7.55	$ 6.22
2024	$ 523.30	$ 22.91	$ 7.77	$ 6.39
2025	$ 523.40	$ 23.41	$ 7.88	$ 6.51
2026	$ 523.56	$ 23.84	$ 8.04	$ 6.64
2027	$ 523.67	$ 24.37	$ 8.14	$ 6.78
2028	$ 523.78	$ 24.80	$ 8.26	$ 6.89
2029	$ 523.97	$ 25.24	$ 8.45	$ 7.08
2030	$ 524.24	$ 25.60	$ 8.72	$ 7.35
2031	$ 524.38	$ 26.09	$ 8.88	$ 7.51
2032	$ 524.52	$ 26.58	$ 9.04	$ 7.68
2033	$ 524.66	$ 27.08	$ 9.20	$ 7.85
2034	$ 524.81	$ 27.59	$ 9.36	$ 8.02
2035	$ 524.95	$ 28.11	$ 9.53	$ 8.20
2036	$ 525.09	$ 28.64	$ 9.70	$ 8.38
2037	$ 525.23	$ 29.18	$ 9.87	$ 8.56
2038	$ 525.37	$ 29.73	$ 10.05	$ 8.75
2039	$ 525.51	$ 30.29	$ 10.23	$ 8.95
2040	$ 525.65	$ 30.86	$ 10.41	$ 9.14
2041	$ 525.79	$ 31.45	$ 10.60	$ 9.34
2042	$ 525.94	$ 32.04	$ 10.79	$ 9.55
2043	$ 526.08	$ 32.64	$ 10.98	$ 9.76
2044	$ 526.22	$ 33.26	$ 11.18	$ 9.97
2045	$ 526.36	$ 33.89	$ 11.38	$ 10.19
LEVELIZED				
2016-2025 (a)	$ 522.72	$ 20.61	$ 7.16	$ 5.88
2016-2030	$ 523.05	$ 21.83	$ 7.50	$ 6.19
2016-2045 (b)	$ 523.98	$ 25.01	$ 8.53	$ 7.22

(a) Real discount rate: 2.43%
(b) Values 2031-2045 extrapolated per Compound Annual Growth Rate (2021-2030)

Exhibit C-7. Connecticut
AESC 2015 - Gas Supply DRIPE and Gas Cross DRIPE (2015$/MMBtu)

Year	Gas Supply DRIPE (applicable to reductions in every end-use)	Gas Cross DRIPE (applicable to reductions by end-use): RESIDENTIAL					COMMERCIAL & INDUSTRIAL				
		Non Heating	Hot Water	Heating	All		Non Heating	Heating	All		ALL RETAIL END USES
	1	2	3	4	5		6	7	8		9
2016	$ 0.06	$ 3.28	$ 3.15	$ 3.11	$ 3.14		$ 3.23	$ 3.15	$ 3.18		$ 3.16
2017	$ 0.06	$ 1.97	$ 1.87	$ 1.84	$ 1.86		$ 1.93	$ 1.87	$ 1.90		$ 1.88
2018	$ 0.06	$ 0.93	$ 0.85	$ 0.83	$ 0.85		$ 0.90	$ 0.85	$ 0.87		$ 0.86
2019	$ 0.06	$ 0.60	$ 0.54	$ 0.51	$ 0.53		$ 0.58	$ 0.53	$ 0.55		$ 0.54
2020	$ 0.06	$ 0.59	$ 0.53	$ 0.51	$ 0.52		$ 0.57	$ 0.53	$ 0.54		$ 0.53
2021	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06		$ 0.10	$ 0.06	$ 0.08		$ 0.07
2022	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06		$ 0.10	$ 0.06	$ 0.08		$ 0.07
2023	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06		$ 0.10	$ 0.06	$ 0.08		$ 0.07
2024	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06		$ 0.10	$ 0.06	$ 0.08		$ 0.07
2025	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06		$ 0.10	$ 0.06	$ 0.08		$ 0.07
2026	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06		$ 0.10	$ 0.06	$ 0.08		$ 0.07
2027	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06		$ 0.10	$ 0.06	$ 0.08		$ 0.07
2028	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06		$ 0.10	$ 0.06	$ 0.08		$ 0.07
2029	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06		$ 0.10	$ 0.06	$ 0.08		$ 0.07
2030	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06		$ 0.10	$ 0.06	$ 0.08		$ 0.07
2031	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06	#	$ 0.10	$ 0.06	$ 0.08	#	$ 0.07
2032	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06	#	$ 0.10	$ 0.06	$ 0.08	#	$ 0.07
2033	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06	#	$ 0.10	$ 0.06	$ 0.08	#	$ 0.07
2034	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06	#	$ 0.10	$ 0.06	$ 0.08	#	$ 0.07
2035	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06	#	$ 0.10	$ 0.06	$ 0.08	#	$ 0.07
2036	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06	#	$ 0.10	$ 0.06	$ 0.08	#	$ 0.07
2037	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06	#	$ 0.10	$ 0.06	$ 0.08	#	$ 0.07
2038	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06	#	$ 0.10	$ 0.06	$ 0.08	#	$ 0.07
2039	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06	#	$ 0.10	$ 0.06	$ 0.08	#	$ 0.07
2040	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06	#	$ 0.10	$ 0.06	$ 0.08	#	$ 0.07
2041	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06	#	$ 0.10	$ 0.06	$ 0.08	#	$ 0.07
2042	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06	#	$ 0.10	$ 0.06	$ 0.08	#	$ 0.07
2043	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06	#	$ 0.10	$ 0.06	$ 0.08	#	$ 0.07
2044	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06	#	$ 0.10	$ 0.06	$ 0.08	#	$ 0.07
2045	$ 0.06	$ 0.12	$ 0.06	$ 0.05	$ 0.06	#	$ 0.10	$ 0.06	$ 0.08	#	$ 0.07
Levelized											
2016-2025	$ 0.06	$ 0.85	$ 0.78	$ 0.76	$ 0.78		$ 0.83	$ 0.78	$ 0.80		$ 0.79
2016-2030	$ 0.06	$ 0.64	$ 0.57	$ 0.55	$ 0.57		$ 0.61	$ 0.57	$ 0.59		$ 0.58
2016-2045	$ 0.07	$ 0.48	$ 0.41	$ 0.39	$ 0.41		$ 0.46	$ 0.41	$ 0.43		$ 0.42

Notes

Values for years 2016 through 2030 from AESC 2015 modeling.
Values for years from 2031 onward held at 2030 levels.
Illustrative real discount rate: 2.43%

Exhibit C-8. Massachusetts
AESC 2015 - Gas Supply DRIPE and Gas Cross DRIPE (2015$/MMBtu)

Year	Gas Supply DRIPE (applicable to reductions in every end-use)	Gas Cross DRIPE (applicable to reductions by end-use)									
		RESIDENTIAL					COMMERCIAL & INDUSTRIAL				
		Non Heating	Hot Water	Heating	All		Non Heating	Heating	All		ALL RETAIL END USES
	1	2	3	4	5		6	7	8		9
2016	$ 0.14	$ 6.12	$ 5.87	$ 5.79	$ 5.86		$ 6.03	$ 5.87	$ 5.94		$ 5.89
2017	$ 0.14	$ 3.60	$ 3.42	$ 3.36	$ 3.41		$ 3.53	$ 3.42	$ 3.47		$ 3.43
2018	$ 0.14	$ 1.69	$ 1.56	$ 1.51	$ 1.55		$ 1.64	$ 1.56	$ 1.59		$ 1.57
2019	$ 0.14	$ 1.09	$ 0.98	$ 0.94	$ 0.97		$ 1.05	$ 0.97	$ 1.01		$ 0.99
2020	$ 0.14	$ 1.08	$ 0.96	$ 0.92	$ 0.95		$ 1.03	$ 0.96	$ 0.99		$ 0.97
2021	$ 0.14	$ 0.21	$ 0.12	$ 0.09	$ 0.11		$ 0.18	$ 0.12	$ 0.14		$ 0.13
2022	$ 0.14	$ 0.21	$ 0.12	$ 0.09	$ 0.11		$ 0.18	$ 0.12	$ 0.14		$ 0.13
2023	$ 0.14	$ 0.21	$ 0.12	$ 0.09	$ 0.11		$ 0.18	$ 0.12	$ 0.14		$ 0.13
2024	$ 0.14	$ 0.21	$ 0.12	$ 0.09	$ 0.11		$ 0.18	$ 0.12	$ 0.14		$ 0.13
2025	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11		$ 0.18	$ 0.12	$ 0.14		$ 0.13
2026	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11		$ 0.18	$ 0.11	$ 0.14		$ 0.12
2027	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11		$ 0.18	$ 0.11	$ 0.14		$ 0.12
2028	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11		$ 0.18	$ 0.11	$ 0.14		$ 0.12
2029	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11		$ 0.18	$ 0.11	$ 0.14		$ 0.12
2030	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11		$ 0.18	$ 0.11	$ 0.14		$ 0.12
2031	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11	#	$ 0.18	$ 0.11	$ 0.14	#	$ 0.12
2032	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11	#	$ 0.18	$ 0.11	$ 0.14	#	$ 0.12
2033	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11	#	$ 0.18	$ 0.11	$ 0.14	#	$ 0.12
2034	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11	#	$ 0.18	$ 0.11	$ 0.14	#	$ 0.12
2035	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11	#	$ 0.18	$ 0.11	$ 0.14	#	$ 0.12
2036	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11	#	$ 0.18	$ 0.11	$ 0.14	#	$ 0.12
2037	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11	#	$ 0.18	$ 0.11	$ 0.14	#	$ 0.12
2038	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11	#	$ 0.18	$ 0.11	$ 0.14	#	$ 0.12
2039	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11	#	$ 0.18	$ 0.11	$ 0.14	#	$ 0.12
2040	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11	#	$ 0.18	$ 0.11	$ 0.14	#	$ 0.12
2041	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11	#	$ 0.18	$ 0.11	$ 0.14	#	$ 0.12
2042	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11	#	$ 0.18	$ 0.11	$ 0.14	#	$ 0.12
2043	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11	#	$ 0.18	$ 0.11	$ 0.14	#	$ 0.12
2044	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11	#	$ 0.18	$ 0.11	$ 0.14	#	$ 0.12
2045	$ 0.14	$ 0.21	$ 0.12	$ 0.08	$ 0.11	#	$ 0.18	$ 0.11	$ 0.14	#	$ 0.12
Levelized											
2016-2025	$ 0.14	$ 1.57	$ 1.44	$ 1.40	$ 1.43		$ 1.52	$ 1.44	$ 1.48		$ 1.45
2016-2030	$ 0.14	$ 1.17	$ 1.05	$ 1.01	$ 1.04		$ 1.13	$ 1.05	$ 1.08		$ 1.06
2016-2045	$ 0.16	$ 0.88	$ 0.76	$ 0.72	$ 0.75		$ 0.84	$ 0.76	$ 0.79		$ 0.77

Notes

Values for years 2016 through 2030 from AESC 2015 modeling.
Values for years from 2031 onward held at 2030 levels.
Illustrative real discount rate: 2.43%

Exhibit C-9. Maine
AESC 2015 - Gas Supply DRIPE and Gas Cross DRIPE (2015$/MMBtu)

	Gas Supply DRIPE (applicable to reductions in every end-use)	Gas Cross DRIPE (applicable to reductions by end-use)									
		RESIDENTIAL					COMMERCIAL & INDUSTRIAL				
Year		Non Heating	Hot Water	Heating	All		Non Heating	Heating	All		ALL RETAIL END USES
	1	2	3	4	5		6	7	8		9
2016	$ 0.02	$ 1.16	$ 1.11	$ 1.10	$ 1.11		$ 1.14	$ 1.11	$ 1.12		$ 1.11
2017	$ 0.02	$ 0.68	$ 0.65	$ 0.64	$ 0.65		$ 0.67	$ 0.65	$ 0.66		$ 0.65
2018	$ 0.02	$ 0.32	$ 0.30	$ 0.29	$ 0.29		$ 0.31	$ 0.29	$ 0.30		$ 0.30
2019	$ 0.02	$ 0.21	$ 0.18	$ 0.18	$ 0.18		$ 0.20	$ 0.18	$ 0.19		$ 0.19
2020	$ 0.02	$ 0.20	$ 0.18	$ 0.17	$ 0.18		$ 0.19	$ 0.18	$ 0.19		$ 0.18
2021	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02		$ 0.03	$ 0.02	$ 0.03		$ 0.02
2022	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02		$ 0.03	$ 0.02	$ 0.03		$ 0.02
2023	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02		$ 0.03	$ 0.02	$ 0.03		$ 0.02
2024	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02		$ 0.03	$ 0.02	$ 0.03		$ 0.02
2025	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02		$ 0.03	$ 0.02	$ 0.03		$ 0.02
2026	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02		$ 0.03	$ 0.02	$ 0.03		$ 0.02
2027	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02		$ 0.03	$ 0.02	$ 0.03		$ 0.02
2028	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02		$ 0.03	$ 0.02	$ 0.03		$ 0.02
2029	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02		$ 0.03	$ 0.02	$ 0.03		$ 0.02
2030	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02		$ 0.03	$ 0.02	$ 0.03		$ 0.02
2031	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02	#	$ 0.03	$ 0.02	$ 0.03	#	$ 0.02
2032	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02	#	$ 0.03	$ 0.02	$ 0.03	#	$ 0.02
2033	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02	#	$ 0.03	$ 0.02	$ 0.03	#	$ 0.02
2034	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02	#	$ 0.03	$ 0.02	$ 0.03	#	$ 0.02
2035	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02	#	$ 0.03	$ 0.02	$ 0.03	#	$ 0.02
2036	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02	#	$ 0.03	$ 0.02	$ 0.03	#	$ 0.02
2037	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02	#	$ 0.03	$ 0.02	$ 0.03	#	$ 0.02
2038	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02	#	$ 0.03	$ 0.02	$ 0.03	#	$ 0.02
2039	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02	#	$ 0.03	$ 0.02	$ 0.03	#	$ 0.02
2040	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02	#	$ 0.03	$ 0.02	$ 0.03	#	$ 0.02
2041	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02	#	$ 0.03	$ 0.02	$ 0.03	#	$ 0.02
2042	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02	#	$ 0.03	$ 0.02	$ 0.03	#	$ 0.02
2043	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02	#	$ 0.03	$ 0.02	$ 0.03	#	$ 0.02
2044	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02	#	$ 0.03	$ 0.02	$ 0.03	#	$ 0.02
2045	$ 0.02	$ 0.04	$ 0.02	$ 0.02	$ 0.02	#	$ 0.03	$ 0.02	$ 0.03	#	$ 0.02
Levelized											
2016-2025	$ 0.02	$ 0.30	$ 0.27	$ 0.26	$ 0.27		$ 0.29	$ 0.27	$ 0.28		$ 0.27
2016-2030	$ 0.02	$ 0.22	$ 0.20	$ 0.19	$ 0.20		$ 0.21	$ 0.20	$ 0.20		$ 0.20
2016-2045	$ 0.02	$ 0.17	$ 0.14	$ 0.14	$ 0.14		$ 0.16	$ 0.14	$ 0.15		$ 0.15

Notes
Values for years 2016 through 2030 from AESC 2015 modeling.
Values for years from 2031 onward held at 2030 levels.
Illustrative real discount rate: 2.43%

Exhibit C-10. New Hampshire
AESC 2015 - Gas Supply DRIPE and Gas Cross DRIPE (2015$/MMBtu)

Year	Gas Supply DRIPE (applicable to reductions in every end-use)	Gas Cross DRIPE (applicable to reductions by end-use)									
		RESIDENTIAL					COMMERCIAL & INDUSTRIAL				
		Non Heating	Hot Water	Heating	All		Non Heating	Heating	All		ALL RETAIL END USES
	1	2	3	4	5		6	7	8		9
2016	$ 0.01	$ 1.23	$ 1.18	$ 1.16	$ 1.18		$ 1.21	$ 1.18	$ 1.19		$ 1.18
2017	$ 0.01	$ 0.73	$ 0.70	$ 0.68	$ 0.69		$ 0.72	$ 0.70	$ 0.71		$ 0.70
2018	$ 0.01	$ 0.35	$ 0.32	$ 0.31	$ 0.32		$ 0.34	$ 0.32	$ 0.33		$ 0.32
2019	$ 0.01	$ 0.23	$ 0.20	$ 0.19	$ 0.20		$ 0.22	$ 0.20	$ 0.21		$ 0.20
2020	$ 0.01	$ 0.22	$ 0.20	$ 0.19	$ 0.20		$ 0.22	$ 0.20	$ 0.21		$ 0.20
2021	$ 0.01	$ 0.04	$ 0.02	$ 0.02	$ 0.02		$ 0.04	$ 0.02	$ 0.03		$ 0.03
2022	$ 0.01	$ 0.04	$ 0.02	$ 0.02	$ 0.02		$ 0.04	$ 0.02	$ 0.03		$ 0.03
2023	$ 0.01	$ 0.05	$ 0.02	$ 0.02	$ 0.02		$ 0.04	$ 0.02	$ 0.03		$ 0.03
2024	$ 0.01	$ 0.05	$ 0.02	$ 0.02	$ 0.02		$ 0.04	$ 0.02	$ 0.03		$ 0.03
2025	$ 0.01	$ 0.05	$ 0.02	$ 0.02	$ 0.02		$ 0.04	$ 0.02	$ 0.03		$ 0.03
2026	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02		$ 0.04	$ 0.02	$ 0.03		$ 0.03
2027	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02		$ 0.04	$ 0.02	$ 0.03		$ 0.03
2028	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02		$ 0.04	$ 0.03	$ 0.03		$ 0.03
2029	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02		$ 0.04	$ 0.03	$ 0.03		$ 0.03
2030	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02		$ 0.04	$ 0.03	$ 0.03		$ 0.03
2031	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02	#	$ 0.04	$ 0.03	$ 0.03	#	$ 0.03
2032	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02	#	$ 0.04	$ 0.03	$ 0.03	#	$ 0.03
2033	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02	#	$ 0.04	$ 0.03	$ 0.03	#	$ 0.03
2034	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02	#	$ 0.04	$ 0.03	$ 0.03	#	$ 0.03
2035	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02	#	$ 0.04	$ 0.03	$ 0.03	#	$ 0.03
2036	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02	#	$ 0.04	$ 0.03	$ 0.03	#	$ 0.03
2037	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02	#	$ 0.04	$ 0.03	$ 0.03	#	$ 0.03
2038	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02	#	$ 0.04	$ 0.03	$ 0.03	#	$ 0.03
2039	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02	#	$ 0.04	$ 0.03	$ 0.03	#	$ 0.03
2040	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02	#	$ 0.04	$ 0.03	$ 0.03	#	$ 0.03
2041	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02	#	$ 0.04	$ 0.03	$ 0.03	#	$ 0.03
2042	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02	#	$ 0.04	$ 0.03	$ 0.03	#	$ 0.03
2043	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02	#	$ 0.04	$ 0.03	$ 0.03	#	$ 0.03
2044	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02	#	$ 0.04	$ 0.03	$ 0.03	#	$ 0.03
2045	$ 0.01	$ 0.05	$ 0.03	$ 0.02	$ 0.02	#	$ 0.04	$ 0.03	$ 0.03	#	$ 0.03
Levelized											
2016-2025	$ 0.01	$ 0.32	$ 0.29	$ 0.28	$ 0.29		$ 0.31	$ 0.29	$ 0.30		$ 0.30
2016-2030	$ 0.01	$ 0.24	$ 0.21	$ 0.21	$ 0.21		$ 0.23	$ 0.21	$ 0.22		$ 0.22
2016-2045	$ 0.01	$ 0.18	$ 0.16	$ 0.15	$ 0.15		$ 0.17	$ 0.16	$ 0.16		$ 0.16

Notes

Values for years 2016 through 2030 from AESC 2015 modeling.
Values for years from 2031 onward held at 2030 levels.
Illustrative real discount rate: 2.43%

Exhibit C-11. Rhode Island
AESC 2015 - Gas Supply DRIPE and Gas Cross DRIPE (2015$/MMBtu)

Year	Gas Supply DRIPE (applicable to reductions in every end-use)	Gas Cross DRIPE (applicable to reductions by end-use)									
		RESIDENTIAL					COMMERCIAL & INDUSTRIAL				ALL RETAIL END USES
		Non Heating	Hot Water	Heating	All		Non Heating	Heating	All		
	1	2	3	4	5		6	7	8		9
2016	$ 0.02	$ 0.81	$ 0.78	$ 0.77	$ 0.78		$ 0.80	$ 0.78	$ 0.79		$ 0.78
2017	$ 0.02	$ 0.48	$ 0.45	$ 0.44	$ 0.45		$ 0.47	$ 0.45	$ 0.46		$ 0.45
2018	$ 0.02	$ 0.22	$ 0.21	$ 0.20	$ 0.20		$ 0.22	$ 0.21	$ 0.21		$ 0.21
2019	$ 0.02	$ 0.14	$ 0.13	$ 0.12	$ 0.13		$ 0.14	$ 0.13	$ 0.13		$ 0.13
2020	$ 0.02	$ 0.14	$ 0.13	$ 0.12	$ 0.12		$ 0.13	$ 0.13	$ 0.13		$ 0.13
2021	$ 0.02	$ 0.03	$ 0.02	$ 0.01	$ 0.01		$ 0.02	$ 0.02	$ 0.02		$ 0.02
2022	$ 0.02	$ 0.03	$ 0.02	$ 0.01	$ 0.01		$ 0.02	$ 0.01	$ 0.02		$ 0.02
2023	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01		$ 0.02	$ 0.01	$ 0.02		$ 0.02
2024	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01		$ 0.02	$ 0.01	$ 0.02		$ 0.02
2025	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01		$ 0.02	$ 0.01	$ 0.02		$ 0.02
2026	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01		$ 0.02	$ 0.01	$ 0.02		$ 0.02
2027	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01		$ 0.02	$ 0.01	$ 0.02		$ 0.02
2028	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01		$ 0.02	$ 0.01	$ 0.02		$ 0.02
2029	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01		$ 0.02	$ 0.01	$ 0.02		$ 0.02
2030	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01		$ 0.02	$ 0.01	$ 0.02		$ 0.02
2031	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01	#	$ 0.02	$ 0.01	$ 0.02	#	$ 0.02
2032	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01	#	$ 0.02	$ 0.01	$ 0.02	#	$ 0.02
2033	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01	#	$ 0.02	$ 0.01	$ 0.02	#	$ 0.02
2034	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01	#	$ 0.02	$ 0.01	$ 0.02	#	$ 0.02
2035	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01	#	$ 0.02	$ 0.01	$ 0.02	#	$ 0.02
2036	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01	#	$ 0.02	$ 0.01	$ 0.02	#	$ 0.02
2037	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01	#	$ 0.02	$ 0.01	$ 0.02	#	$ 0.02
2038	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01	#	$ 0.02	$ 0.01	$ 0.02	#	$ 0.02
2039	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01	#	$ 0.02	$ 0.01	$ 0.02	#	$ 0.02
2040	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01	#	$ 0.02	$ 0.01	$ 0.02	#	$ 0.02
2041	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01	#	$ 0.02	$ 0.01	$ 0.02	#	$ 0.02
2042	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01	#	$ 0.02	$ 0.01	$ 0.02	#	$ 0.02
2043	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01	#	$ 0.02	$ 0.01	$ 0.02	#	$ 0.02
2044	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01	#	$ 0.02	$ 0.01	$ 0.02	#	$ 0.02
2045	$ 0.02	$ 0.03	$ 0.01	$ 0.01	$ 0.01	#	$ 0.02	$ 0.01	$ 0.02	#	$ 0.02
Levelized											
2016-2025	$ 0.02	$ 0.21	$ 0.19	$ 0.18	$ 0.19		$ 0.20	$ 0.19	$ 0.19		$ 0.19
2016-2030	$ 0.02	$ 0.15	$ 0.14	$ 0.13	$ 0.14		$ 0.15	$ 0.14	$ 0.14		$ 0.14
2016-2045	$ 0.02	$ 0.12	$ 0.10	$ 0.09	$ 0.10		$ 0.11	$ 0.10	$ 0.10		$ 0.10

Notes

Values for years 2016 through 2030 from AESC 2015 modeling.
Values for years from 2031 onward held at 2030 levels.
Illustrative real discount rate: 2.43%

Exhibit C-12. Vermont
AESC 2015 - Gas Supply DRIPE and Gas Cross DRIPE (2015$/MMBtu)

Year	Gas Supply DRIPE (applicable to reductions in every end-use)	Gas Cross DRIPE (applicable to reductions by end-use)									
		RESIDENTIAL					COMMERCIAL & INDUSTRIAL				ALL RETAIL END USES
		Non Heating	Hot Water	Heating	All		Non Heating	Heating	All		
	1	2	3	4	5		6	7	8		9
2016	$ 0.005	$ 0.016	$ -	$ 0.008	$ 0.012		$ 0.016	$ 0.008	$ 0.009		$ 0.011
2017	$ 0.005	$ 0.016	$ -	$ 0.008	$ 0.012		$ 0.016	$ 0.008	$ 0.009		$ 0.011
2018	$ 0.005	$ 0.016	$ -	$ 0.008	$ 0.012		$ 0.016	$ 0.008	$ 0.008		$ 0.010
2019	$ 0.005	$ 0.015	$ -	$ 0.008	$ 0.012		$ 0.015	$ 0.008	$ 0.008		$ 0.010
2020	$ 0.005	$ 0.015	$ -	$ 0.008	$ 0.012		$ 0.015	$ 0.008	$ 0.008		$ 0.010
2021	$ 0.005	$ 0.015	$ -	$ 0.008	$ 0.012		$ 0.015	$ 0.008	$ 0.008		$ 0.010
2022	$ 0.005	$ 0.015	$ -	$ 0.008	$ 0.012		$ 0.015	$ 0.008	$ 0.008		$ 0.010
2023	$ 0.005	$ 0.015	$ -	$ 0.008	$ 0.011		$ 0.015	$ 0.008	$ 0.008		$ 0.010
2024	$ 0.005	$ 0.015	$ -	$ 0.008	$ 0.011		$ 0.015	$ 0.008	$ 0.008		$ 0.010
2025	$ 0.005	$ 0.015	$ -	$ 0.008	$ 0.011		$ 0.015	$ 0.008	$ 0.008		$ 0.010
2026	$ 0.005	$ 0.014	$ -	$ 0.008	$ 0.011		$ 0.014	$ 0.008	$ 0.008		$ 0.010
2027	$ 0.005	$ 0.014	$ -	$ 0.008	$ 0.011		$ 0.014	$ 0.008	$ 0.008		$ 0.010
2028	$ 0.005	$ 0.014	$ -	$ 0.008	$ 0.011		$ 0.014	$ 0.008	$ 0.008		$ 0.009
2029	$ 0.005	$ 0.014	$ -	$ 0.007	$ 0.011		$ 0.014	$ 0.007	$ 0.007		$ 0.009
2030	$ 0.005	$ 0.014	$ -	$ 0.007	$ 0.011		$ 0.014	$ 0.007	$ 0.007		$ 0.009
2031	$ 0.005	$ 0.014	$ -	$ 0.007	$ 0.011	#	$ 0.014	$ 0.007	$ 0.007	#	$ 0.009
2032	$ 0.005	$ 0.014	$ -	$ 0.007	$ 0.011	#	$ 0.014	$ 0.007	$ 0.007	#	$ 0.009
2033	$ 0.005	$ 0.014	$ -	$ 0.007	$ 0.011	#	$ 0.014	$ 0.007	$ 0.007	#	$ 0.009
2034	$ 0.005	$ 0.014	$ -	$ 0.007	$ 0.011	#	$ 0.014	$ 0.007	$ 0.007	#	$ 0.009
2035	$ 0.005	$ 0.014	$ -	$ 0.007	$ 0.011	#	$ 0.014	$ 0.007	$ 0.007	#	$ 0.009
2036	$ 0.005	$ 0.014	$ -	$ 0.007	$ 0.011	#	$ 0.014	$ 0.007	$ 0.007	#	$ 0.009
2037	$ 0.005	$ 0.014	$ -	$ 0.007	$ 0.011	#	$ 0.014	$ 0.007	$ 0.007	#	$ 0.009
2038	$ 0.005	$ 0.014	$ -	$ 0.007	$ 0.011	#	$ 0.014	$ 0.007	$ 0.007	#	$ 0.009
2039	$ 0.005	$ 0.014	$ -	$ 0.007	$ 0.011	#	$ 0.014	$ 0.007	$ 0.007	#	$ 0.009
2040	$ 0.005	$ 0.014	$ -	$ 0.007	$ 0.011	#	$ 0.014	$ 0.007	$ 0.007	#	$ 0.009
2041	$ 0.005	$ 0.014	$ -	$ 0.007	$ 0.011	#	$ 0.014	$ 0.007	$ 0.007	#	$ 0.009
2042	$ 0.005	$ 0.014	$ -	$ 0.007	$ 0.011	#	$ 0.014	$ 0.007	$ 0.007	#	$ 0.009
2043	$ 0.005	$ 0.014	$ -	$ 0.007	$ 0.011	#	$ 0.014	$ 0.007	$ 0.007	#	$ 0.009
2044	$ 0.005	$ 0.014	$ -	$ 0.007	$ 0.011	#	$ 0.014	$ 0.007	$ 0.007	#	$ 0.009
2045	$ 0.005	$ 0.014	$ -	$ 0.007	$ 0.011	#	$ 0.014	$ 0.007	$ 0.007	#	$ 0.009
Levelized											
2016-2025	$ 0.005	$ 0.015	$ -	$ 0.008	$ 0.012		$ 0.015	$ 0.008	$ 0.008		$ 0.010
2016-2030	$ 0.005	$ 0.015	$ -	$ 0.008	$ 0.012		$ 0.015	$ 0.008	$ 0.008		$ 0.010
2016-2045	$ 0.006	$ 0.016	$ -	$ 0.009	$ 0.013		$ 0.016	$ 0.009	$ 0.009		$ 0.011

Notes Values for years 2016 through 2030 from AESC 2015 modeling.
Values for years from 2031 onward held at 2030 levels.
Illustrative real discount rate: 2.43%

Exhibit C-13. New England
AESC 2015 - Gas Supply DRIPE and Gas Cross DRIPE (2015$/MMBtu)

Year	Gas Supply DRIPE (applicable to reductions in every end-use)	Gas Cross DRIPE (applicable to reductions by end-use)									
		RESIDENTIAL					COMMERCIAL & INDUSTRIAL				ALL RETAIL END USES
		Non Heating	Hot Water	Heating	All		Non Heating	Heating	All		
	1	2	3	4	5		6	7	8		9
2016	$ 0.25	$ 13.19	$ 12.66	$ 12.49	$ 12.63		$ 13.00	$ 12.66	$ 12.81		$ 12.71
2017	$ 0.25	$ 7.82	$ 7.42	$ 7.29	$ 7.40		$ 7.67	$ 7.42	$ 7.53		$ 7.46
2018	$ 0.25	$ 3.68	$ 3.39	$ 3.29	$ 3.37		$ 3.57	$ 3.38	$ 3.46		$ 3.41
2019	$ 0.25	$ 2.38	$ 2.12	$ 2.04	$ 2.10		$ 2.28	$ 2.12	$ 2.19		$ 2.14
2020	$ 0.25	$ 2.34	$ 2.08	$ 2.00	$ 2.07		$ 2.24	$ 2.08	$ 2.15		$ 2.11
2021	$ 0.25	$ 0.46	$ 0.25	$ 0.19	$ 0.24		$ 0.38	$ 0.25	$ 0.31		$ 0.27
2022	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24		$ 0.38	$ 0.25	$ 0.31		$ 0.27
2023	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24		$ 0.38	$ 0.25	$ 0.31		$ 0.27
2024	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24		$ 0.38	$ 0.25	$ 0.31		$ 0.27
2025	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24		$ 0.38	$ 0.25	$ 0.31		$ 0.27
2026	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24		$ 0.38	$ 0.25	$ 0.31		$ 0.27
2027	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24		$ 0.38	$ 0.25	$ 0.31		$ 0.27
2028	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24		$ 0.38	$ 0.25	$ 0.31		$ 0.27
2029	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24		$ 0.38	$ 0.25	$ 0.31		$ 0.27
2030	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24		$ 0.38	$ 0.25	$ 0.31		$ 0.27
2031	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24	#	$ 0.38	$ 0.25	$ 0.31	#	$ 0.27
2032	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24	#	$ 0.38	$ 0.25	$ 0.31	#	$ 0.27
2033	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24	#	$ 0.38	$ 0.25	$ 0.31	#	$ 0.27
2034	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24	#	$ 0.38	$ 0.25	$ 0.31	#	$ 0.27
2035	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24	#	$ 0.38	$ 0.25	$ 0.31	#	$ 0.27
2036	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24	#	$ 0.38	$ 0.25	$ 0.31	#	$ 0.27
2037	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24	#	$ 0.38	$ 0.25	$ 0.31	#	$ 0.27
2038	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24	#	$ 0.38	$ 0.25	$ 0.31	#	$ 0.27
2039	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24	#	$ 0.38	$ 0.25	$ 0.31	#	$ 0.27
2040	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24	#	$ 0.38	$ 0.25	$ 0.31	#	$ 0.27
2041	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24	#	$ 0.38	$ 0.25	$ 0.31	#	$ 0.27
2042	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24	#	$ 0.38	$ 0.25	$ 0.31	#	$ 0.27
2043	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24	#	$ 0.38	$ 0.25	$ 0.31	#	$ 0.27
2044	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24	#	$ 0.38	$ 0.25	$ 0.31	#	$ 0.27
2045	$ 0.25	$ 0.46	$ 0.25	$ 0.18	$ 0.24	#	$ 0.38	$ 0.25	$ 0.31	#	$ 0.27
Levelized											
2016-2025	$ 0.25	$ 3.40	$ 3.12	$ 3.03	$ 3.10		$ 3.30	$ 3.12	$ 3.20		$ 3.15
2016-2030	$ 0.25	$ 2.54	$ 2.28	$ 2.19	$ 2.26		$ 2.44	$ 2.27	$ 2.35		$ 2.30
2016-2045	$ 0.30	$ 1.91	$ 1.64	$ 1.55	$ 1.63		$ 1.81	$ 1.64	$ 1.71		$ 1.67

Notes Values for years 2016 through 2030 from AESC 2015 modeling.
Values for years from 2031 onward held at 2030 levels.
Illustrative real discount rate: 2.43%

AESC 2015 Exhibit D - 1

Avoided Costs of Petroleum Fuels by Sector, asnd Other Fuels(2015$/MMBtu)

Year	Fuel Oils							Other Fuels				
	Residential	Commercial			Industrial			Residential				Industrial
	Distillate Fuel Oil	Distillate Fuel Oil	Residual Fuel	Weighted Average	Distillate Fuel Oil	Residual Fuel Oil	Weighted Average	Cord Wood	Wood Pellets	Kerosene	Propane	Kerosene
	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu
	2015$	2015$	2015$	2015$	2015$	2015$	2015$	2015$	2015$	2015$	2015$	2015$
2015	$ 15.35	$ 14.09	$ 12.67	$ 13.89	$ 14.42	$ 15.58	$ 14.72	$ 5.44	$ 6.19	$ 16.75	$ 14.10	$ 14.42
2016	$ 16.17	$ 14.91	$ 13.41	$ 14.70	$ 14.67	$ 13.41	$ 14.34	$ 5.73	$ 6.52	$ 17.64	$ 15.29	$ 14.67
2017	$ 17.51	$ 16.23	$ 14.51	$ 15.99	$ 16.04	$ 14.51	$ 15.64	$ 6.20	$ 7.06	$ 19.10	$ 17.14	$ 16.04
2018	$ 18.61	$ 17.28	$ 15.37	$ 17.02	$ 17.09	$ 15.37	$ 16.65	$ 6.59	$ 7.50	$ 20.30	$ 18.38	$ 17.09
2019	$ 18.99	$ 17.69	$ 15.60	$ 17.40	$ 17.52	$ 15.60	$ 17.02	$ 6.73	$ 7.65	$ 20.72	$ 18.57	$ 17.52
2020	$ 19.36	$ 18.05	$ 15.89	$ 17.75	$ 17.88	$ 15.89	$ 17.36	$ 6.86	$ 7.80	$ 21.12	$ 18.70	$ 17.88
2021	$ 19.74	$ 18.44	$ 16.15	$ 18.12	$ 18.27	$ 16.15	$ 17.72	$ 6.99	$ 7.95	$ 21.53	$ 18.92	$ 18.27
2022	$ 20.13	$ 18.85	$ 16.57	$ 18.53	$ 18.70	$ 16.57	$ 18.14	$ 7.13	$ 8.11	$ 21.96	$ 19.09	$ 18.70
2023	$ 20.48	$ 19.18	$ 16.83	$ 18.85	$ 19.00	$ 16.83	$ 18.44	$ 7.25	$ 8.25	$ 22.34	$ 19.21	$ 19.00
2024	$ 20.84	$ 19.49	$ 17.03	$ 19.15	$ 19.29	$ 17.03	$ 18.70	$ 7.38	$ 8.40	$ 22.73	$ 19.37	$ 19.29
2025	$ 21.16	$ 19.82	$ 17.24	$ 19.46	$ 19.63	$ 17.24	$ 19.01	$ 7.50	$ 8.53	$ 23.09	$ 19.55	$ 19.63
2026	$ 21.41	$ 20.08	$ 17.60	$ 19.73	$ 19.89	$ 17.60	$ 19.29	$ 7.58	$ 8.63	$ 23.35	$ 19.70	$ 19.89
2027	$ 21.75	$ 20.42	$ 17.94	$ 20.07	$ 20.22	$ 17.94	$ 19.63	$ 7.71	$ 8.77	$ 23.73	$ 19.85	$ 20.22
2028	$ 21.97	$ 20.63	$ 18.04	$ 20.26	$ 20.42	$ 18.04	$ 19.80	$ 7.78	$ 8.85	$ 23.97	$ 19.98	$ 20.42
2029	$ 22.25	$ 20.90	$ 18.45	$ 20.55	$ 20.69	$ 18.45	$ 20.11	$ 7.88	$ 8.97	$ 24.27	$ 20.12	$ 20.69
2030	$ 22.47	$ 21.13	$ 18.65	$ 20.78	$ 20.93	$ 18.65	$ 20.33	$ 7.96	$ 9.06	$ 24.51	$ 20.25	$ 20.93
2031	$ 22.76	$ 21.42	$ 18.92	$ 21.07	$ 21.21	$ 18.92	$ 20.61	$ 8.06	$ 9.17	$ 24.83	$ 20.39	$ 21.21
2032	$ 23.06	$ 21.71	$ 19.19	$ 21.36	$ 21.50	$ 19.19	$ 20.90	$ 8.17	$ 9.29	$ 25.16	$ 20.53	$ 21.50
2033	$ 23.36	$ 22.01	$ 19.47	$ 21.65	$ 21.79	$ 19.47	$ 21.19	$ 8.28	$ 9.42	$ 25.49	$ 20.67	$ 21.79
2034	$ 23.67	$ 22.31	$ 19.75	$ 21.95	$ 22.09	$ 19.75	$ 21.48	$ 8.38	$ 9.54	$ 25.82	$ 20.81	$ 22.09
2035	$ 23.98	$ 22.61	$ 20.04	$ 22.25	$ 22.39	$ 20.04	$ 21.78	$ 8.49	$ 9.66	$ 26.16	$ 20.95	$ 22.39
2036	$ 24.29	$ 22.92	$ 20.33	$ 22.56	$ 22.70	$ 20.33	$ 22.08	$ 8.60	$ 9.79	$ 26.50	$ 21.09	$ 22.70
2037	$ 24.61	$ 23.24	$ 20.62	$ 22.87	$ 23.01	$ 20.62	$ 22.39	$ 8.72	$ 9.92	$ 26.84	$ 21.24	$ 23.01
2038	$ 24.93	$ 23.56	$ 20.92	$ 23.19	$ 23.32	$ 20.92	$ 22.70	$ 8.83	$ 10.05	$ 27.19	$ 21.38	$ 23.32
2039	$ 25.25	$ 23.88	$ 21.22	$ 23.51	$ 23.64	$ 21.22	$ 23.01	$ 8.95	$ 10.18	$ 27.55	$ 21.53	$ 23.64
2040	$ 25.58	$ 24.21	$ 21.53	$ 23.83	$ 23.96	$ 21.53	$ 23.33	$ 9.06	$ 10.31	$ 27.91	$ 21.68	$ 23.96
2041	$ 25.92	$ 24.54	$ 21.84	$ 24.16	$ 24.29	$ 21.84	$ 23.65	$ 9.18	$ 10.45	$ 28.27	$ 21.82	$ 24.29
2042	$ 26.26	$ 24.87	$ 22.16	$ 24.49	$ 24.62	$ 22.16	$ 23.98	$ 9.30	$ 10.58	$ 28.64	$ 21.97	$ 24.62
2043	$ 26.60	$ 25.21	$ 22.48	$ 24.83	$ 24.96	$ 22.48	$ 24.31	$ 9.42	$ 10.72	$ 29.02	$ 22.12	$ 24.96
2044	$ 26.95	$ 25.56	$ 22.80	$ 25.17	$ 25.30	$ 22.80	$ 24.65	$ 9.55	$ 10.86	$ 29.40	$ 22.27	$ 25.30
2045	$ 27.30	$ 25.91	$ 23.13	$ 25.52	$ 25.64	$ 23.13	$ 24.99	$ 9.67	$ 11.00	$ 29.78	$ 22.43	$ 25.64
Levelized Costs												
2016-2025	$ 19.20	$ 17.90	$ 15.79	$ 17.60	$ 17.71	$ 15.79	$ 17.21	$ 6.80	$ 7.74	$ 20.94	$ 18.35	$ 17.71
2016-2030	$ 20.01	$ 18.70	$ 16.47	$ 18.39	$ 18.51	$ 16.47	$ 17.98	$ 7.09	$ 8.06	$ 21.83	$ 18.83	$ 18.51
2016-2045	$ 21.99	$ 20.65	$ 18.26	$ 20.32	$ 20.44	$ 18.26	$ 19.88	$ 7.79	$ 8.86	$ 23.99	$ 19.85	$ 20.44

Notes

2031-2045 costs extrapolated based on 2021-2030 compound annual growth rate

Real discount rate 2.43%

AESC 2015 Exhibit D -2

Avoided Costs of Crude Oil and Fuel Prices by Sector in New England (2015$/MMBtu)

Year	Crude Oil Prices				Electric Generation		Residential			Commercial			Industrial		
	AEO 2014 Reference case WTI	WTI NYMEX Futures as of December 18 2014	AESC 2015 Forecast WTI		Distillate Fuel Oil	Residual Fuel Oil	Distillate Fuel Oil	Kerosene	Cord Wood	Distillate Fuel Oil	Residual Fuel	Kerosene	Distillate Fuel Oil	Residual Fuel Oil	Kerosene
	$/MMBtu	$/MMBtu	$/MMBtu	$/BBl	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu	$/MMBtu
	2015$	2015$	2015$	2015$	2015$	2015$	2015$	2015$	2015$	2015$	2015$	2015$	2015$	2015$	2015$
2015	$ 16.21	$ 9.65	$ 9.72	$ 56.40	$ 12.77	7.11	15.35	16.75	5.44	$ 14.09	$ 12.67	$ 16.75	$ 14.42	$ 15.58	$ 14.42
2016	$ 15.90	$ 10.25	$ 10.34	$ 59.96	$ 13.37	7.38	16.17	17.64	5.73	$ 14.91	$ 13.41	$ 17.64	$ 14.67	$ 13.41	$ 14.67
2017	$ 16.10	$ 10.58	$ 11.46	$ 66.46	$ 14.44	7.91	17.51	19.10	6.20	$ 16.23	$ 14.51	$ 19.10	$ 16.04	$ 14.51	$ 16.04
2018	$ 16.31	$ 10.68	$ 12.23	$ 70.94	$ 15.38	8.42	18.61	20.30	6.59	$ 17.28	$ 15.37	$ 20.30	$ 17.09	$ 15.37	$ 17.09
2019	$ 16.72	$ 10.69	$ 12.54	$ 72.74	$ 15.76	8.64	18.99	20.72	6.73	$ 17.69	$ 15.60	$ 20.72	$ 17.52	$ 15.60	$ 17.52
2020	$ 17.14	$ 10.61	$ 12.85	$ 74.54	$ 16.13	8.94	19.36	21.12	6.86	$ 18.05	$ 15.89	$ 21.12	$ 17.88	$ 15.89	$ 17.88
2021	$ 17.59	$ 10.45	$ 13.19	$ 76.50	$ 16.51	9.20	19.74	21.53	6.99	$ 18.44	$ 16.15	$ 21.53	$ 18.27	$ 16.15	$ 18.27
2022	$ 18.04	$ 10.26	$ 13.53	$ 78.49	$ 16.90	9.62	20.13	21.96	7.13	$ 18.85	$ 16.57	$ 21.96	$ 18.70	$ 16.57	$ 18.70
2023	$ 18.52	$ 10.06	$ 13.89	$ 80.57	$ 17.25	9.88	20.48	22.34	7.25	$ 19.18	$ 16.83	$ 22.34	$ 19.00	$ 16.83	$ 19.00
2024	$ 18.97	$ -	$ 14.23	$ 82.52	$ 17.61	10.08	20.84	22.73	7.38	$ 19.49	$ 17.03	$ 22.73	$ 19.29	$ 17.03	$ 19.29
2025	$ 19.39	$ -	$ 14.54	$ 84.33	$ 17.93	10.29	21.16	23.09	7.50	$ 19.82	$ 17.24	$ 23.09	$ 19.63	$ 17.24	$ 19.63
2026	$ 19.74	$ -	$ 14.80	$ 85.86	$ 18.18	10.64	21.41	23.35	7.58	$ 20.08	$ 17.60	$ 23.35	$ 19.89	$ 17.60	$ 19.89
2027	$ 20.18	$ -	$ 15.13	$ 87.77	$ 18.52	10.99	21.75	23.73	7.71	$ 20.42	$ 17.94	$ 23.73	$ 20.22	$ 17.94	$ 20.22
2028	$ 20.53	$ -	$ 15.40	$ 89.32	$ 18.74	11.09	21.97	23.97	7.78	$ 20.63	$ 18.04	$ 23.97	$ 20.42	$ 18.04	$ 20.42
2029	$ 20.90	$ -	$ 15.68	$ 90.92	$ 19.02	11.50	22.25	24.27	7.88	$ 20.90	$ 18.45	$ 24.27	$ 20.69	$ 18.45	$ 20.69
2030	$ -	$ -	$ 15.90	$ 90.92	$ 19.02	11.50	22.47	24.51	7.96	$ 21.13	$ 18.65	$ 24.51	$ 20.93	$ 18.65	$ 20.93
Levelized Costs															
2016-2025	$ 17.39	$ 8.56	$ 12.80	$ 74.22	$ 16.04	$ 8.97	$ 19.20	$ 20.94	$ 6.80	$ 17.90	$ 15.79	$ 20.94	$ 17.71	$ 15.79	$ 17.71
2016-2030	$ 17.11	$ 6.04	$ 13.55	$ 78.54	$ 16.82	$ 9.61	$ 20.01	$ 21.83	$ 7.09	$ 18.70	$ 16.47	$ 21.83	$ 18.51	$ 16.47	$ 18.51

Notes

Real discount rate 2.43%

AESC 2015 Exhibit D -3

Fuel Oil Emission Values (2015$/MMBtu)

Year	Residential				Commercial				Industrial			
	SO2	NOx	CO2	CO2 at $100/ton	SO2	NOx	CO2	CO2 at $100/ton	SO2	NOx	CO2	CO2 at $100/ton
2015	$ 0.000	$ 0.000	$ 0.513	$ 8.162	$ 0.000	$ 0.000	$ 0.512	$ 8.151	$ 0.000	$ 0.000	$ 0.512	$ 8.155
2016	$ 0.000	$ 0.000	$ 0.592	$ 8.162	$ 0.000	$ 0.000	$ 0.592	$ 8.151	$ 0.000	$ 0.000	$ 0.592	$ 8.155
2017	$ 0.000	$ 0.000	$ 0.642	$ 8.162	$ 0.000	$ 0.000	$ 0.641	$ 8.151	$ 0.000	$ 0.000	$ 0.641	$ 8.155
2018	$ 0.000	$ 0.000	$ 0.691	$ 8.162	$ 0.000	$ 0.000	$ 0.691	$ 8.151	$ 0.000	$ 0.000	$ 0.691	$ 8.155
2019	$ 0.000	$ 0.000	$ 0.761	$ 8.162	$ 0.000	$ 0.000	$ 0.760	$ 8.151	$ 0.000	$ 0.000	$ 0.760	$ 8.155
2020	$ 0.000	$ 0.000	$ 0.830	$ 8.162	$ 0.000	$ 0.000	$ 0.829	$ 8.151	$ 0.000	$ 0.000	$ 0.829	$ 8.155
2021	$ 0.000	$ 0.000	$ 1.024	$ 8.162	$ 0.000	$ 0.000	$ 1.022	$ 8.151	$ 0.000	$ 0.000	$ 1.023	$ 8.155
2022	$ 0.000	$ 0.000	$ 1.218	$ 8.162	$ 0.000	$ 0.000	$ 1.216	$ 8.151	$ 0.000	$ 0.000	$ 1.217	$ 8.155
2023	$ 0.000	$ 0.000	$ 1.412	$ 8.162	$ 0.000	$ 0.000	$ 1.410	$ 8.151	$ 0.000	$ 0.000	$ 1.410	$ 8.155
2024	$ 0.000	$ 0.000	$ 1.606	$ 8.162	$ 0.000	$ 0.000	$ 1.604	$ 8.151	$ 0.000	$ 0.000	$ 1.604	$ 8.155
2025	$ 0.000	$ 0.000	$ 1.800	$ 8.162	$ 0.000	$ 0.000	$ 1.797	$ 8.151	$ 0.000	$ 0.000	$ 1.798	$ 8.155
2026	$ 0.000	$ 0.000	$ 1.994	$ 8.162	$ 0.000	$ 0.000	$ 1.991	$ 8.151	$ 0.000	$ 0.000	$ 1.992	$ 8.155
2027	$ 0.000	$ 0.000	$ 2.188	$ 8.162	$ 0.000	$ 0.000	$ 2.185	$ 8.151	$ 0.000	$ 0.000	$ 2.186	$ 8.155
2028	$ 0.000	$ 0.000	$ 2.382	$ 8.162	$ 0.000	$ 0.000	$ 2.379	$ 8.151	$ 0.000	$ 0.000	$ 2.380	$ 8.155
2029	$ 0.000	$ 0.000	$ 2.576	$ 8.162	$ 0.000	$ 0.000	$ 2.572	$ 8.151	$ 0.000	$ 0.000	$ 2.574	$ 8.155
2030	$ 0.000	$ 0.000	$ 2.770	$ 8.162	$ 0.000	$ 0.000	$ 2.766	$ 8.151	$ 0.000	$ 0.000	$ 2.767	$ 8.155

Levelized

2016-2025	$ 0.0000	$ 0.0001	$ 0.6370	$ 8.1625	$ 0.0000	$ 0.0001	$ 0.6361	$ 8.1514	$ 0.0000	$ 0.0001	$ 0.6364	$ 8.1548
2016-2030	$ 0.0000	$ 0.0001	$ 0.9055	$ 8.1625	$ 0.0000	$ 0.0001	$ 0.9043	$ 8.1514	$ 0.0000	$ 0.0001	$ 0.9047	$ 8.1548

Notes

Real Discount rate	2.43%

Financial Parameters for AESC 2015

1.1 Introduction

This appendix describes the assumptions and methods AESC 2015 used to develop the common financial parameters the TCR team used to prepare the study.

AESC 2015 requires that values be reported in constant 2015 dollars (2015$), which requires a set of inflators and deflators to convert values in other year dollars to 2015$. AESC 2015 also requires levelized avoided costs be calculated n 2015$ for three specific time periods: 10 years (2016-2025); 15 years (2016-2030); and 30 years (2016-2045). These levelized costs, which are used for summary reporting and comparison purposes, are to be calculated using an illustrative constant$ or "real" discount rate.

Exhibit E - 1 reports the long-term inflation rate and real discount rate used in AESC 2015. The inflation rate is consistent with the value used in prior AESC studies. The real discount rate is higher than the value used in AESC 2013 but consistent with the values used in AESC 2009 and AESC 2011 of 2.22% and 2.46% respectively.

Exhibit E - 1 Summary of Common Financial Parameters AESC 2015 versus AESC 2013.

	AESC 2015	AESC 2013
Inflation Rate	1.88%	2.00%
Real Discount Rate	2.43%	1.36%

Exhibit E - 2 reports the resulting AESC 2015 inflator and deflator values by year.

Exhibit E - 2. Inflators and Deflators to Convert Nominal to 2015$

Year	GDP Chain-Type Price Index	Annual Inflation	Inflators/Deflators to convert nominal $ to 2015$
2000	81.89	2.28%	1.349
2001	83.75	2.28%	1.319
2002	85.04	1.53%	1.299
2003	86.74	1.99%	1.274
2004	89.12	2.75%	1.240
2005	91.99	3.22%	1.201
2006	94.81	3.07%	1.165
2007	97.34	2.66%	1.135
2008	99.25	1.96%	1.113
2009	100.00	0.76%	1.105
2010	101.22	1.22%	1.092
2011	103.31	2.06%	1.070
2012	105.17	1.80%	1.051
2013	106.73	1.49%	1.035
2014	108.55	1.70%	1.018
2015	110.50	1.80%	1.000
2016	112.38	1.70%	0.983
2017	114.52	1.90%	0.965
2018	116.81	2.00%	0.946
2019	119.14	2.00%	0.927
2020	121.52	2.00%	0.909
2021	123.95	2.00%	0.891
2022	126.43	2.00%	0.874
2023	128.96	2.00%	0.857
2024	131.54	2.00%	0.840
2025	134.01	1.72%	0.825
2026	136.53	1.73%	0.809
2027	139.10	1.75%	0.794
2028	141.72	1.77%	0.780
2029	144.38	1.83%	0.765
2030	147.09	1.88%	0.751

Data Sources:

1	Values through 2013 from Bureau of Economic Analysis, Table 1.1.9	
2	Values for 2014 through 2024 derived from *An Update to the Budget and Economic Outlook: 2014 to 2024*, Congressional Budget Office, August 2014, Table B-1	
3	Values for 2025 onward based on AEO 2014 inflation rate of	1.78%

1.2 Assumptions and Methodology Used to Develop Inflators and Deflators

AESC 2015 calculated the inflators to convert nominal dollars from prior years (i.e., pre-2015) into 2015$ from the Gross Domestic Product (GDP) chain-type price index published by the U.S. Department of Commerce's Bureau of Economic Analysis (BEA)[1].

AESC 2015 developed the deflators to convert nominal dollars from future years (i.e., post-2015) into 2015$ for 2015 through 2024 from the Congressional Budget Office (CBO) projection of inflation as of August 2014, the most recent available at the time it was developing these parameters[2] For the period 2025 to 2030 AESC 2015 use the projection of inflation from the Energy Information Administration (EIA) Annual Energy Outlook 2014 (AEO 2014), which was released May 2014. The resulting composite long-term inflation rate over the period 2015 through 2030 is 1.88%. That long-term rate is consistent with the 20-year annual average inflation rate from 1995 to 2014 of 1.95 percent implied by the Gross Domestic Product (GDP) chain-type price index.

1.3 Assumptions and Methodology Used to Develop Real Discount Rate

AESC 2015 uses a real discount rate of 2.43 percent for calculations of illustrative levelized costs. It calculated that illustrative real discount rate according to the formula used for each AESC study since 2007:

Real discount rate = ((1+ long-term nominal interest rate)/ (1+inflation rate)-1)

One input to that formula is the long-term projected inflation rate of 1.88 percent, discussed above. The other input is a projection of the long-term nominal interest rate, which AESC 2015 developed from two projections of the nominal rate of return for 10-year Treasury Bonds. Those two projections are the same as those AESC 2015 used for the long-term inflation rate, i.e., the CBO projection as of August 2014 for the period 2015 through 2024 and the EIA AEO 2014 for the period 2025 through 2030.

[1] Bureau of Economic Analysis, Table 1.1.9.

[2] *An Update to the Budget and Economic Outlook: 2014 to 2024*, Congressional Budget Office forecast, August 2014, Table B-1

Exhibit E - 3 presents a summary comparison of interest rates, inflation rates and real discount rates. The AESC 2015 real discount rate is higher than the value used in AESC 2013. However it is consistent with the values used in AESC 2009 and AESC 2011 of 2.22 percent and 2.46 percent respectively. The rate is also consistent with the real discount rate through 2040 of 2.36 percent implied in the macroeconomic forecasts for AEO 2014 and through 2024 of 2.42 percent implied in the CBO projections.[3] It is higher than the rate derived from the average of 30 year Treasury Bills issued to date in 2014. However, the 2014 average of 30 year Treasury Bill rates is a "snapshot" of current expectations regarding interest rates over the AESC study period, rather than a projection like that provided by the CBO and AEO 2014.

[3] Ibid. Table B-1.

Exhibit E - 3. Comparison of Real Discount Rate Estimates

Comparison of Financial Parameter Estimates						
Parameter / Source & Vintage	**AESC 2011 (1)**	**AESC 2013 (1)**	**AEO 2014 (2)**	**Congressional Budget Office (3)**	**30 year T-bill (4)**	**AESC 2015**
	Mar-11	Mar-13	May-14	**Aug-2014**	**Nov-14**	**November-14**
Long Term Nominal Rate	4.51%	3.39%	4.23%	4.41%	3.40%	4.36%
Source	30 year T-Bills as of February 2011	30 year T-Bills over last six years.	average forecast for 10 yr Treasury Bills 2015 - 2040	Average forecast for 10 yr Treasury notes 2015-2024	Average actual Jan 2, 2014 thru Nov 14, 2014	Composite CBO thru 2024, AEO 2014 thru 2030
Inflation Rate (GDP Deflator)	2.00%	**2.00%**	**1.84%**	**1.94%**	**1.88%**	**1.88%**
Source	Consistent with 20 year historic average inflation of 2.16%, but slightly lower to reflect economic forecasts.	Consistent with 20 year historic average inflation of 2.07%, but slightly lower to reflect economic forecasts.	average, 2015-2040	Average GDP chain link forecast, 2015-2024	AEO 2014 Reference Case	Composite CBO thru 2024, AEO 2014 thru 2030
Long Term Real Rate	2.46%	**1.36%**	**2.36%**	2.42%	**1.49%**	**2.43%**
Source	Calculated from long term nominal rate and inflation rate.					

Data Sources:

1 *AESC 2013*, Exhibit E-2
2 *AEO 2014,* EIA, Reference Case, Table 20 Macroeconomic Indicators
3 *An Update to the Budget and Economic Outlook: 2014 to 2024*, CBO, August 2014, Table B-1, page 66.
4 Daily Treasury Yield Curve Rates, http://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/TextView.aspx?data=yieldYear&year=2014
Downloaded November 17, 2014

Exhibit F-1. AESC 2015 Renewable Portfolio Standard (RPS) Targets, Renewable Energy Credit (REC) Price Forecasts, and Avoided RPS Costs in $/MWh of Load (2015$)

State	Category	Class	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
CONNECTICUT	RPS Targets (%)	Class 1	12.5%	14.0%	15.5%	17.0%	18.5%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%
		Class 2	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
		Class 3	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%
	REC Prices ($/MWh)	Class 1	$ 53.10	$ 49.96	$ 47.62	$ 45.27	$ 42.92	$ 40.57	$ 36.75	$ 46.63	$ 43.94	$ 42.00	$ 38.74	$ 35.79	$ 32.86	$ 30.13	$ 32.66	$ 30.46
		Class 2	$ 2.25	$ 2.46	$ 2.46	$ 2.46	$ 2.46	$ 2.46	$ 2.46	$ 2.46	$ 2.46	$ 2.46	$ 2.46	$ 2.46	$ 2.46	$ 2.46	$ 2.46	$ 2.46
		Class 3	$ 27.25	$ 26.30	$ 25.81	$ 25.31	$ 24.81	$ 24.32	$ 23.85	$ 23.38	$ 22.92	$ 22.47	$ 22.06	$ 21.65	$ 21.25	$ 20.86	$ 20.47	$ 20.10
		Loss Adjustment	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
	Avoided RPS Cost: $/MWh of Load	Class 1	$7.17	$7.55	$7.97	$8.31	$8.58	$8.76	$7.94	$10.07	$9.49	$9.07	$8.37	$7.73	$7.10	$6.51	$7.05	$6.58
		Class 2	$0.07	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08
		Class 3	$1.18	$1.14	$1.12	$1.09	$1.07	$1.05	$1.03	$1.01	$0.99	$0.97	$0.95	$0.94	$0.92	$0.90	$0.88	$0.87
MAINE	RPS Targets (%)	Class 1	8.0%	9.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
		Class 2	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%
	REC Prices ($/MWh)	Class 1	$ 4.38	$ 5.41	$ 4.27	$ 5.99	$ 7.39	$ 8.04	$ 5.60	$ 2.39	$ 2.00	$ 2.00	$ 2.00	$ 2.00	$ 2.00	$ 2.00	$ 2.00	$ 2.00
		Class 2	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30
		Loss Adjustment	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
	Avoided RPS Cost: $/MWh of Load	Class 1	$0.38	$0.53	$0.46	$0.65	$0.80	$0.87	$0.60	$0.26	$0.22	$0.22	$0.22	$0.22	$0.22	$0.22	$0.22	$0.22
		Class 2	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10
MASSACHUSETTS	RPS Targets (%)	Class 1	10.00%	11.00%	12.00%	13.00%	14.00%	15.00%	16.00%	17.00%	18.00%	19.00%	20.00%	21.00%	22.00%	23.00%	24.00%	25.00%
		SCO	2.14%	2.25%	2.68%	3.02%	3.32%	3.55%	3.43%	3.10%	2.58%	1.94%	1.57%	1.32%	0.92%	0.61%	0.30%	0.06%
		Class 1 Net of SCO	7.86%	8.75%	9.32%	9.98%	10.68%	11.45%	12.57%	13.90%	15.42%	17.06%	18.43%	19.68%	21.08%	22.39%	23.70%	24.94%
		Class 2	2.00%	2.53%	2.53%	2.53%	2.53%	2.53%	2.53%	2.53%	2.53%	2.53%	2.53%	2.53%	2.53%	2.53%	2.53%	2.53%
		Class 2-WTE	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%
		APS	3.75%	4.00%	4.25%	4.50%	4.75%	5.00%	5.25%	5.50%	5.75%	6.00%	6.25%	6.50%	6.75%	7.00%	7.25%	7.50%
	REC Prices ($/MWh)	Class 1	$ 57.56	$ 56.34	$ 52.40	$ 48.46	$ 44.52	$ 40.57	$ 50.50	$ 46.69	$ 43.62	$ 41.38	$ 38.74	$ 35.72	$ 32.86	$ 35.28	$ 32.66	$ 30.46
		Class 2	$26.50	$ 24.00	$ 21.50	$ 19.00	$ 16.50	$ 14.00	$ 14.05	$ 14.11	$ 14.16	$ 14.22	$ 14.29	$ 14.36	$ 14.44	$ 14.51	$ 14.58	$ 14.66
		Class 2-WTE	$9.44	$ 9.48	$ 9.50	$ 9.53	$ 9.56	$ 9.60	$ 9.64	$ 9.67	$ 9.71	$ 9.75	$ 9.80	$ 9.85	$ 9.90	$ 9.95	$ 10.00	$ 10.05
		APS	$ 21.00	$ 21.00	$ 20.83	$ 20.66	$ 20.49	$ 20.15	$ 20.23	$ 20.31	$ 20.39	$ 20.47	$ 20.57	$ 20.68	$ 20.78	$ 20.89	$ 21.00	$ 21.10
		Loss Adjustment	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
	Avoided RPS Cost: $/MWh of Load	Class 1	$4.88	$5.33	$5.28	$5.22	$5.13	$5.02	$6.86	$7.01	$7.26	$7.62	$7.71	$7.59	$7.48	$8.53	$8.36	$8.20
		Class 2	$0.57	$0.66	$0.59	$0.52	$0.45	$0.38	$0.38	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.40	$0.40	$0.40
		Class 2-WTE	$0.36	$0.36	$0.36	$0.36	$0.36	$0.36	$0.36	$0.37	$0.37	$0.37	$0.37	$0.37	$0.37	$0.38	$0.38	$0.38
		APS	$0.85	$0.91	$0.96	$1.00	$1.05	$1.09	$1.15	$1.21	$1.27	$1.33	$1.39	$1.45	$1.52	$1.58	$1.64	$1.71

Exhibit F-1. AESC 2015 Renewable Portfolio Standard (RPS) Targets, Renewable Energy Credit (REC) Price Forecasts, and Avoided RPS Costs in $/MWh of Load (2015$)

			2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
NEW HAMPSHIRE	RPS Targets (%)	Class 1	6.0%	6.9%	7.8%	8.7%	9.6%	10.5%	11.4%	12.3%	13.2%	14.1%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
		Class 1 - Thermal	0.6%	1.3%	1.4%	1.5%	1.6%	1.7%	1.8%	1.9%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
		Class 1 - Non-Therma	5.4%	5.6%	6.4%	7.2%	8.0%	8.8%	9.6%	10.4%	11.2%	12.1%	13.0%	13.0%	13.0%	13.0%	13.0%	13.0%
		Class 2	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%
		Class 3	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%
		Class 4	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
	REC Prices ($/MWh)	Class 1 - Non-Therma	$ 54.97	$ 52.50	$ 49.52	$ 46.54	$ 43.56	$ 40.57	$ 49.61	$ 46.69	$ 43.94	$ 41.38	$ 38.74	$ 35.72	$ 32.86	$ 30.13	$ 32.66	$ 30.46
		Class 1 - Thermal	$ 22.81	$ 22.66	$ 22.48	$ 22.30	$ 22.11	$ 21.94	$ 21.76	$ 21.59	$ 21.42	$ 21.26	$ 21.11	$ 20.97	$ 20.83	$ 20.69	$ 20.56	$ 20.42
		Class 2	$ 50.18	$ 49.85	$ 49.46	$ 49.05	$ 46.74	$ 42.60	$ 47.88	$ 47.51	$ 45.80	$ 43.45	$ 40.68	$ 37.51	$ 34.50	$ 37.04	$ 34.29	$ 31.98
		Class 3	$ 40.50	$ 39.82	$ 39.08	$ 29.14	$ 29.23	$ 29.34	$ 29.46	$ 29.57	$ 29.69	$ 29.80	$ 29.96	$ 30.11	$ 30.26	$ 30.13	$ 30.57	$ 30.46
		Class 4	$ 24.51	$ 24.60	$ 24.68	$ 24.75	$ 24.82	$ 24.92	$ 25.02	$ 25.12	$ 25.21	$ 25.31	$ 25.44	$ 25.57	$ 25.70	$ 25.83	$ 25.97	$ 26.10
		Loss Adjustment	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
	Avoided RPS Cost: $/MWh of Load	**Class 1 - Non-Therma**	**$3.21**	**$3.18**	**$3.42**	**$3.62**	**$3.76**	**$3.86**	**$5.14**	**$5.24**	**$5.31**	**$5.41**	**$5.44**	**$5.02**	**$4.61**	**$4.23**	**$4.59**	**$4.28**
		Class 1 - Thermal	**$0.15**	**$0.32**	**$0.34**	**$0.36**	**$0.38**	**$0.40**	**$0.42**	**$0.44**	**$0.46**	**$0.46**	**$0.46**	**$0.45**	**$0.45**	**$0.45**	**$0.44**	**$0.44**
		Class 1 - Total	**$3.35**	**$3.49**	**$3.76**	**$3.98**	**$4.15**	**$4.26**	**$5.57**	**$5.69**	**$5.78**	**$5.87**	**$5.90**	**$5.47**	**$5.06**	**$4.68**	**$5.03**	**$4.72**
		Class 2	**$0.16**	**$0.16**	**$0.16**	**$0.16**	**$0.15**	**$0.14**	**$0.16**	**$0.15**	**$0.15**	**$0.14**	**$0.13**	**$0.12**	**$0.11**	**$0.12**	**$0.11**	**$0.10**
		Class 3	**$3.50**	**$3.44**	**$3.38**	**$2.52**	**$2.53**	**$2.54**	**$2.54**	**$2.56**	**$2.57**	**$2.58**	**$2.59**	**$2.60**	**$2.61**	**$2.60**	**$2.64**	**$2.63**
		Class 4	**$0.40**	**$0.40**	**$0.40**	**$0.40**	**$0.40**	**$0.40**	**$0.41**	**$0.41**	**$0.41**	**$0.41**	**$0.41**	**$0.41**	**$0.42**	**$0.42**	**$0.42**	**$0.42**
RHODE ISLAND	RPS Targets (%)	New	6.5%	8.0%	9.5%	11.0%	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%
		Existing	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
	REC Prices ($/MWh)	New	$ 53.50	$ 49.16	$ 47.02	$ 44.87	$ 42.72	$ 40.57	$ 48.78	$ 46.69	$ 43.39	$ 41.38	$ 38.74	$ 35.72	$ 32.86	$ 30.13	$ 32.66	$ 30.46
		Existing	$ 0.80	$ 0.80	$ 0.80	$ 0.80	$ 0.80	$ 0.80	$ 0.80	$ 0.80	$ 0.80	$ 0.80	$ 0.80	$ 0.80	$ 0.80	$ 0.80	$ 0.80	$ 0.80
		Loss Adjustment	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
	Avoided RPS Cost: $/MWh of Load	**New**	**$3.76**	**$4.25**	**$4.82**	**$5.33**	**$5.77**	**$5.48**	**$6.59**	**$6.30**	**$5.86**	**$5.59**	**$5.23**	**$4.82**	**$4.44**	**$4.07**	**$4.41**	**$4.11**
		Existing	**$0.02**	**$0.02**	**$0.02**	**$0.02**	**$0.02**	**$0.02**	**$0.02**	**$0.02**	**$0.02**	**$0.02**	**$0.02**	**$0.02**	**$0.02**	**$0.02**	**$0.02**	**$0.02**
VERMONT	RPS Targets (%)	New	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
	REC Prices ($/MWh)	New	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
		Loss Adjustment	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
	Avoided RPS Cost: $/MWh of Load	**New**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**

Assumptions:

1	RPS Targets for CT, ME, MA, NH & RI are based on state-specific legislation and regulation in effect as of December 31, 2015.
2	Vermont does not currently have an RPS. AESC 2015 assumes that Vermont resources can be counted toward other states' RPS obligations through 2016.
3	REC prices for 2015 and 2016 are based on those listed in Exhibit 5-39.
4	Prices beyond 2016 for MA Class I, CT Class I, NH Class I, and RI "New" based on supply curve analysis (2020 onward) and interpolation (2017-2019).
5	CT Class II, MA Class II-WTE, ME Class II, and RI "Existing" REC markets are in surplus. Therefore, REC prices in these markets are expected to remain relatively constant.
6	The MA Class II market has overlapping eligibility with CT Class I. In addition, while there is theoretically ample supply to meet MA Class II, fewer generators than expected have undertaken the steps necessary to comply with the eligibility criteria and become certified. Therefore, the MA Class II market has been in shortage, and the legislature directed the DOER to take measures necessary to bring the market into balance. Long-run MA Class II REC prices are therefore assumed to be the lesser of CT Class I REC prices and 50 percent of the MA Class II ACP rate.
7	Long-term REC prices for MA APS and NH Class 1 thermal are forecast at 90 percent of the ACP rate; CT Class III prices are expected to remain at about 86 percent of ACP (nominal terms) over the period.
8	Existing solar facilities across New England are eligible for NH Class II. As such, this market is expected to remain in balance at about 90 to 95 percent of ACP, as solar resources age out of solar carve outs and competing Class 1 prices drop.
9	The NH Class III and NH Class IV markets have overlapping eligibility with CT Class I, and in the near term, the markets face uncertainty. NH-III and NH-IV REC prices are assumed to be the lesser of CT Class I and 90% of their respective Alternative Compliance Payment (ACP) rates.

Exhibit F-2. Alternative Compliance Payment (ACP) Rates, by RPS Class, by Year (2015$/MWh)

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Connecticut	Class 1	$55.00	$54.08	$53.07	$52.03	$51.01	$50.01	$49.03	$48.07	$47.13	$46.20	$45.35	$44.51	$43.69	$42.89	$42.09	$41.32
	Class 2	$55.00	$54.08	$53.07	$52.03	$51.01	$50.01	$49.03	$48.07	$47.13	$46.20	$45.35	$44.51	$43.69	$42.89	$42.09	$41.32
	Class 3	$31.00	$30.48	$29.91	$29.33	$28.75	$28.19	$27.64	$27.09	$26.56	$26.04	$25.56	$25.09	$24.63	$24.17	$23.73	$23.29
Maine	Class 1	$67.07	$67.33	$67.53	$67.73	$67.93	$68.20	$68.46	$68.73	$69.00	$69.27	$69.63	$69.98	$70.34	$70.70	$71.06	$71.42
	Class 2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Massachusetts	Class 1	$67.07	$67.33	$67.53	$67.73	$67.93	$68.20	$68.46	$68.73	$69.00	$69.27	$69.63	$69.98	$70.34	$70.70	$71.06	$71.42
	Class 2	$27.53	$27.64	$27.72	$27.80	$27.88	$27.99	$28.10	$28.21	$28.32	$28.43	$28.58	$28.73	$28.87	$29.02	$29.17	$29.32
	Class 2-WTE	$11.01	$11.05	$11.09	$11.12	$11.15	$11.20	$11.24	$11.28	$11.33	$11.37	$11.43	$11.49	$11.55	$11.61	$11.67	$11.72
	APS	$22.02	$22.11	$22.17	$22.24	$22.30	$22.39	$22.48	$22.57	$22.66	$22.74	$22.86	$22.98	$23.09	$23.21	$23.33	$23.45
New Hampshire	Class 1	$55.75	$55.39	$54.96	$54.50	$54.05	$53.62	$53.20	$52.79	$52.37	$51.96	$51.61	$51.27	$50.93	$50.59	$50.25	$49.91
	Class 1 - Thermal	$25.34	$25.18	$24.98	$24.77	$24.57	$24.37	$24.18	$23.99	$23.80	$23.62	$23.46	$23.30	$23.15	$22.99	$22.84	$22.69
	Class 2	$55.75	$55.39	$54.96	$54.50	$54.05	$53.62	$53.20	$52.79	$52.37	$51.96	$51.61	$51.27	$50.93	$50.59	$50.25	$49.91
	Class 3	$45.00	$44.25	$43.42	$32.38	$32.47	$32.60	$32.73	$32.86	$32.99	$33.12	$33.28	$33.45	$33.63	$33.80	$33.97	$34.14
	Class 4	$27.23	$27.34	$27.42	$27.50	$27.58	$27.69	$27.80	$27.91	$28.02	$28.12	$28.27	$28.41	$28.56	$28.70	$28.85	$29.00
Rhode Island	New	$67.07	$67.33	$67.53	$67.73	$67.93	$68.20	$68.46	$68.73	$69.00	$69.27	$69.63	$69.98	$70.34	$70.70	$71.06	$71.42
	Existing	$67.07	$67.33	$67.53	$67.73	$67.93	$68.20	$68.46	$68.73	$69.00	$69.27	$69.63	$69.98	$70.34	$70.70	$71.06	$71.42
Vermont	Not Applicable																

Assumptions:
Nominal values fixed or escalated as a function of projected CPI according to each state's rules. Real values in 2015$ deflated from nominal values per deflators in AESC 2015 Common Financial Parameters.

Appendix G: Survey of Transmission and Distribution Capacity Values

1.1 Introduction

The AESC 2015 project team issued a survey to the sponsoring electric utilities requesting the estimates of avoided Transmission and Distribution costs they use in their analyses of efficiency measure cost-effectiveness. The survey also requested a description of the methodology on which those estimates were based. Exhibit G-1 summarizes the results of the survey:

Exhibit G-1. Summary of Electric Utilities' T&D Cost Survey

Company	Year $	Transmission $kW-year	Distribution $kW-year	Total T&D $kW-year	Methodology
CL&P (CT)	2015	$1.25	$32.19	$33.44	ICF Tool
National Grid MA	2015	$23.01	$124.28	$147.29	ICF Tool
National Grid RI	2015	$37.86	$162.47	$200.33	ICF Tool
United Illuminating	2015	$2.74	$49.75	$52.49	B&V Report
Efficiency Maine	2015	NA	NA	$81.67	Historical (1)
Vermont	2015	$50.45	$113.51	$163.96	Historical

Notes
NA= Not applicable
ICF Tool = ICF workbook developed in 2009.
B&V Report = United Illuminating Avoided Transmission & Distribution Cost Study Report, Black & Veatch, September 2009.

Descriptions of the methodology used by respondents are detailed below.

1.2 ICF Tool

A complete description of the ICF model used by National Grid and other electric utilities was detailed in the AESC 2005 report. In summary, the ICF Tool is a workbook developed by ICF as part of the 2005 AESC Study. Inputs for the workbook are: 1) historical and budgeted future capital costs, 2) historical and future load, and 3) various accounting parameters from FERC Form 1 data.

Analysis period cost data is divided by analysis period load data to derive an average capital cost/kW. This is multiplied by a factor representing the percentage of capital costs that is avoidable by energy efficiency (another input variable). This avoidable $/kW is further modified by a carrying charge determined from the accounting inputs, to develop an annualized avoided capacity value in $/kW. Based on review of some of the carrying charge calculations in the AESC 2009 study, National Grid has updated this part of the workbook to create the updated ICF Tool. Other utilities have updated the workbook at other intervals.

1.3 Black and Veatch Report

United Illuminating's methodology is detailed in a Black and Veatch Report. Black and Veatch's methodology follows briefly:

- Identification of historical and future T&D capacity additions which could have been fully or partially avoided with additional energy efficiency programs.
- Collection of historical costs plus AFUDC associated with projects identified in the first step. Calculated project costs are then divided by each project's incremental MW load carrying capacity to derive a marginal capital cost for capacity per MW.
- Calculation of marginal O&M expenses.
- Converting marginal capital costs to annual costs adjusting for revenue requirements based on accounting inputs.
- Calculation of energy efficiency savings based on historical and projected load growth.
- Calculations of annual avoided cost based on annual costs and identified energy efficiency savings.

Appendix H: Pooled Transmission Losses Methodology

There is a loss of electricity between the generating unit and ISO-NE's delivery points, where power is delivered from the ISO-NE administered pooled transmission facilities (PTF) to the distribution utility local transmission and distribution systems. Therefore, a kilowatt load reduction at the ISO-NE's delivery points, as a result of DSM on a given distribution network, reduces the quantity of electricity that generators have to produce by one kilowatt plus the additional quantity that would have been required to compensate for losses. The energy prices forecast by pCA/PSO model reflect these losses. However, the forecast of capacity costs from the FCM do not and therefore, the forecast avoided capacity costs should be adjusted for transmission losses.

AESC 2015 estimated the PTF loss factor during the summer peak period by analyzing six summer-peak power flow cases ISO New England filed in its FERC Form 715. The summer peak loss factors for ISO New England in those six cases ranges from 2.14% to 2.34% with the average across these cases being 2.20%. Based on this analysis, AESC 2015 uses a marginal PTF demand loss factor of 2.20% for capacity costs. This is higher than the AESC 2013 factor of 1.5%

Exhibit H-1. PTF Losses vs. Non-PTF Demand for the Top 100 Summer Hours, 2010

Power Year summer	Peak Load (MW)	Losses (MW)	Loss Factor (%)	Loss Factor Averages (%)
2013/2013 (1)	27196.79	636.45	2.34%	
2013/2018 (1)	28671	638.71	2.23%	
2013/2023 (1)	29372	591.23	2.01%	
Three summer average				2.19%
2014/2014 (2)	27471	623.04	2.27%	
2014/2019 (2)	29057	637.35	2.19%	
2014/2024 (2)	30308	649.39	2.14%	
Three summer average				2.20%
Six summer average				2.20%
Sources				
1	ISO-NE 2013 FERC 715 Summer Peak Cases, 2013, 2018, 2023			
2	ISO-NE 2014 FERC 715 Summer Peak Cases, 2014, 2019, 2024			

K. **Examples of Demonstration Project Reports**

Evaluation of 2013–2014 Smart Thermostat Pilots: Home Energy Monitoring, Automatic Temperature Control, Demand Response

July 7, 2015

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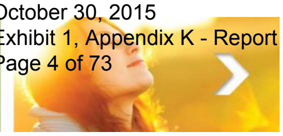

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Executive Summary

National Grid is investigating the influence of three key Wi-Fi thermostat features on its residential customers' energy usage, behavior, and satisfaction:

1. Integrated energy meters that provide whole-house energy consumption information.
2. HVAC control optimization.
3. A platform for participation in demand response (DR) events.

Working in partnership with Ecobee and Earth Networks, National Grid conducted a study to demonstrate the functionality of the Ecobee Smart Thermostat and integrated energy meter, and to evaluate the impact of Earth Networks' HVAC control optimization software and of four DR events on residential customers' natural gas and electric usage.

Objectives

National Grid engaged Cadmus to complete the following:

1. Assess the value and use of the Ecobee Smart Thermostat and integrated energy meter information to customers.
2. Determine the energy (natural gas and electric) impacts of the Ecobee thermostat with and without Earth Networks' HVAC optimization controls.
3. Verify the demand impacts of and participant experiences with each of the four DR events.

Technology

National Grid chose the Ecobee Smart Thermostat to represent a Wi-Fi thermostat in this study. The user could control their HVAC system settings at the thermostat itself, using a web portal or with a mobile application (app). In addition, each participant received an integrated home energy meter, which provided participants with information regarding energy usage and costs at their thermostats and web portals. This offered them access to viewing their whole-house electricity usage and costs, electricity bill projections, HVAC runtime histories, and weather-adjusted HVAC runtime histories.

As part of the evaluation, a portion of the participants' thermostats used HVAC control optimization software by Earth Networks (this report refers to this software as Automatic Temperature Control [ATC]). The software's algorithms use real-time, hyper-local weather data from WeatherBug weather stations, historical HVAC runtime data from the Ecobee Smart Thermostat, and historical energy usage data from the integrated energy meter to optimize HVAC runtimes, seeking to save energy while maintaining comfort.

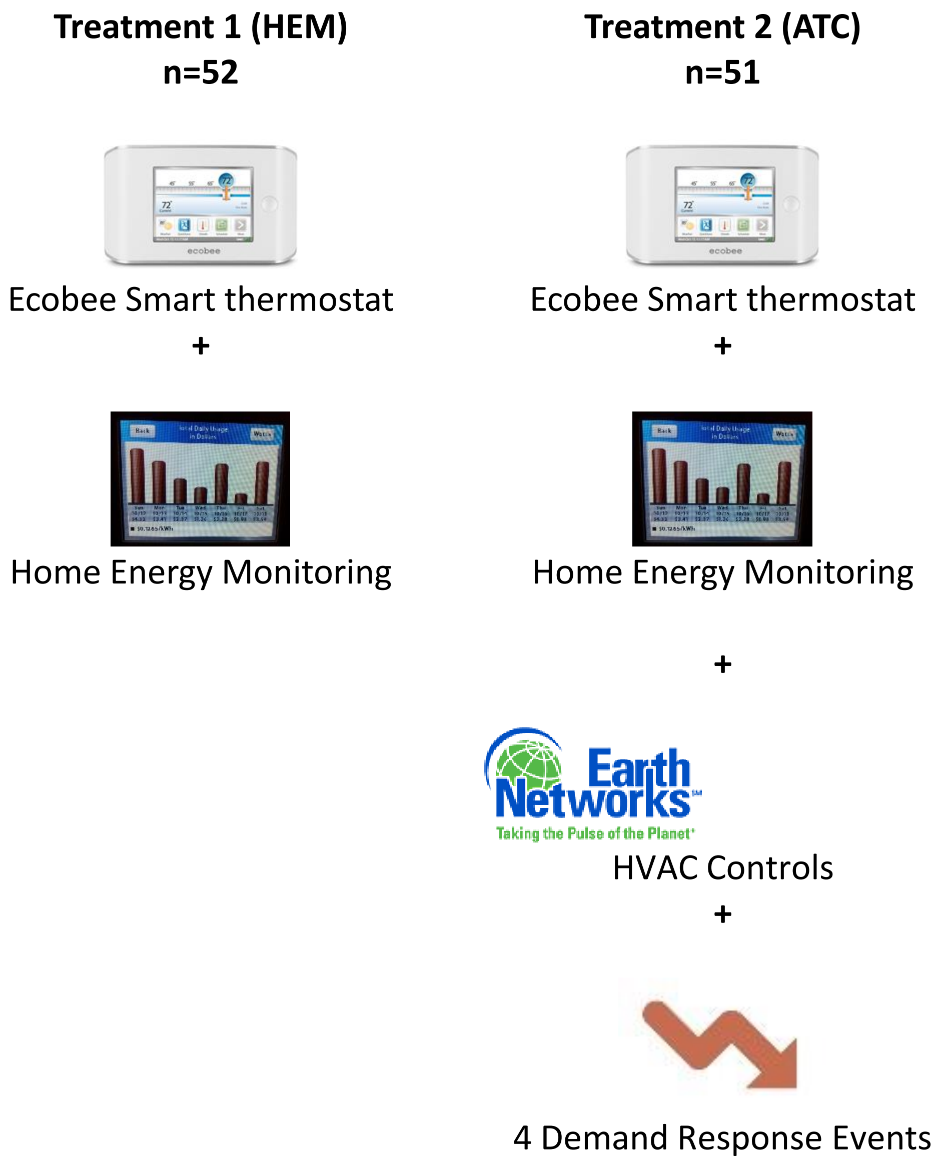
The implementer also tested a variety of DR event styles over the summer 2014, with the implementer choosing days forecast to be especially hot for running DR events. In total, the implementer ran three unique types of DR events across four days.

Methodology

National Grid administered the pilot using two treatment groups. Both groups received an Ecobee Smart thermostat and home energy monitoring capabilities via the integrated energy meter. In addition, one of the treatment groups' thermostats connected to Earth Networks' HVAC optimization controls, and they were invited to participate in the four DR events.

Figure 1 illustrates treatments for each group. This report references treatment group 1 as the Home Energy Monitoring (HEM) group and treatment group 2 as the ATC group.

Figure 1. Pilot Design



To accomplish the project objectives, Cadmus completed the following project tasks:

1. Collect and analyze smart thermostat and integrated energy meter data.
2. Conduct national gas billing analysis.
3. Conduct electric billing analysis.
4. Verify reported impacts from DR events.
5. Design, conduct, and analyze participant surveys.

Findings and Recommendations

Objective 1: Value of Ecobee Smart Thermostat and Integrated Energy Meter

Participants found having the ability to remotely control their thermostat using the smartphone app or the web portal as the most valuable feature of the Ecobee Smart Thermostat. Although some participants used the integrated energy meter features, including energy monitoring and bill estimation tools, interest in these features decreased significantly after two weeks.

Usefulness of Features

Participants found the Ecobee Smart Thermostat's basic functions more valuable than the integrated energy meter. Participants awarded the thermostat's temperature changing feature an average usefulness rating of 9.27/10.00, compared to 7.22/10.00 for the viewing energy usage feature and only 5.24/10.00 for the bill estimation feature.

Participants found remotely controlling and monitoring their thermostats as the thermostat's most valuable feature. Participants found flexible schedule programming, ease of use, and energy reports approximately one-half as valuable and considered convenience, checking outside temperatures, and the actual thermostats as the least valuable features/characteristics.

Persistence in Use of Features

Participants' interactions with their thermostats declined over time. During the program's first two weeks, participants reported viewing their energy usage more frequently, with the majority viewing their energy usage a couple of times each week. Several weeks into the program, the majority of customers viewed their energy usage only a few times each month. Use of the bill estimation feature also declined over time, with 10% of participants using the bill estimation feature multiple times per day for the first two weeks of the program, then losing interest after the initial period, with only 2% continuing to use the feature daily. All customers continued using the thermostat to change their home's temperature, with some additional activity occurring during the pilot's first two weeks.

Recommendations

An area for further research may address methods for keeping customers engaged with the energy usage and bill estimation information, perhaps by updating it regularly with new facts or comparisons to the past week's usage or to neighborhood averages.

Objective 2: Impact of HVAC Control Optimization

The HVAC optimization controls provided energy savings during the heating and cooling seasons, while regulating temperature setpoints more accurately than the comparison participant group without HVAC optimization controls. In terms of energy savings, the HVAC optimization controls outperformed the comparison group significantly in the cooling season, but provided similar savings in the heating season.

Temperature Regulation

During the heating and cooling seasons, HVAC systems with HVAC optimization controls more effectively regulated temperatures than HVAC systems without HVAC optimization controls. Indoor air temperatures for the group with HVAC optimization controls (the ATC group) more closely matched setpoints compared to the group without HVAC optimization controls (HEM group):

- In the heating season, indoor air temperatures (IAT) in the ATC group averaged 1.8 degrees warmer than setpoints, compared to 5.1 degrees warmer than setpoints in the HEM group.
- When cooling was required in the cooling season, IAT in the ATC group averaged 0.7 degrees warmer than the setpoint, compared to 2.4 degrees warmer than the setpoint in the HEM group.

Heating Season Energy Savings

Heating systems with HVAC optimization controls saved about the same in natural gas as heating systems without HVAC optimization controls. When comparing ATC and HEM participants with just one thermostat, Cadmus found natural gas savings to be about the same between the two groups. The HEM group performed slightly better when considering savings as a percentage of total gas usage, while the ATC group performed slightly better when considering savings as percentage of the disaggregated heating load and savings per square foot:

- As a percentage of total gas usage, the HEM group saved an average of 9.5%, compared to 9.1% for participants in the ATC group.
- As a percentage of the disaggregated heating load, the ATC group saved an average of 13.1% of heating gas usage, compared to 12.4% for participants in the HEM group.
- On a per-square-foot level, the ATC group saved 0.0480 therms/sqft compared to 0.0460 therms/sqft for the HEM group.

Cooling Season Energy Savings

Cooling systems with HVAC optimization controls saved significantly more electricity than cooling systems without HVAC optimization controls. When comparing ATC and HEM participants with just one thermostat, Cadmus found the ATC group outperformed the HEM by three times when considering the disaggregated cooling load and five times when considering savings per square foot:

- As a percentage of the disaggregated cooling load, the ATC group saved 16.5%, compared to 5.1% for the HEM group.

- On a per-square-foot level, the ATC group saved 0.1808 kWh/sqft, compared to 0.0358 kWh/sqft.

Recommendations

HVAC optimization controls show promise as an effective measure for reducing heating and cooling energy usage while improving temperature regulation, but energy savings calculations should be updated with larger sample sizes to improve the precision of estimates.

Objective 3: Impact of DR

Overall, DR events reduced participants' HVAC system runtimes without creating discomfort for participants.

Demand Impacts

DR events occurred and affected runtimes. The runtime impacts confirmed DR events occurred. Across all events, an average estimated runtime reduction of 7.9 minutes occurred in the first event hour and 3.6 minutes occurred in the second hour.

Evaluated kW impacts are likely overstated. Cadmus found statistically significant estimates of demand reductions were almost twice the value expected, given runtime reductions and the average tonnage of air conditioners (AC) in the program. This suggests a number of possible problems, some of which could indicate the study's demand impacts are overstated. Cadmus suspects this resulted from quality issues with the integrated energy meter dataset.

Smart cooling-style DR events had the largest impact on savings. During the two smart pre-cooling events, average estimated demand reductions of 0.847 kW and 0.267 kW resulted. Across all four events, average estimated demand reductions were 0.520 kW in the first hour and 0.472 kW in the second event hour.

Comfort

Participants in general did not find events uncomfortable. The majority of ATC participants (65% - 80%, depending on DR event) did not notice a change in comfort level during the DR events. Fourteen to 29% noticed the house was warmer but found the comfort level to be acceptable. Only 0-8% (depending on the DR event) found the house to be considerably less comfortable.

Recommendations

Cadmus recommends improving the estimated demand impacts by completing the actions that follow. However, if necessary to use this year's results for program planning, runtime impact results can be used with the average population EER and tonnage data to calculate estimated demand impacts.

To improve the estimated demand impacts:

- Improve the quality of the integrated energy meter data used to estimate DR impacts. For example, missing data should be clearly differentiated from true zeroes, and the source of high and low outliers should be investigated and corrected (for instance, readings over 40 kWh per hour).

- If possible, AC energy efficiency rating (EER) and tonnage data should be collected for new program participants at the time of thermostat installation. Better AMI data and a bigger sample of AC nameplate data will improve the accuracy of the DR program's demand impact estimates.

Introduction

Wi-Fi programmable thermostats (Wi-Fi thermostats) offer a broad range of features that could provide benefits to utilities and their customers. With the ability to communicate with utility program implementers and to collect and display historical performance data, Wi-Fi thermostats provide utilities with a platform from which to implement programs, while empowering customers with more HVAC control options than previously available.

National Grid is investigating the influence of three key Wi-Fi thermostat features on its residential customers' energy usage, behavior, and satisfaction:

1. Integrated energy meters that provide whole-house energy consumption information.
2. HVAC control optimization.
3. A platform for participation in demand response (DR) events.

Working in partnership with Ecobee and Earth Networks, National Grid conducted a study to demonstrate the functionality of the Ecobee Smart Thermostat and integrated energy meter, and to evaluate the impact of Earth Networks' HVAC control optimization software and of four DR events on residential customers' natural gas and electric usage.

Project Objectives and Scope

National Grid engaged Cadmus to evaluate the following:

1. Assess the value and use of the Ecobee Smart Thermostat and integrated energy meter information to customers.
2. Determine the energy (natural gas and electric) impacts of the Ecobee thermostat with and without Earth Networks' HVAC optimization controls.
3. Verify the demand impacts of and participant experience with each of the four DR events.

Wi-Fi Thermostat Features

This section describes the Wi-Fi thermostat features offered by Ecobee and Earth Networks and evaluated by Cadmus. These include the features of the Ecobee Smart Thermostat, the home energy monitoring system, Earth Networks' HVAC control optimization software (Automatic Temperature Control [ATC]), and the DR platform.

Ecobee Smart Thermostat

National Grid chose the Ecobee Smart Thermostat as a Wi-Fi thermostat in this study. Users can control their HVAC system settings at the thermostat, using a web portal, or via a mobile application (app). Descriptions follow of these three control platforms.

Thermostat

The Ecobee Smart Thermostat uses a color touch screen display. As shown in Figure 2, the Home screen displays the following: (1) the current space temperature; (2) the current setpoint (which can be adjusted by dragging the slider right or left); (3) the current operating mode; (4) the current date and time; (5) an Internet connection indicator; and (6) a Wi-Fi signal strength indication.

From the thermostat, the user can also access the following features: (7) check the current outdoor temperature; (8) put the HVAC system in an energy savings mode called QuickSave; (9) view system details, including humidity levels and fan settings; and (10) program setpoints for each day of the week. The user also can set up HVAC maintenance reminders, temperature alerts, and adjust display settings from the thermostat (11).

Figure 2. Ecobee Smart Thermostat

Web Portal

The Ecobee Smart Thermostat's web portal offers many of the same features as those available at the thermostat, including checking indoor and outdoor temperatures, adjusting setpoints, viewing and editing schedules, and setting up alerts. In addition, the web portal allows users to view and download HVAC system runtime histories and indoor temperature histories from the web portal, as shown in Figure 3.

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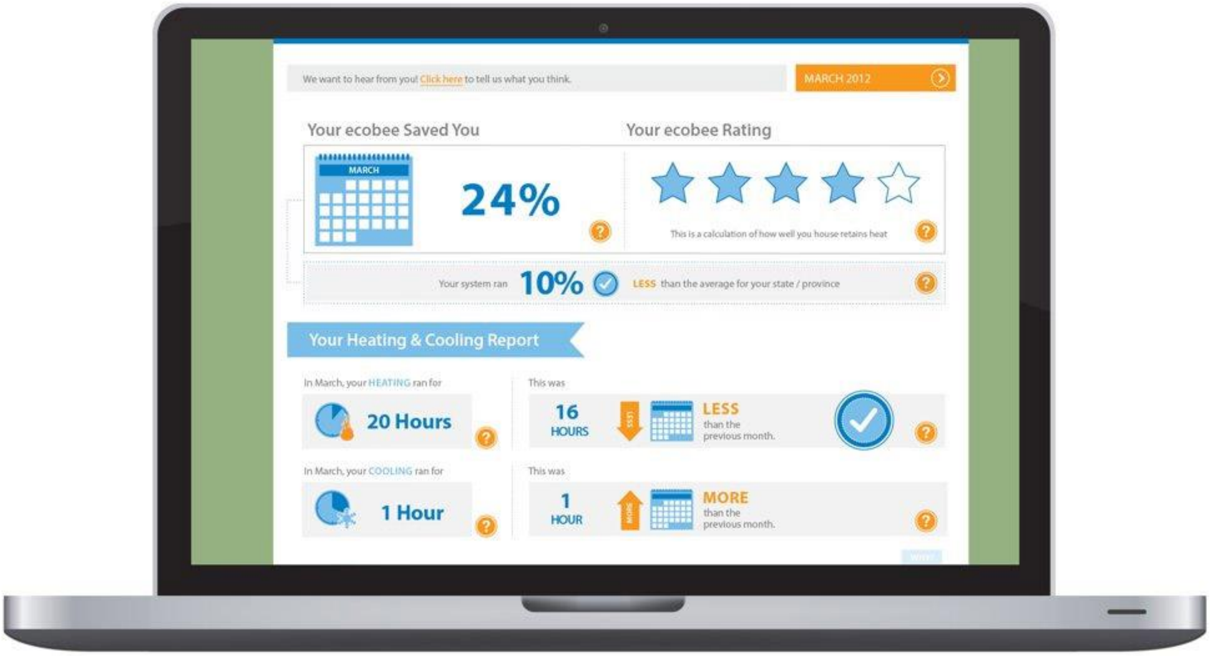
Figure 3. Ecobee Smart Thermostat Web Portal



Mobile App

From the Ecobee Smart Thermostat mobile app, users can check indoor and outdoor temperatures, adjust setpoints, change operating modes, and set thermostats to vacation mode, as shown in Figure 4.

Figure 4. Ecobee Smart Thermostat Mobile App

HEM

Cadmus's evaluation objectives included assessing the value of the integrated home energy meter to participants. The energy meter provided participants with information on energy usage and costs via the thermostat and web portal. Participants could view their whole-house electricity usage and costs, electricity bill projections, HVAC runtime histories, and weather-adjusted HVAC runtime histories. Descriptions follow of each of these monitoring tools.

Whole-House Electricity Usage and Costs

Participants could monitor their whole-house electricity usage and costs via the thermostat and web portal. At the thermostat, participants could view their energy usage down to 20-minute increments, along with current electricity rates and costs-to-date for each day, as shown in Figure 5). They could also view electricity usage and cost totals on daily (Figure 6 and Figure 7) and weekly (Figure 8 and Figure 9) levels. As shown in Figure 10, the web portal offer participants similar information.

Figure 5. 20-minute Electricity Usage (Thermostat)

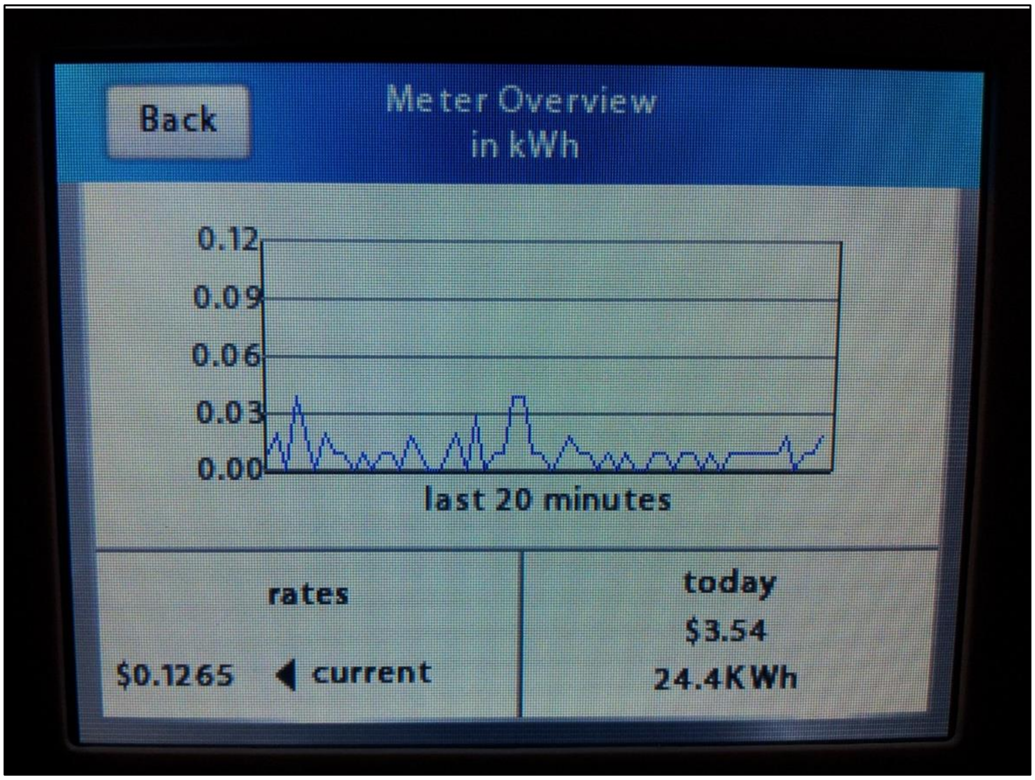


Figure 6. Daily Electricity Usage (Thermostat)

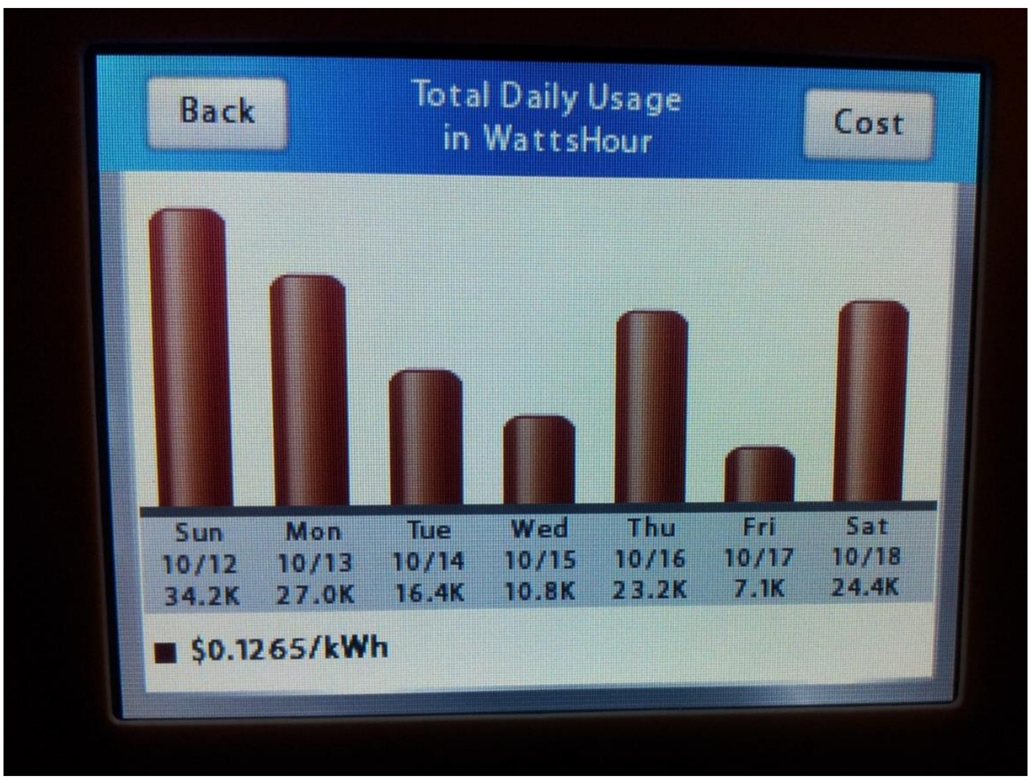


Figure 7. Daily Electricity Costs (Thermostat)

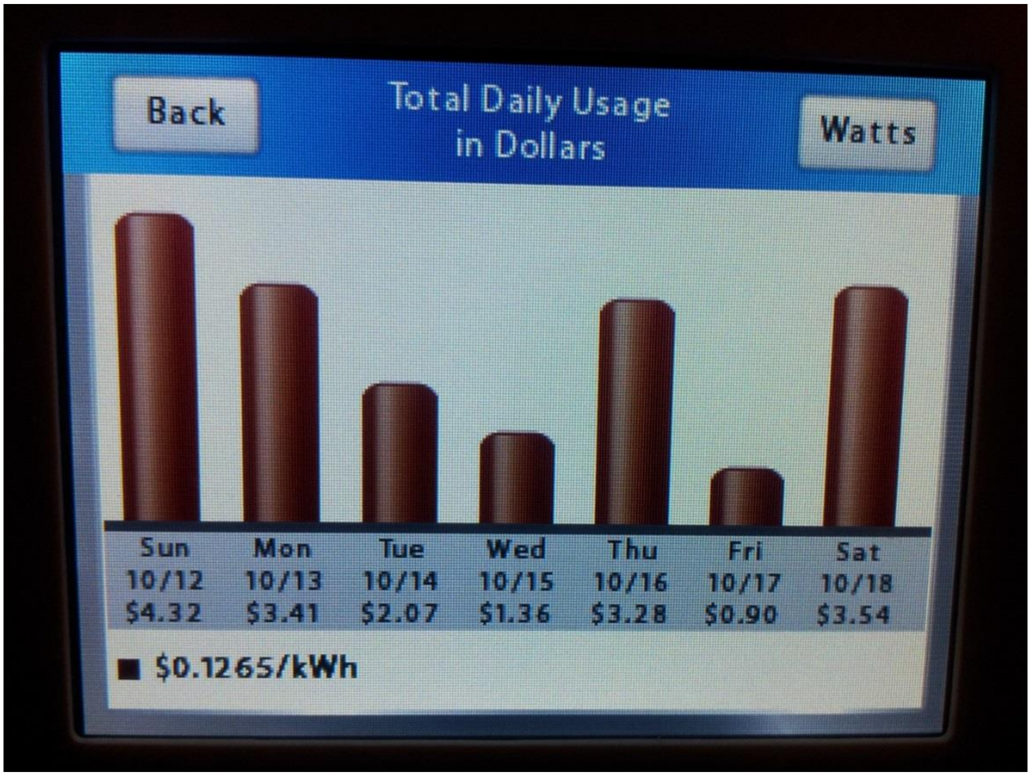


Figure 8. Weekly Electricity Usage (Thermostat)

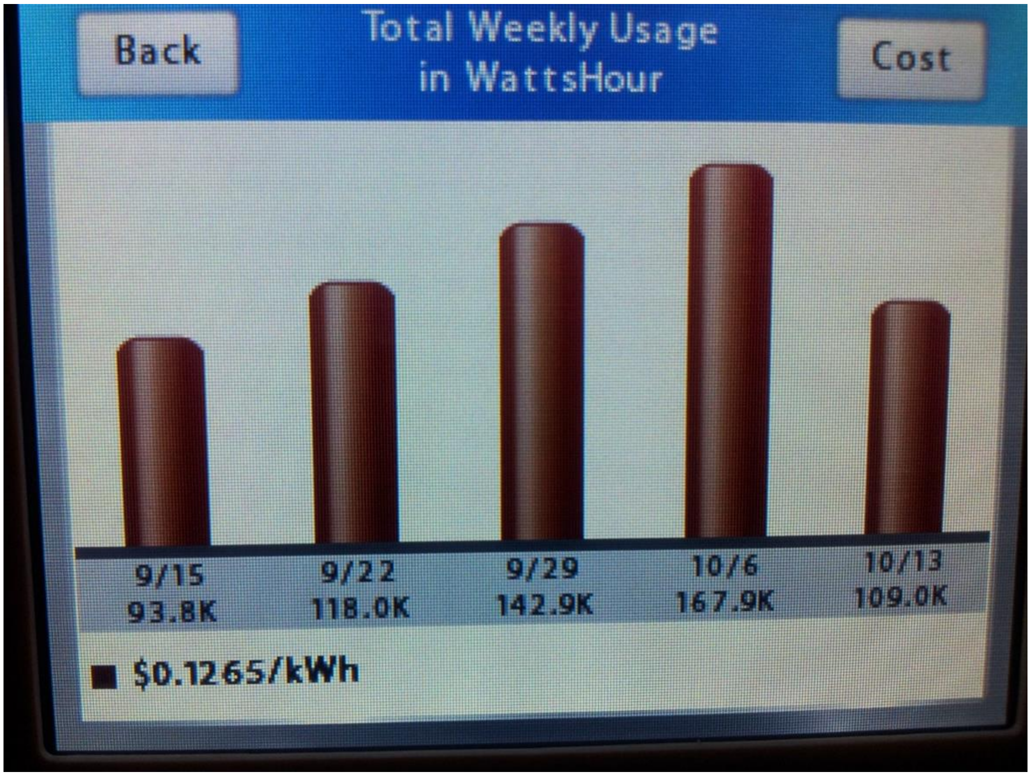


Figure 9. Weekly Electricity Costs (Thermostat)

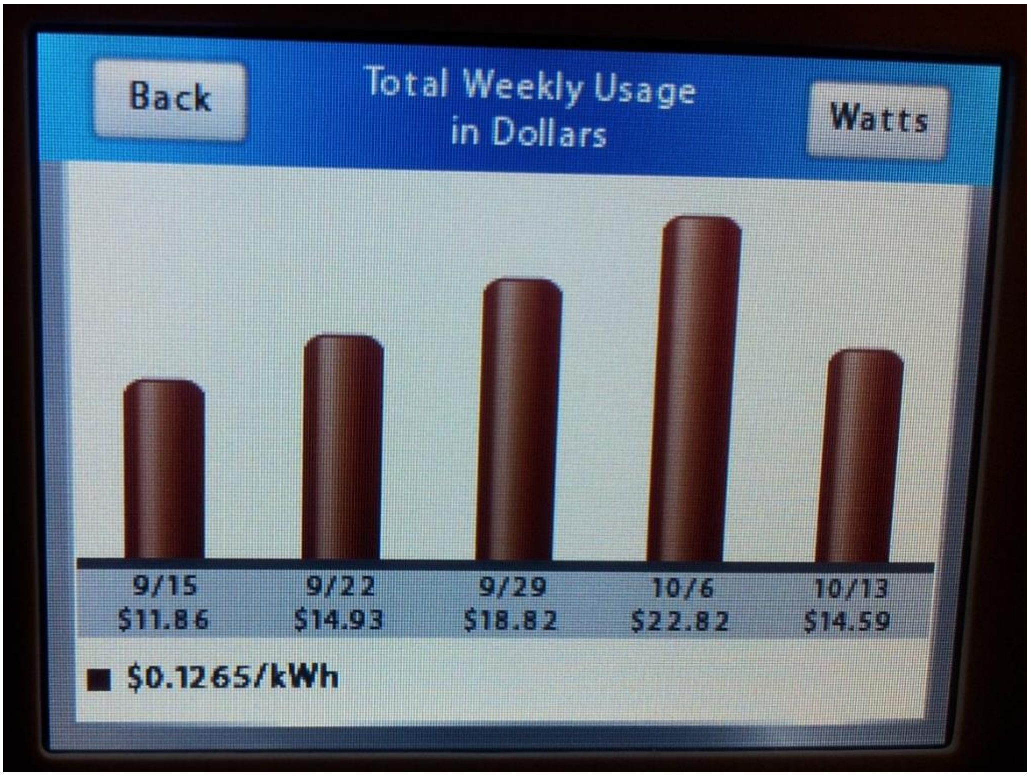
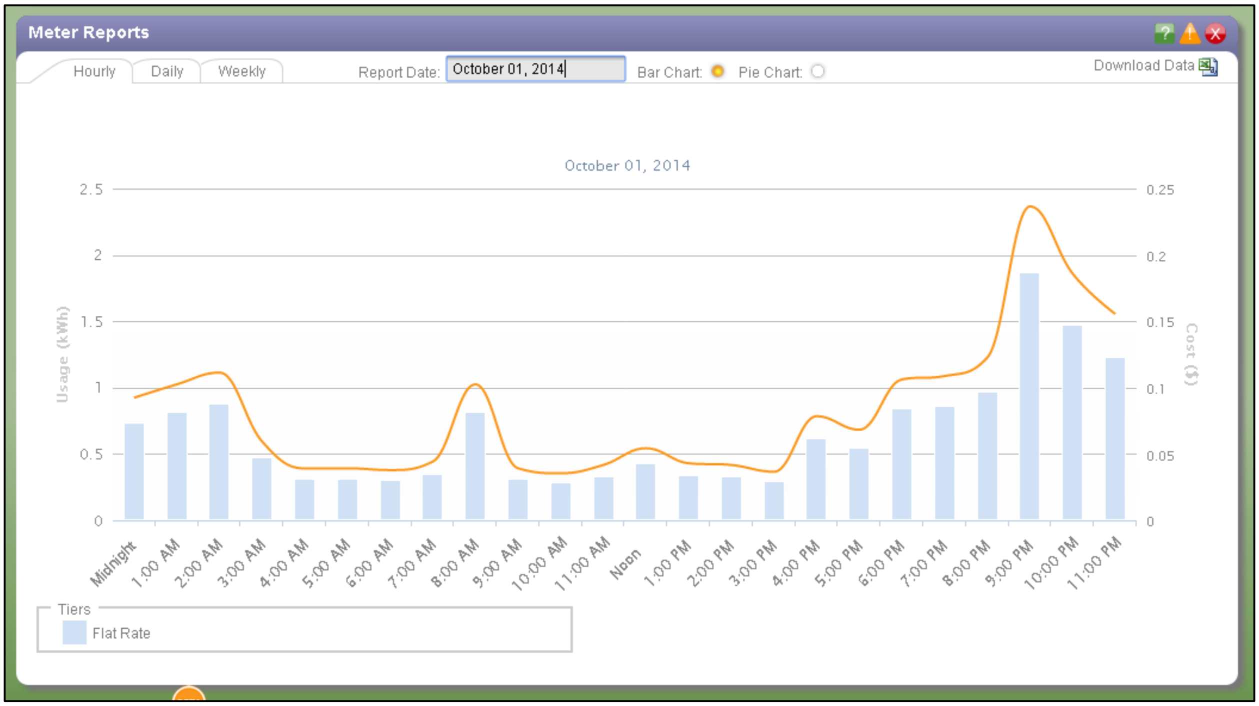


Figure 10. Hourly Electricity Usage (Web Portal)



Bill Projection

In addition to monitoring current electricity usage and costs, participants had access to an electricity bill project tool, which allowed them to set a monthly electricity budget and define their budget's billing period. They could view their current bill and projected bill against their budget (Figure 11) and set up alerts for notifications if their current or projected usage exceeded their budget (Figure 12).

Figure 11. Bill Projection Tool (Thermostat)

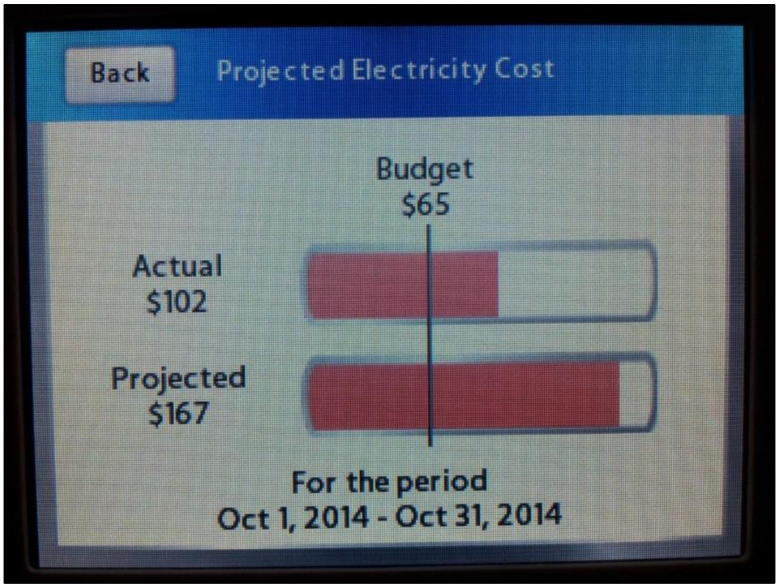
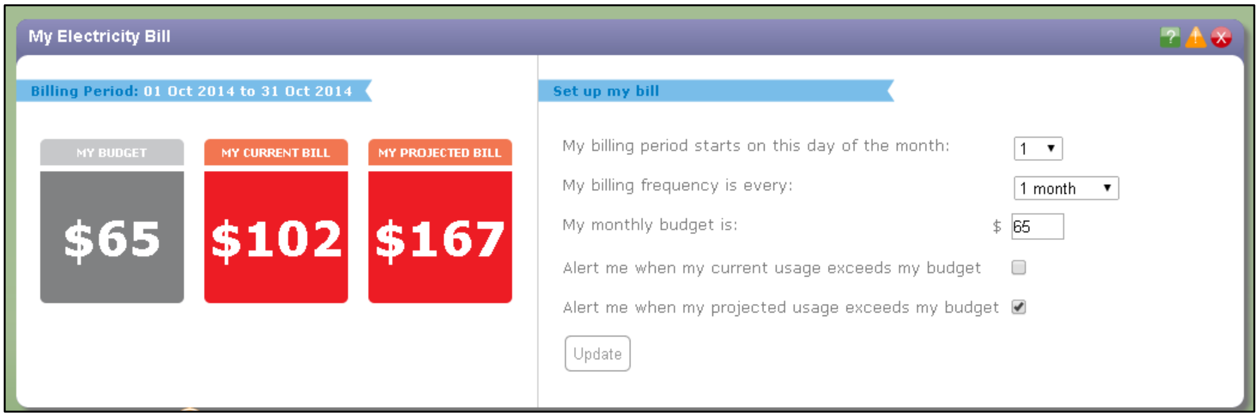


Figure 12. Bill Projection Tool (Web Portal)



Runtime History

Via the web portal, participants could access their HVAC system's total raw runtimes (Figure 13) and weather-normalized runtimes (Figure 14) by month, and compare this to previous years' runtimes. For each month, they also could view the average indoor and outdoor air temperatures (OAT) for each month.

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Figure 13. HVAC Runtime Comparison

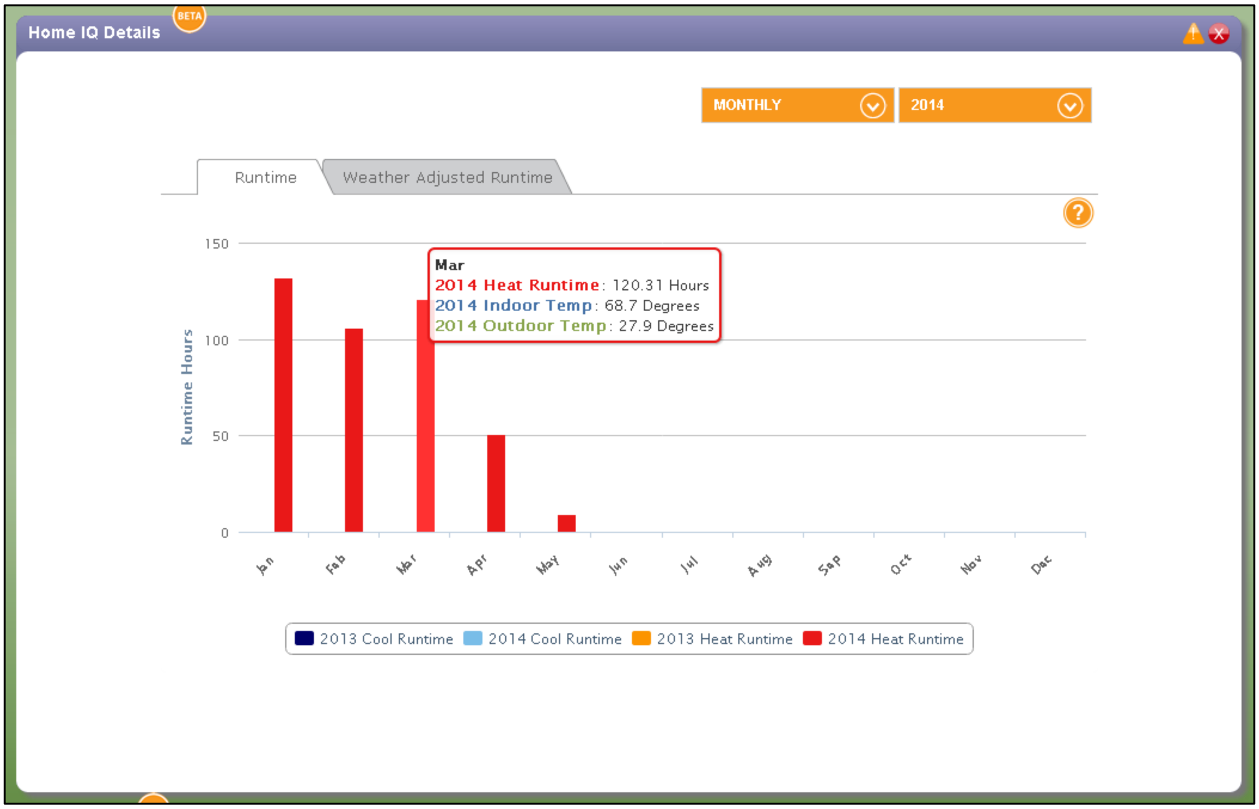
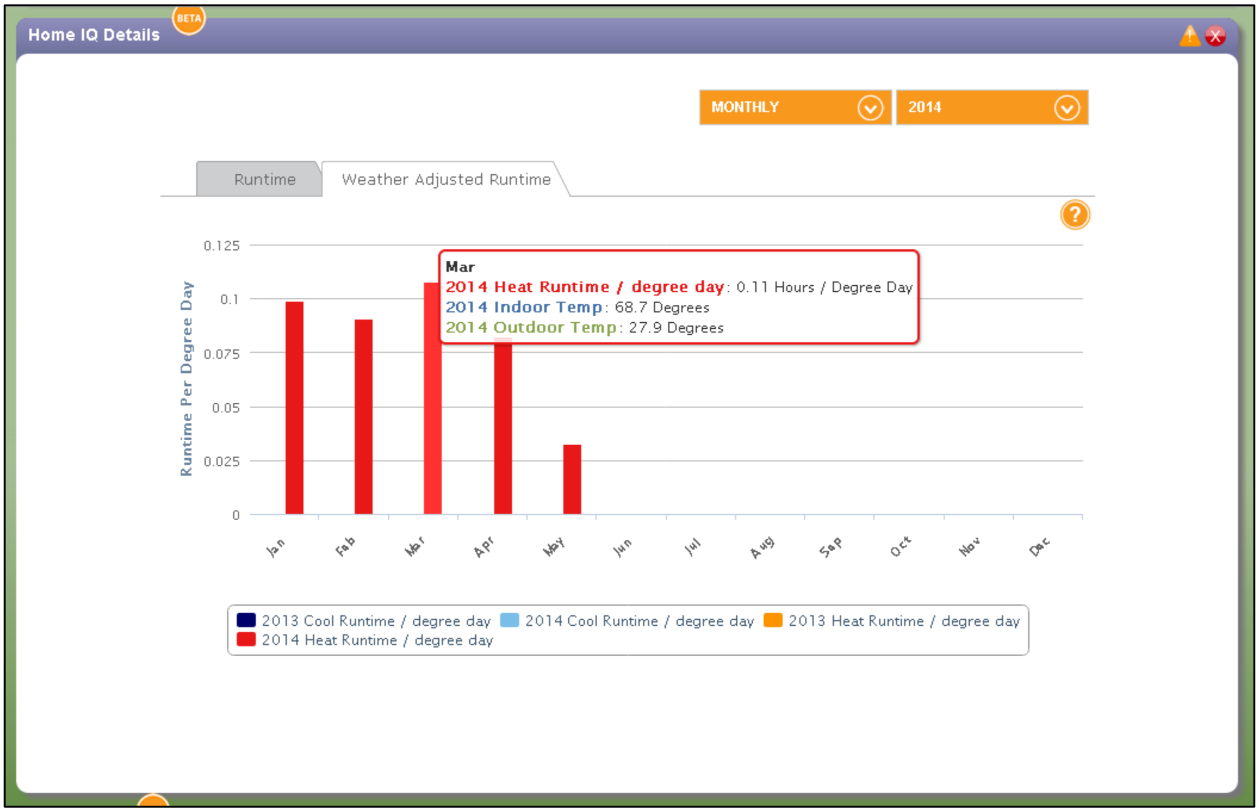


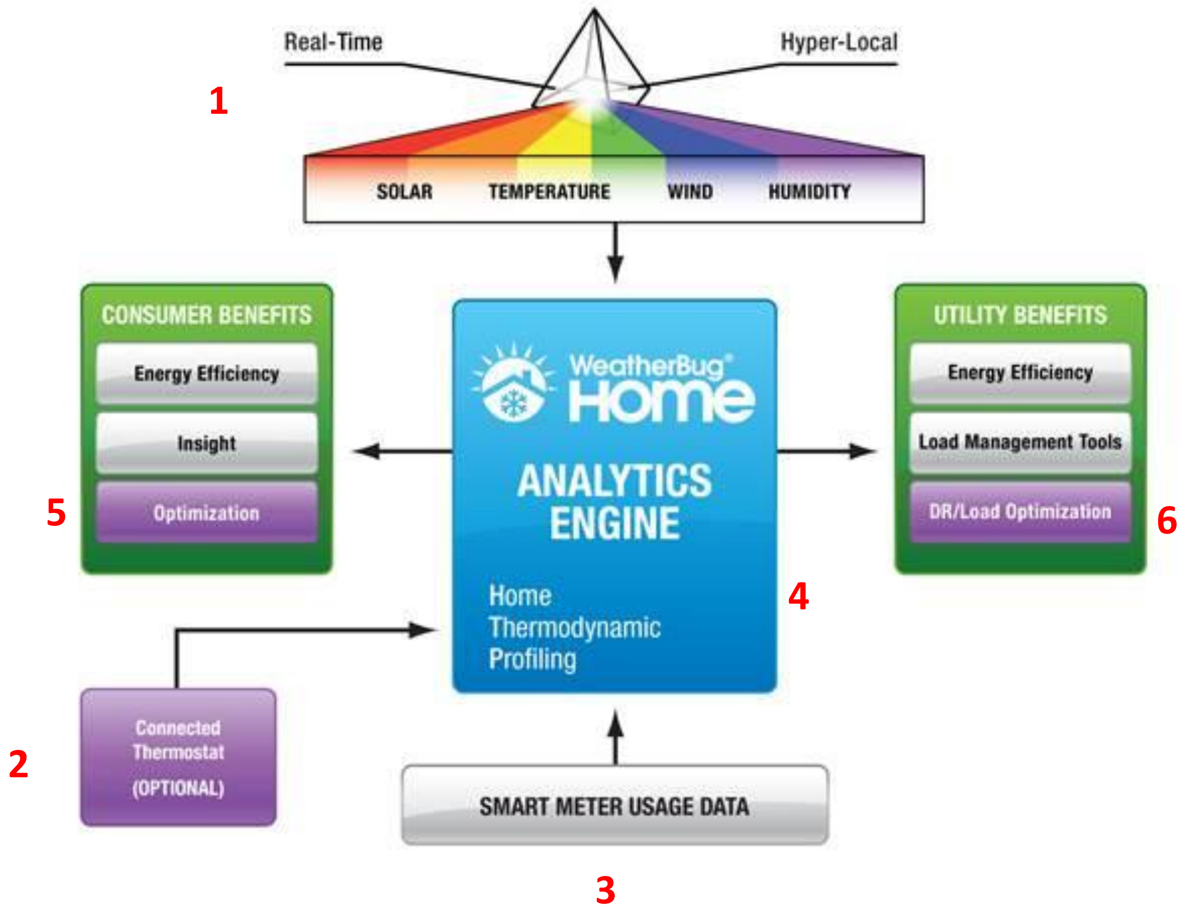
Figure 14. Weather-Normalized HVAC Runtime



ATC

As part of the evaluation, a portion of participants had Earth Networks' HVAC control optimization software on their thermostats (i.e., ATC). The software's algorithms use real-time, hyper-local weather data from participants' local WeatherBug weather stations, historical HVAC runtime data from the Ecobee Smart Thermostat, and historical energy usage data from the integrated energy meter to optimize HVAC runtimes, seeking to save energy while maintaining comfort. Figure 15 outlines ATC model inputs and outputs.

Figure 15. Earth Networks' ATC Model



The ATC model algorithms use three inputs to optimize HVAC control: (1) real-time, hyper-local weather data, including solar irradiance, outdoor temperature, wind speed, and humidity from WeatherBug stations; (2) one-minute interval data on HVAC runtimes, indoor temperatures, and setpoints from the Ecobee smart thermostat; and (3) integrated energy meter data on electricity consumption. Algorithms in the analytics engine (4) use the inputs to optimize the time required to heat or cool a home to meet a setpoint at a particular time (5). In addition to optimizing HVAC control, National Grid used the Earth Networks system as a platform for implementing a DR pilot (6).

DR

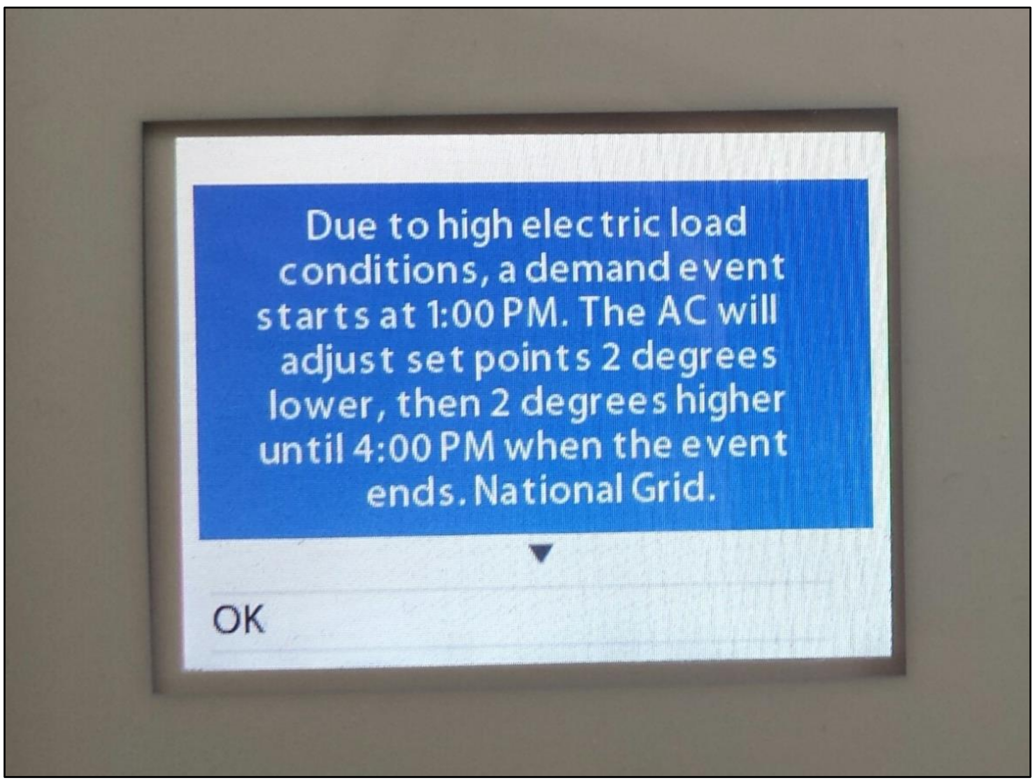
The implementer tested a variety of styles of DR events over summer 2014, running the events on days forecast as especially hot. In total, the implementer ran three unique types of DR events across four days. Table 1 summarizes the date, duration, type, and description of each event.

Table 1. Summary of DR Events

Date of Event	Duration	Event Type	Event Description
7/9/2014	1:00–3:00 pm	No pre-cooling	Raise all participants' setpoints by 2 °F.
8/26/2014	1:00–4:00 pm	Standard pre-cooling	Reduce all participants' setpoints by 2 °F for the hour prior to desired load reduction (1:00–2:00 pm), then raise setpoints by 2 °F (2:00–3:00 pm).
8/27/2014	1:00–4:00 pm	Smart pre-cooling	Use thermodynamic models to reduce all participants' setpoints by 2 °F for a minimum required time prior to desired load reduction, then raise setpoints by 2 °F.
9/5/2014	1:00–4:00 pm	Smart pre-cooling	Use thermodynamic models to reduce all participants' setpoints by 2 °F for a minimum required time prior to desired load reduction, then raise setpoints by 2 °F.

National Grid sent notifications to participants about each DR event 24 hours before events took place, via messages on participants' thermostats (shown in Figure 16) and e-mails (included as Appendix A).

Figure 16. Thermostat Notification of DR Event



During each DR event, the thermostat home screen displayed a message indicating the event was in progress (shown in Figure 17). At any time, participants could opt-out of each event (shown in Figure 18).

Figure 17. DR Event in Progress

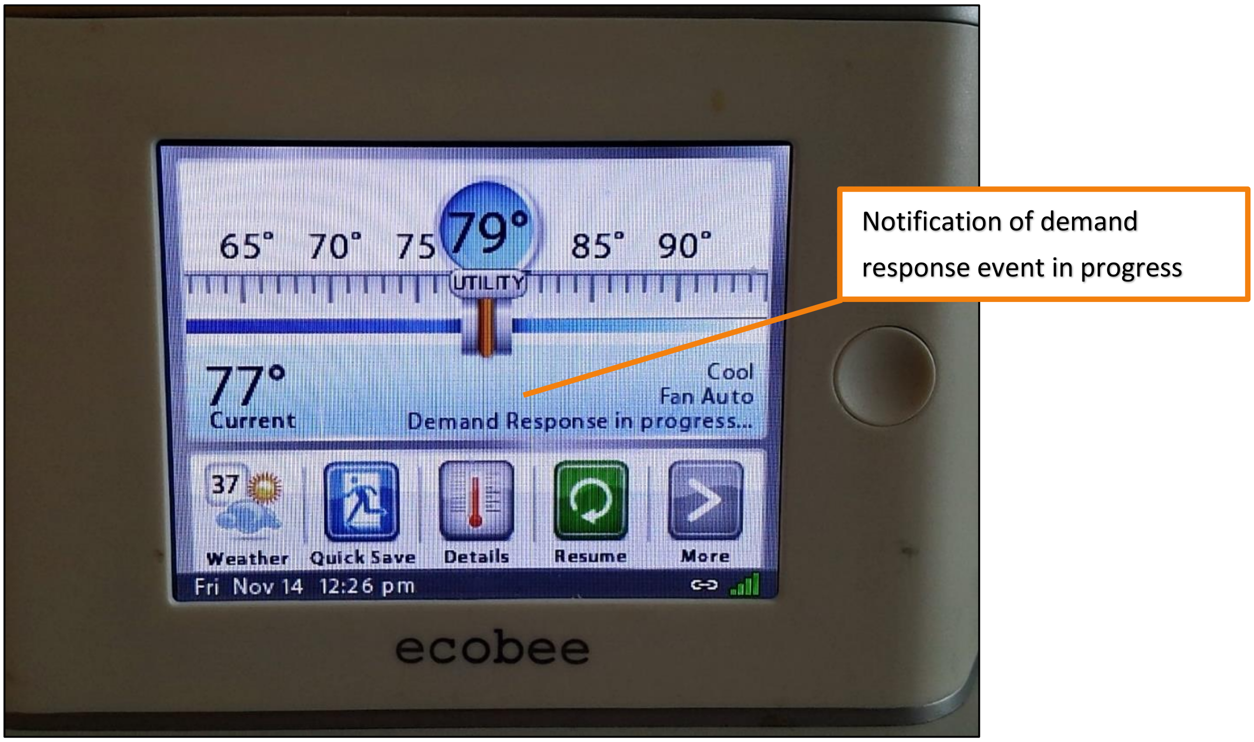
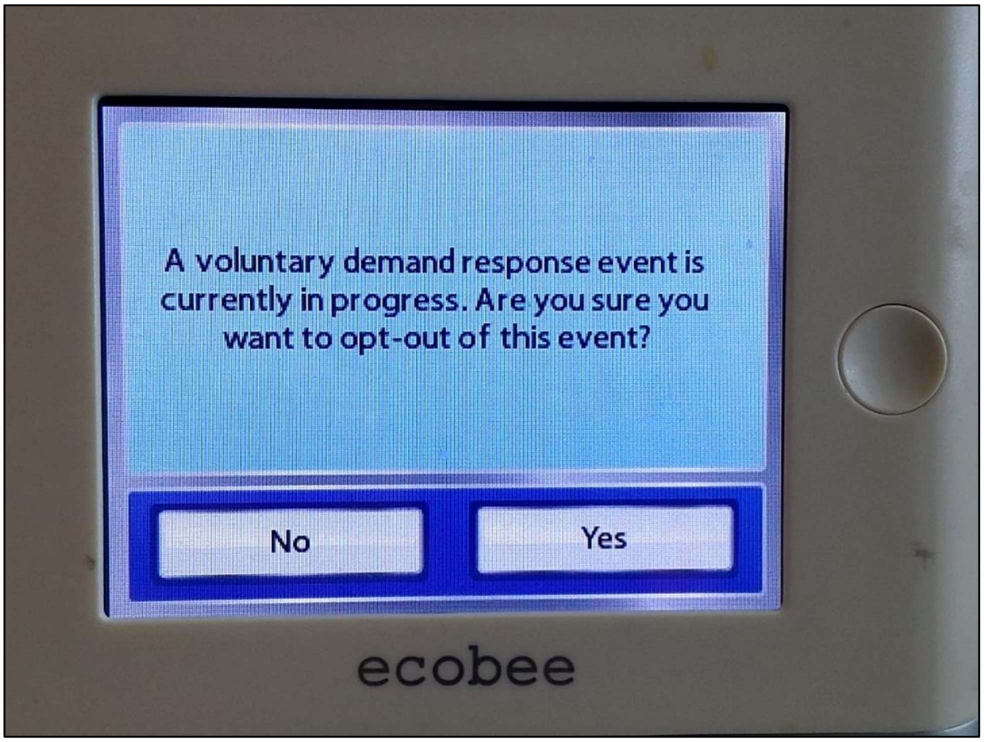


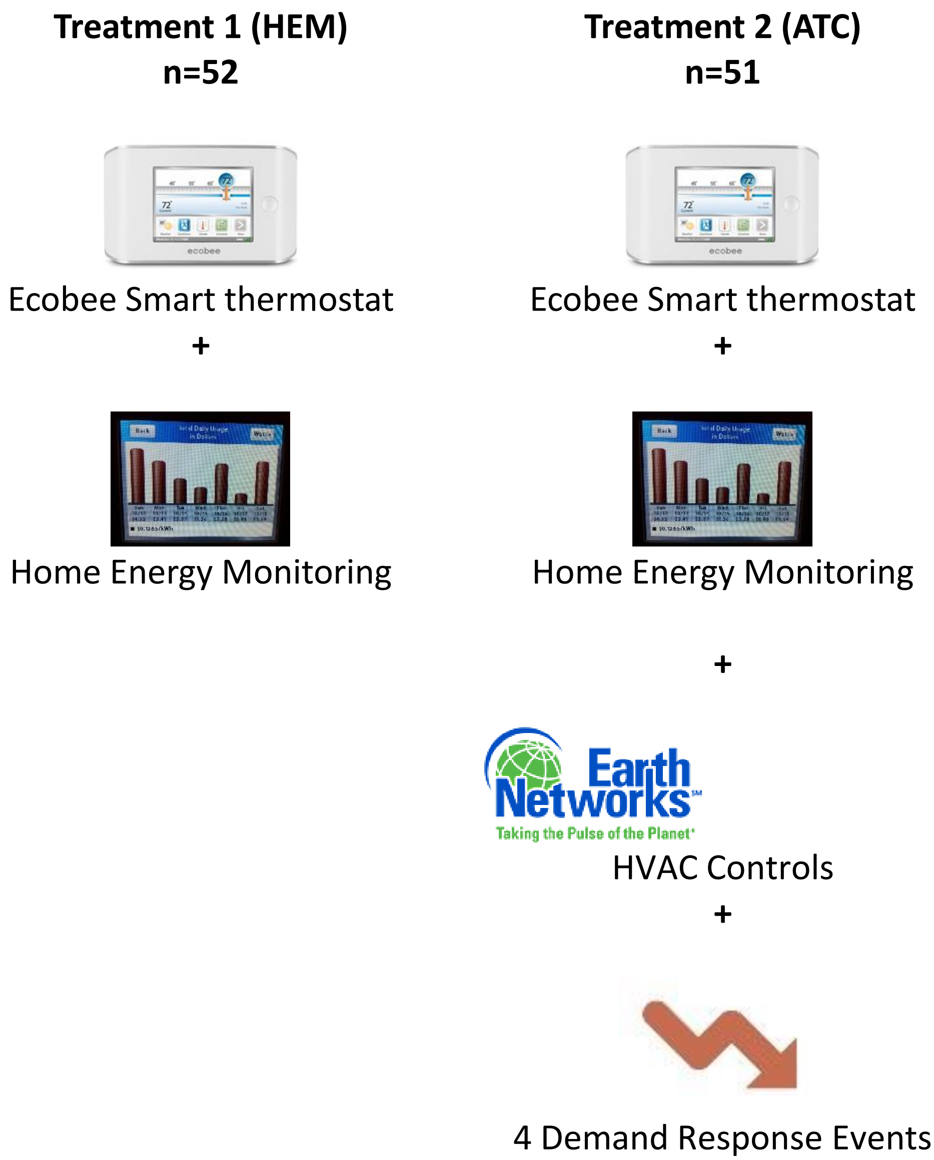
Figure 18. Opt-out Notification



Methodology

National Grid administered the pilot using two treatment groups. Both received an Ecobee Smart thermostat and home energy monitoring capabilities via integrated energy meters. In addition, one groups' thermostats connected to Earth Networks' HVAC optimization controls, and they were invited to participate in the four DR events. Figure 19 shows treatments for each group. The study refers to Treatment Group 1 as the Home Energy Monitoring (HEM) group, and Treatment Group 2 as the ATC group.

Figure 19. Pilot Design



To achieve project objectives, Cadmus completed the following tasks:

1. Collect and analyze smart thermostat and integrated energy meter data.
2. Conduct national gas billing analysis.
3. Conduct electric billing analysis.
4. Verify reported impacts from DR events.
5. Design, conduct, and analyze participant surveys.

Descriptions of these tasks follow.

Task 1. Collect and Analyze Thermostat Meter Data

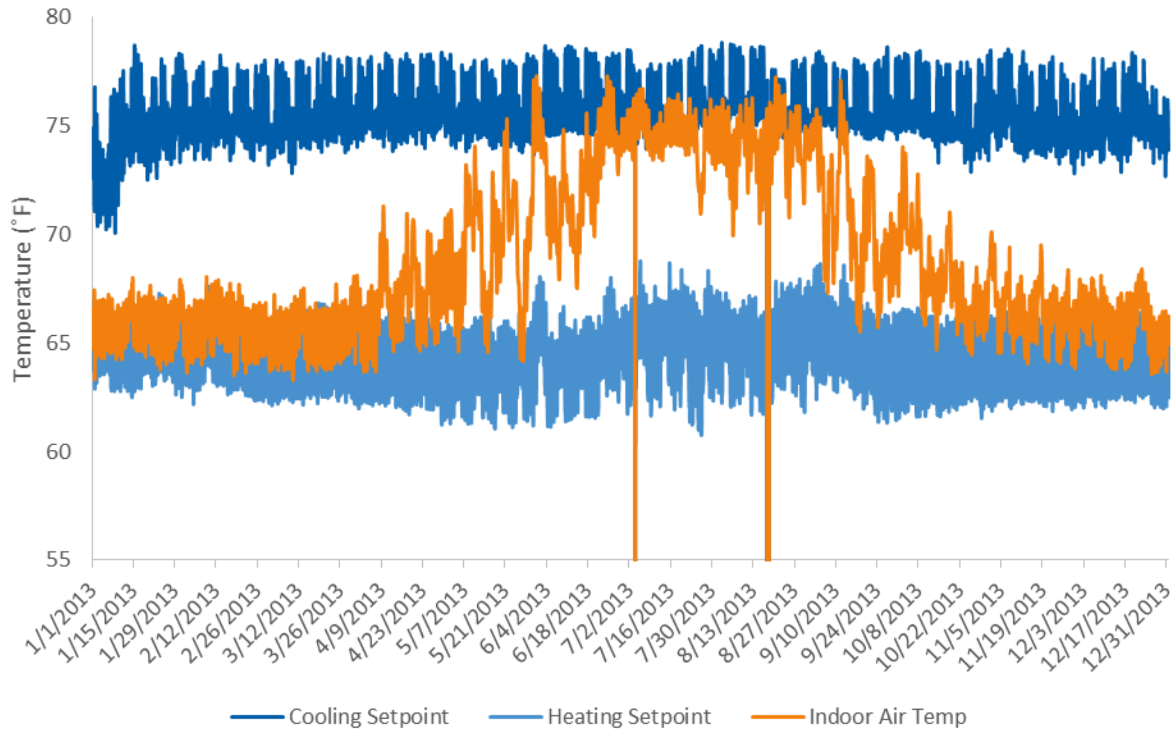
Cadmus used a combination of integrated energy meter and smart thermostat data to understand how participants set their thermostats and to compare participants with HVAC optimization controls and DR event participation (ATC group) and without (HEM group).

Defining Heating and Cooling Seasons

To analyze the smart thermostat data, Cadmus first defined the heating and cooling seasons, plotting heating and cooling setpoints against the measured indoor air temperature (IAT) for the year. Cadmus determined the heating season based on when the IAT most closely aligned with heating setpoints and the cooling season based on when the IAT most closely aligned with the cooling setpoints.

As shown in Figure 20, the evaluation team determined the heating season spanned November through March and the cooling season spanned June through August. The remaining time periods, classified as shoulder months, were not analyzed due to the lower HVAC usage rate in these months.

Figure 20. Determination of Heating and Cooling Seasons (N=103)



Task 2. Conduct Natural Gas Billing Analysis

Cadmus performed a natural gas billing analysis to determine smart thermostat impacts with and without HVAC controls on gas usage. The evaluation team requested one year of pre-installation and one year of post-installation gas billing data (from March 2012 to September 2014), and evaluated gas savings attributable to the program by conducting a billing analysis, following the steps below:

1. Matched thermostat installation dates and customer information to billing data.
2. Used participant zip codes to map to the nearest weather stations.
3. Obtained daily average temperature weather data from March 2012 through September 2014 for eight National Oceanic and Atmospheric Administration (NOAA) weather stations, representing all participant zip codes.
4. Used daily temperatures to determine base 45–85 heating degree days (HDDs) and cooling degree days (CDDs) for each weather station; and mapped the typical meteorological year series (TMY3) normal HDDs and CDDs by zip code for each home.[1]
5. Matched billing data periods with the CDDs and HDDs from associated stations.

[1] Cadmus used the PRISM models to select the best base temperature for each home.

Gas Billing Analysis Model

Cadmus estimated savings from each customer using a PRInceton Scorekeeping Method (PRISM) specification, using pre- and post-installation billing data for each participant in the HEM and ATC treatment groups. These models provided weather-normalized, pre- and post-installation annual usage for each participant and nonparticipant.

Through this regression model approach, the evaluation team obtained estimates of energy savings for each group and each participant, estimating heating-only PRISM models for each participant in the pre- and post-installation periods to weather-normalize raw billing data. Each model allowed heating reference temperatures to range from 45 degrees to 85 degrees.

The evaluation used the following PRISM model specification:

$$ADC_{it} = \alpha_i + \beta_1 HDD_{it} + \varepsilon_{it}$$

Where for each customer 'i' and month 't':

ADC_{it}	=	Average daily gas consumption in the pre- or post-installation program period
α_i	=	The participant intercept representing the average daily base load
β_1	=	The model space heating slope
HDD_{it}	=	The base 45-85 average daily HDDs for the specific location
ε_{it}	=	The error term

Using this model, Cadmus computed weather-normalized annual consumption (NAC) for each heating reference temperature as follows:

$$NAC_i = \alpha_i * 365 + \beta_1 LRHDD_{it} + \varepsilon_{it}$$

Where:

NAC_i	=	The normalized annual consumption
α_i	=	An intercept representing the average daily base load for each participant
$\alpha_i * 365$	=	The annual base load consumption (non-weather sensitive)
β_1	=	The heating slope (usage per HDD from the model above)
$LRHDD_{it}$	=	Annual, long-term HDDs of a typical meteorological year (TMY3) in the 1991–2005 series from NOAA for the specific location
$\beta_1 LRHDD_{it}$	=	The weather-normalized, weather-sensitive, annual heating usage (HEATNAC)
ε_{it}	=	The error term

Cadmus screened and removed accounts yielding negative heating NACs from the analysis. From the models with correct signs on all parameters, the team chose the best model of each participant's pre- and post-installation periods, based on those with the highest R-squared value.

Task 3. Conduct Electric Billing Analysis

Cadmus evaluated electric savings from the disaggregated cooling load, using one year of pre-installation and one year of post-installation electric billing data (from March 2012 to September 2014). To weather-normalize savings, Cadmus also collected daily temperature weather data from the National Climatic Data Center for weather stations corresponding to the participants' zip codes.

As thermostats' impact on cooling energy typically constitutes a small fraction of total electric energy consumption and can be difficult to disaggregate, the evaluation team crosschecked the billing analysis results with results from a regression analysis of the daily AC runtimes versus total usage.

Electric Billing Analysis Model

Cadmus estimated savings for each customer using a PRISM specification, which utilized pre- and post-installation billing data for each participant in HEM and ATC groups. These models provided weather-normalized, pre- and post-installation, annual usage for each participant.

Through this regression model approach, the team obtained estimates of energy savings for each group and each customer. For each participant and control home, the team estimated heating-only PRISM models in pre- and post-installation periods to weather-normalize raw billing data. Each model allowed heating reference temperatures to range from 45 degrees to 85 degrees and cooling reference temperatures to range from the heating reference temperature to 85 degrees.

The evaluation used the following PRISM model specification:

$$ADC_{it} = \alpha_i + \beta_1 HDD_{it} + \beta_2 CDD_{it} + \varepsilon_{it}$$

Where for each customer 'i' and month 't':

ADC_{it} = Average daily electric consumption in the pre- or post-installation program period

α_i = The participant intercept representing the average daily base load

β_1 = The model space heating slope

HDD_{it} = The base 45–85 average daily HDDs for the specific location

β_2 = The model space cooling slope

HDD_{it} = The base 45–85 average daily CDDs for the specific location

ε_{it} = The error term

Using this model, Cadmus computed weather-NAC for each heating and cooling reference temperature as follows:

$$NAC_i = \alpha_i * 365 + \beta_1 LRHDD_{it} + \beta_2 LRCDD_{it} + \varepsilon_{it}$$

Where:

NAC_i	=	The normalized annual consumption
α_i	=	An intercept representing the average daily base load for each participant
$\alpha_i * 365$	=	The annual base load consumption (non-weather sensitive)
β_1	=	The heating slope (usage per HDD from the model above)
$LRHDD_{it}$	=	Annual, long-term HDDs of a typical meteorological year (TMY3) in the 1991–2005 series from NOAA for specific location
$\beta_1 LRHDD_{it}$	=	The weather-normalized, weather-sensitive, annual heating usage (HEATNAC)
β_2	=	The cooling slope (usage per CDD from the model above)
$LRCDD_{it}$	=	Annual, long-term CDDs of a typical meteorological year (TMY3) in the 1991–2005 series from NOAA for the specific location
$\beta_2 LRCDD_{it}$	=	The weather-normalized, weather-sensitive annual cooling usage (COOLNAC)
ε_{it}	=	The error term

Cadmus screened and removed any accounts from the analysis that yielded negative cooling NACs and negative base loads. If a model produced a negative heating slope, the team estimated a cooling-only PRISM model. From the various models with correct signs on all parameters, the team chose the best model of each participant's pre- and post-installation periods based, on the model with the highest R-squared value.

Task 4. Verify Reported Impacts from DR Events

Before analyzing the AMI data, Cadmus performed extensive data quality checks and data cleaning. During this process, the team identified widespread errors in the data, including sites with over 5% zero kWh readings and sites with hourly readings over 100 kWh. Extensive hourly zero kWh datapoints could result from unoccupied houses or missing data, and extremely large datapoints (over 38 kWh per hour) could result from measurement error. To address these problems, the team flagged customers with zero readings at least 5% of the time, and customers with kWh readings greater than 38 kWh 5% of the time. Finally, Cadmus included only meters marked by Earth Networks as containing valid data, removing all these observations from the dataset used for analysis.

Cadmus estimated demand savings using a panel regression of hourly kWh for dates from June 15, 2014, to September 15, 2014. The model controlled for day of the week (weekend vs. weekday), the hour of day, weather (cooling degree hours), and event hours. Standard errors were clustered on homes to account for energy consumption correlations over time.

The evaluation team also ran the same model with AC runtimes as the dependent variable. Sufficient model data (e.g., EER, age, tonnage) were unavailable for all units in the DR sample; so the team could not convert AC runtimes to kW. Runtime analysis results served as comparison to results obtained from the kWh regression.

Task 5. Design, Conduct, and Analyze Participant Surveys

Cadmus designed surveys for both HEM and ATC participant groups to collect household demographics and to assess participants' use of thermostats and integrated energy meter information.

The survey primarily sought to increase an understanding of program participants' motivations, previous thermostat usage and behaviors, behaviors during the program (including features participants found valuable), and overall comfort during the pilot (including behavior shifting). The survey included satisfaction and willingness-to-pay questions. DR group participants were asked further questions about comfort and about opt-out or temperature-changing behaviors. Survey results also informed the billing analysis.

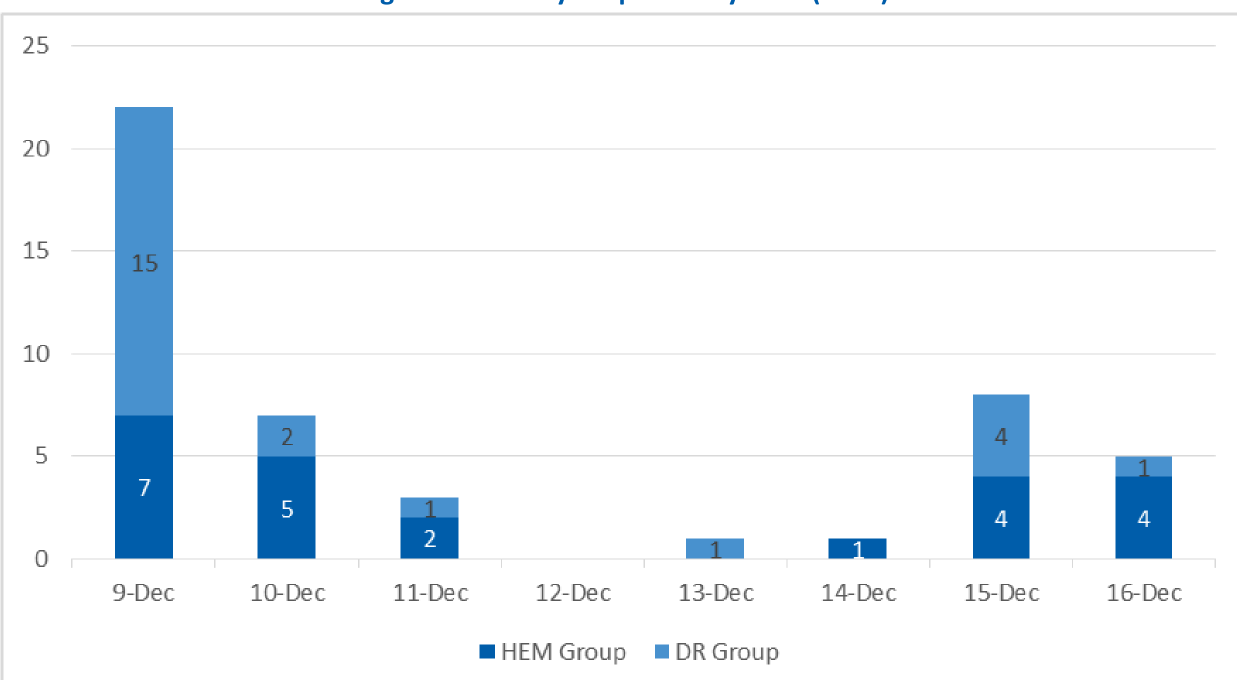
Cadmus fielded a web-based survey to pilot program participants from December 9–16, 2014, for all 103 program participants. Participants received an e-mail invitation to the survey, which included a link. Upon completion, participants could include contact information to enroll in two $100 gift card drawings.

Surveys achieved excellent response rates, for a total of 47 completes (i.e., 46% response rate). Program groups produced the following response rates:

- 24 of 51 DR Group (47%)
- 23 of 52 HEM Group (44%)

Figure 21 shows survey response rates over time.

Figure 21. Survey Responses by Date (n=47)



Results

This section presents results for each of the five project tasks.

Task 1. Analysis of Thermostat Data

For the heating and cooling seasons, Cadmus assessed setpoints, IAT, and HVAC runtimes by hour and by day of week.

Heating Season Setpoints

Setpoint data represent temperatures that participants chose for their homes. Figure 22 and Figure 23 show average hourly weekday and weekend heating setpoints programmed by participants.

Figure 22. Weekday Heating Setpoints, by Hour (n_{ATC}=51, n_{HEM}=52)

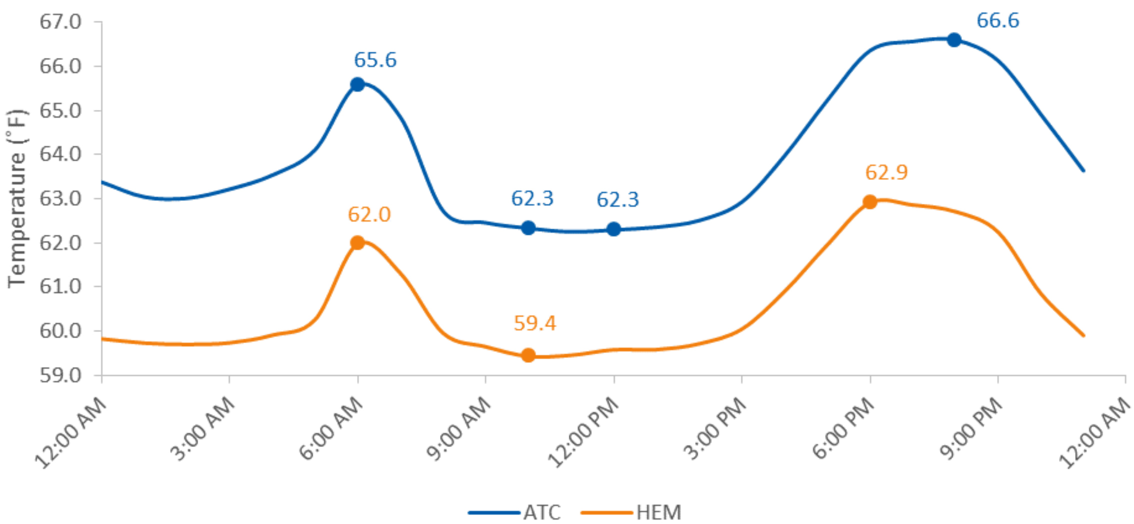


Figure 23. Weekend Heating Setpoints, by Hour (n_{ATC}=51, n_{HEM}=52)

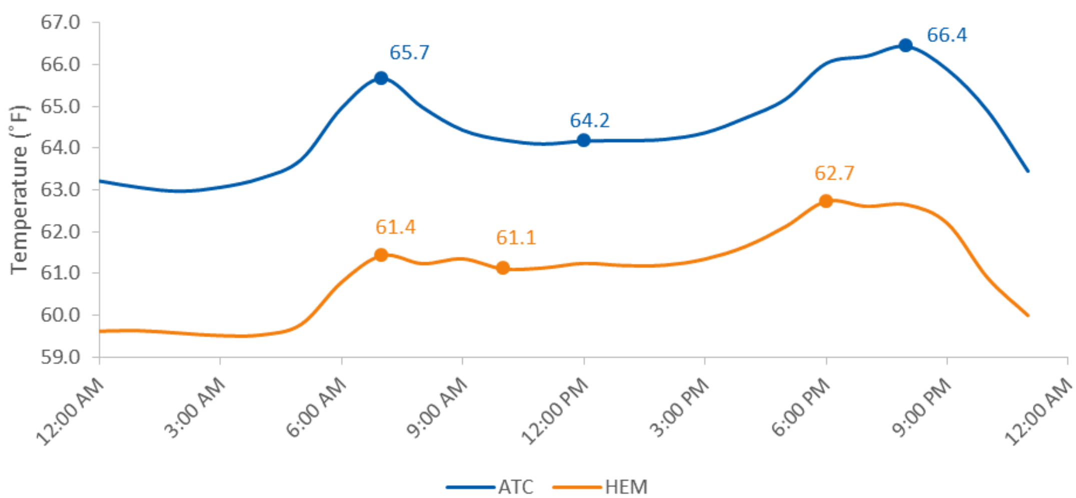


Figure 22 shows a very similar schedule of setbacks between the two groups. Generally, a peak occurred at approximately 6:00 a.m. on weekdays and 7:00 a.m. on weekends, followed by a setback in the middle of the day. The setpoint increased in the evening, peaking between 6:00 p.m. and 9:00 p.m., followed by another setback at night, lasting until the early morning. These patterns are consistent with energy-efficient usage, whereby tenants turn down their heating systems when not at home or when sleeping.

A key difference emerged between the groups: the HEM group used lower setpoints than the ATC group, averaging three to four degrees lower than the ATC group. The ATC group also exhibited a deeper daytime setback compared to the HEM group, with an average setback of 3.3 on weekdays (the setpoint dropping from 65.6 degrees to 62.3 degrees) and 1.5 degrees on weekends. The HEM group used a daytime setback of 2.6 degrees on weekdays and 0.3 degrees on the weekends.

Heating Season Indoor Air Temperatures

In addition to thermostat setpoint data, Cadmus assessed actual IAT data. The evaluation team used these data to develop trends showing average air temperatures for each hour of the day during weekdays and weekends. Figure 24 shows weekday trends (including hourly IAT during the week for ATC and HEM groups), and Figure 25 shows weekend trends for the heating season.

Figure 24. Weekday IAT, by Hour (n_{ATC}=51, n_{HEM}=52)

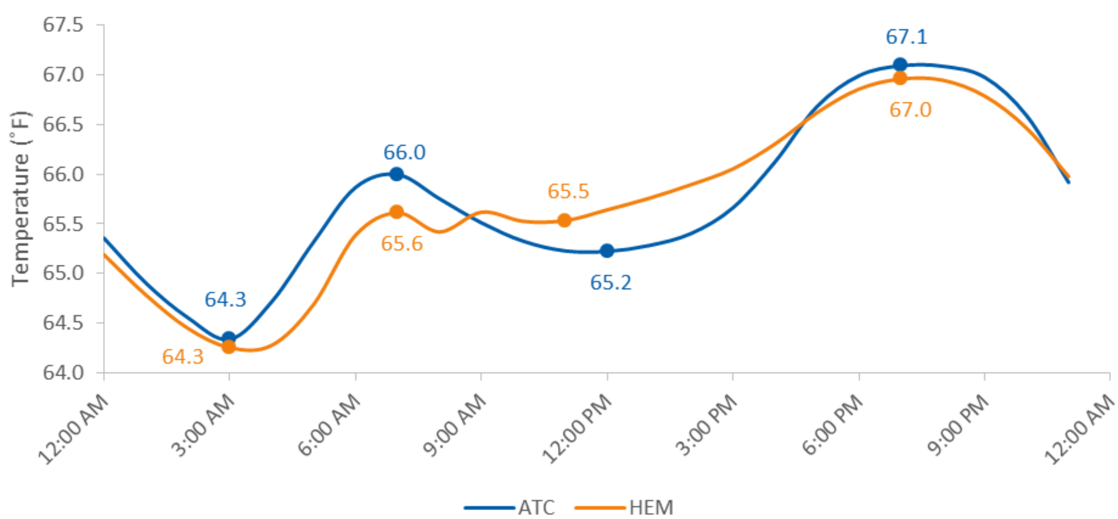


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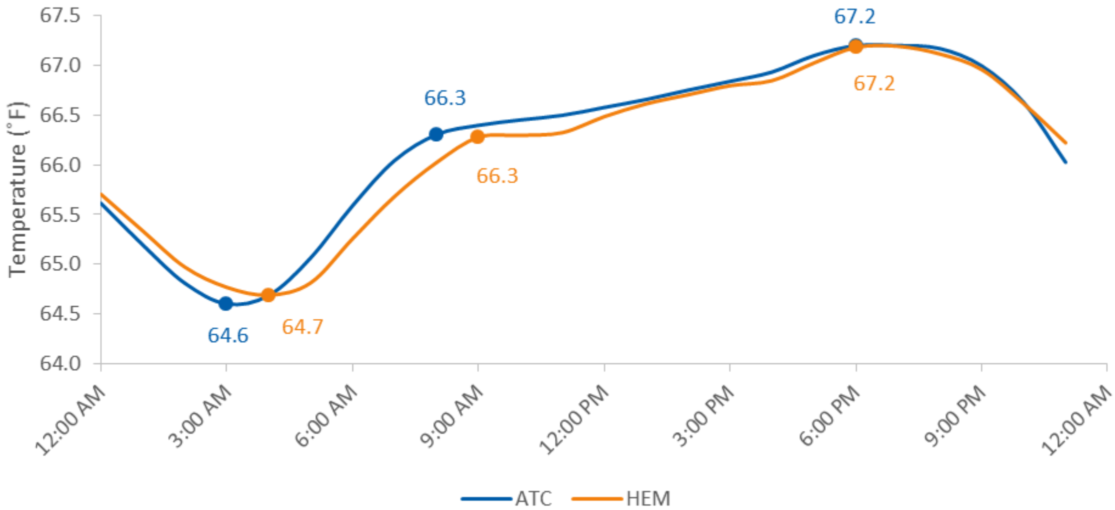
Figure 25. Weekend Indoor Air Temperature, by Hour (n_{ATC}=51, n_{HEM}=52)



The two groups exhibited similar profiles: a peak in the morning; a second peak in the evening; and a deep valley at night. The two groups show a large difference, however, in the middle of the day (roughly from 9:00 a.m. to 3:00 p.m.). During this period, average indoor temperatures in the ATC group dropped from 66 degrees during the morning peak to 65.2 degrees around midday. The HEM group exhibited a short dip immediately following the morning peak, before temperatures increased gradually throughout the day, eventually hitting the evening peak. The evaluation team found it notable that, despite a significantly lower weekday setpoint (62.0 degrees vs. 65.6 degrees), the HEM group had nearly the same IAT as the ATC group during the morning peak.

Cadmus believes the difference in IAT load shapes largely resulted from the magnitude of the setback programmed by each group. The ATC group programmed a setback of 3.3 degrees, with a resulting IAT drop of 0.8 degrees. The HEM group used a setback of 2.6 degrees, with a resulting IAT drop of 0.1 degrees. Both groups showed a 2.5-degree difference between the degree of the setback and the actual drop in IAT. Assuming the homes in the two groups otherwise share the same qualities, this finding makes intuitive sense: heat transfer rates from the interior of a home to the outdoors would be nearly the same as temperature differentials were very nearly the same.

Figure 25 shows hourly IAT during weekends for both participant groups, with load shapes essentially identical. The weekend profiles do exhibit a striking detail: the IAT did not drop during the middle of the day, as on weekdays. This largely results from the lower setback degree occurring during weekends. This lower setback degree, coupled with a higher occupancy rate, resulted in an IAT that actually increased throughout the day. Data from both participant groups indicated a very linear increase in IAT from the morning peak to the evening peak. This likely resulted from increased activity within the home, a lower setback degree, and solar heat gains throughout the day.

Heating Season Setpoint and Indoor Temperature Comparisons

Cadmus compared participants' average heating season setpoints to actual IAT for each hour of the day to assess how effectively the HVAC controls met setpoints. In interpreting these results, readers should note: it is normal for space temperatures to vary up to three degrees above and below thermostat setpoints (termed the temperature differential); and a variety of factors impact how well a thermostat regulates space temperatures, including home insulation types, level of solar heat gains, and HVAC system types.

Figure 26. HEM Average Heating Season Setpoints and IAT, by Hour (n_{HEM}=52)

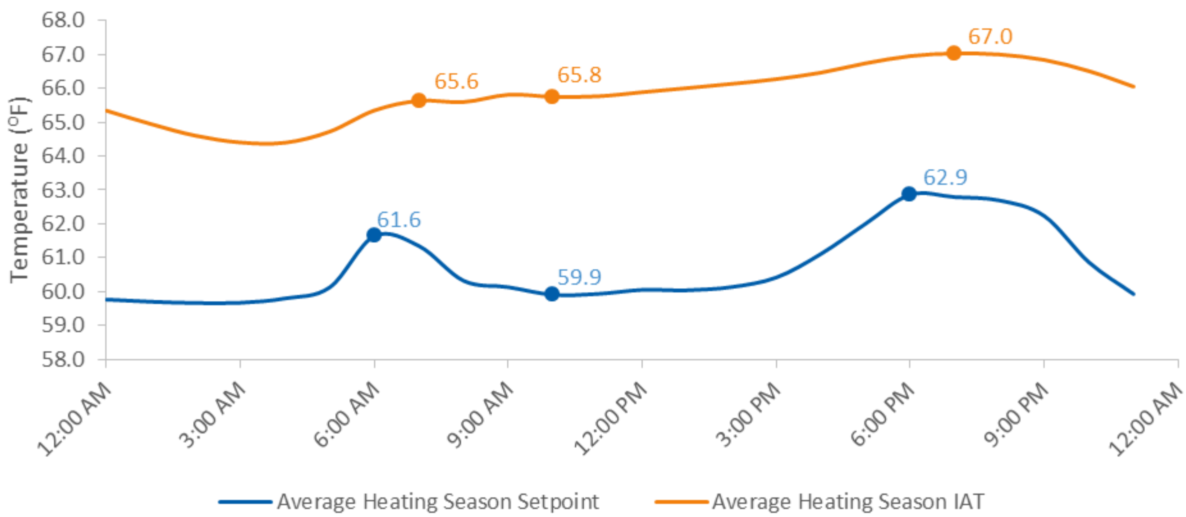
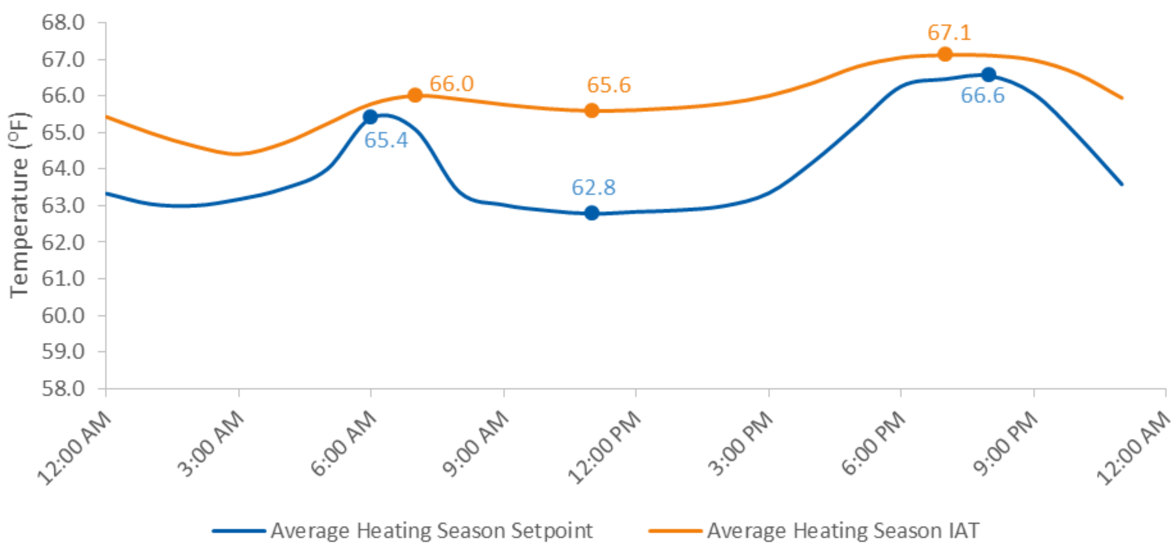


Figure 27. ATC Average Heating Season Setpoints and IAT, by Hour (n_{ATC}=51)



In the heating season, the IAT in the ATC group more closely matched setpoints than in the HEM group, where the IAT averaged 1.8 degrees warmer than setpoints, compared to 5.1 degrees warmer in the HEM group.

For both groups, the IAT came the closest to matching setpoints during non-setback periods. Cadmus expected this result as, during setbacks, it takes time for homes to lose heat and temperatures to drift down to setpoints. In the HEM group, the IAT came within 3.7 degrees of the setpoint at 6:00 a.m. and 4.1 degrees of the setpoint at 6:00 p.m. In the ATC group, the IAT came within 0.4 degrees of the setpoint at 6:00 a.m. and 0.6 degrees at 8:00 p.m. Although many factors can impact how well a thermostat regulates temperature, sample results indicated heating systems with HVAC optimization controls (the ATC group) performed better at meeting setpoints than heating systems without HVAC optimization controls.

Heating Season HVAC Runtimes

Cadmus assessed HVAC system runtimes by overlaying average hourly runtimes with the average hourly IAT and setpoint data, as shown in Figure 28 and Figure 29.

Figure 28. HEM Heating Season HVAC Runtime, Setpoints, and IAT, by Hour (n_{HEM}=52)

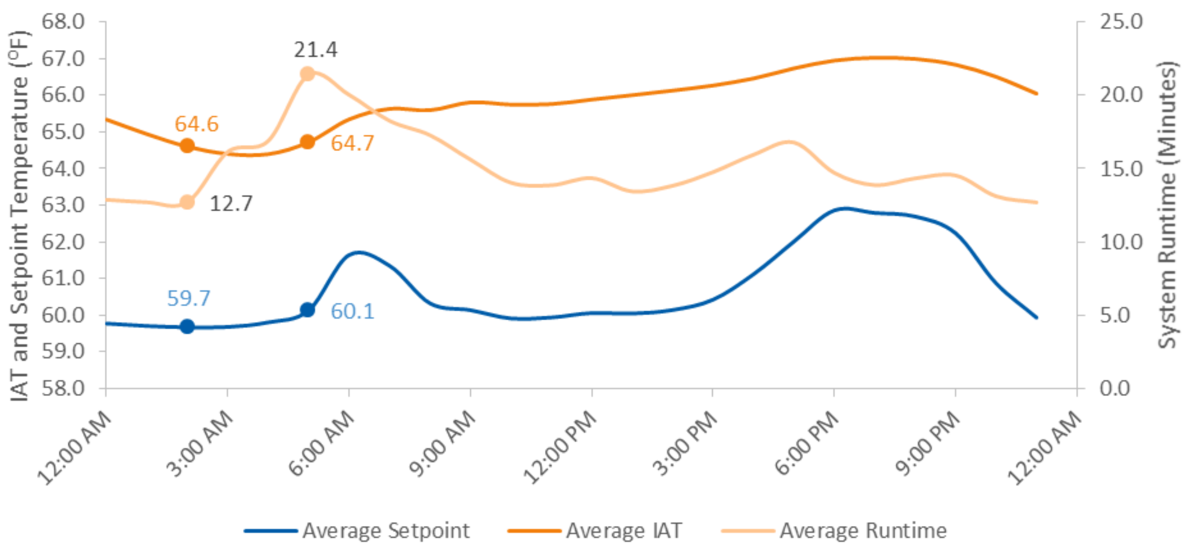
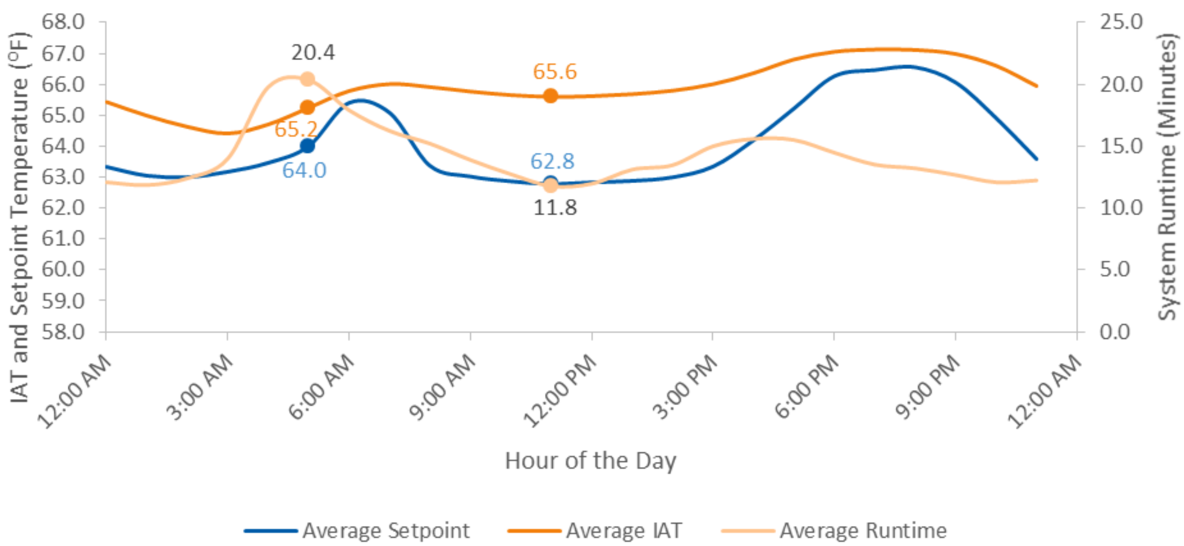


Figure 29. ATC Heating Season HVAC Runtime, Setpoints, and IAT, but Hour (n_{ATC}=51)



In both groups, average hourly heating system runtimes peaked at 5:00 a.m., when systems sought to meet increased setpoints at 6:00 a.m. HEM group runtimes last one minute longer than those of the ATC group (e.g., 21.4 minutes compared to 20.4 minutes). For the rest of the day, average hourly runtimes remained around 13–14 minutes per hour for the HEM group and 12–13 minutes per hour for the ATC group. Both had slight increases in runtimes from approximately 4:00 p.m. to 5:00 p.m., when runtimes increases to 16–17 minutes per hour for HEM and 15–16 minutes per hour for HEM.

Cooling Season Setpoints

Setpoints represent temperatures that participants chose for their homes. Figure 30 and Figure 31 show weekday and weekend cooling setpoints programmed by the participants, by hour.

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Figure 30 Weekday Cooling Setpoints, by Hour (n_{ATC}=51, n_{HEM}=52)

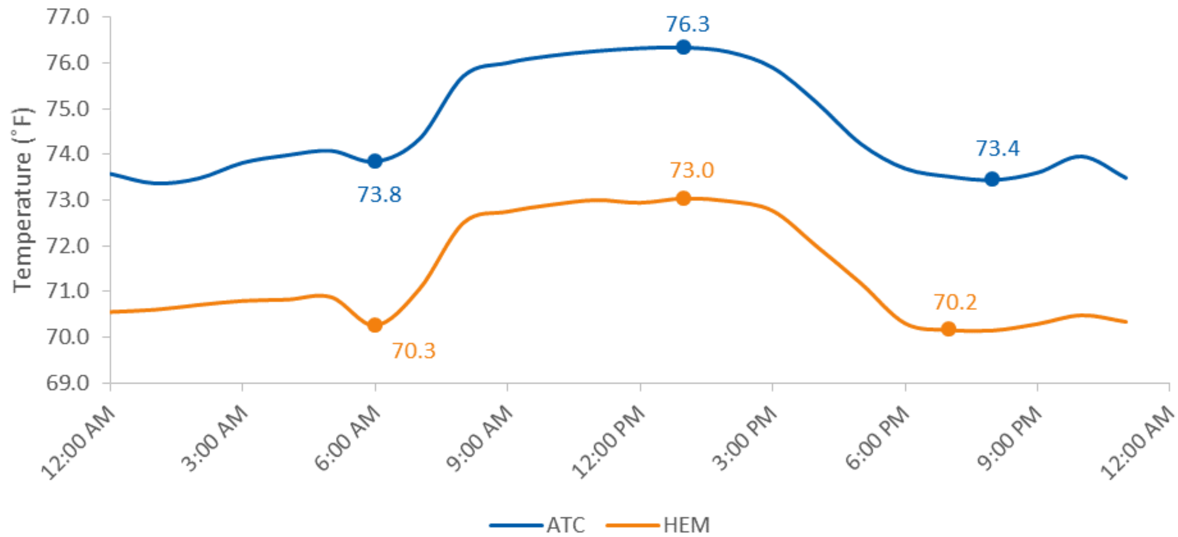


Figure 31. Weekend Cooling Setpoints, by Hour (n_{ATC}=51, n_{HEM}=52)

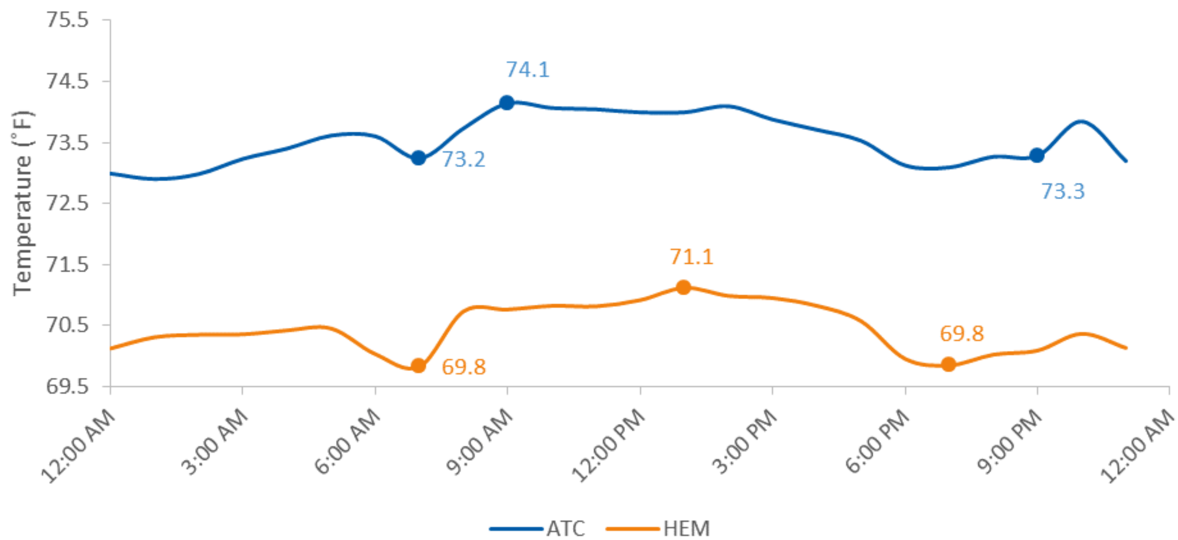


Figure 30 shows weekday setpoint schedules very similar between the groups. Generally, a valley occurred between 6:00 a.m. and 7:00 a.m. in the morning, followed by a long peak in midday. Setpoints dropped again in evenings, bottoming out between 6:00 p.m. and 9:00 p.m. Temperature remained fairly constant until the morning. This produced patterns consistent with energy-efficient cooling season usage, whereby tenants turn up temperatures while not at home.

During the week, the two groups primarily differed in temperature setpoints for various peaks and valleys throughout the day. The ATC group turned their ACs down to approximately 73.8 degrees at night, turned them up to 76.3 degrees while away during the day, and then lowered temperatures to approximately 73.4 degrees when returning home in the evening. As in the heating season, the HEM group and the ATC group followed the same general pattern: both exhibited a valley in the early morning, peaked during the day, dipped in the evening, and remained fairly constant throughout the night. The HEM group, however, used lower setpoints, typically between 3 and 6 degrees lower than the ATC group. Assuming all else remained equal, the HEM groups' lower setpoints suggested they would consume more energy than the ATC group.

Similar to Figure 30, Figure 31 shows setpoint schedule load shapes similar between the groups on weekends. The load shape followed the same peak-valley pattern seen during the week, but the magnitude of the shift between peaks and valleys was much smaller. For instance, the ATC group had a weekday setback of 2.5 degrees (from 73.8 degrees to 76.3 degrees), but this setback more than halved on the weekends, to 0.9 degrees—a finding consistent with the HEM group, which exhibited setbacks of 2.7 degrees during the week, but only 1.3 degrees on the weekend.

The smaller setback largely can be explained by participants' presence within their homes during the day on weekends. As participants would be home more often on weekends, they preferred to keep household temperatures at comfortable levels at that time. A small setback occurred on the weekends, but was not as extreme as during the week. Following the slight setback during the day, a valley again occurred in the evenings, likely due to increased occupancy during that time.

Cooling Season Indoor Temperatures

In addition to thermostat setpoint data, Cadmus looked at IAT data recorded by the thermostat. The evaluation team used these data to develop trends showing average air temperatures for each hour of the day during weekdays and weekends. Figure 32 shows weekday trends and Figure 33 shows weekend trends during the cooling season.

Figure 32. Weekday IAT, by Hour (n_{ATC}=51, n_{HEM}=52)

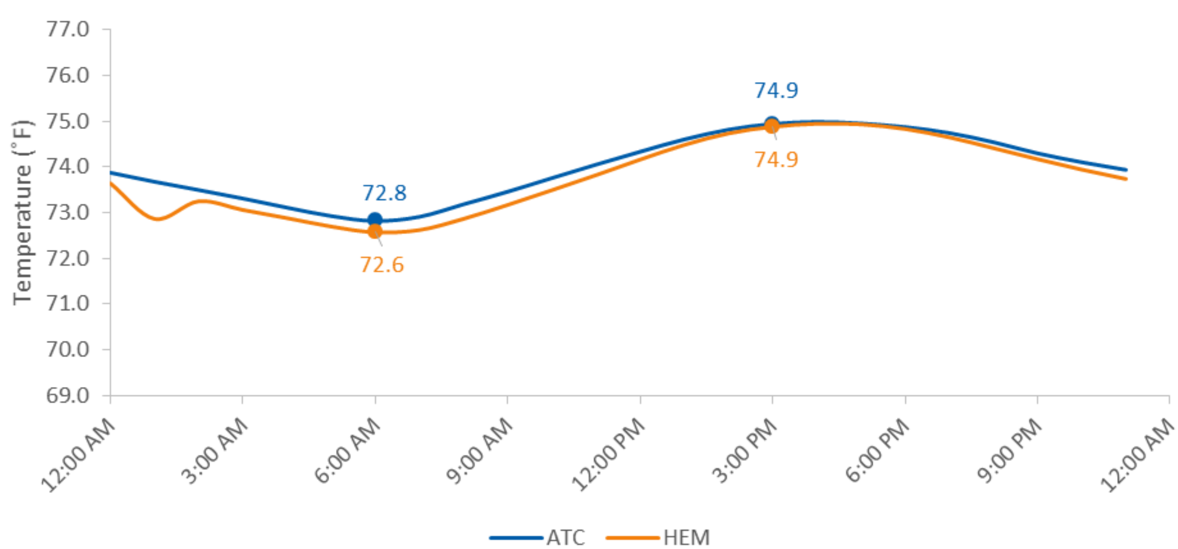


Figure 33. Weekend IAT, by Hour (n_{ATC}=51, n_{HEM}=52)

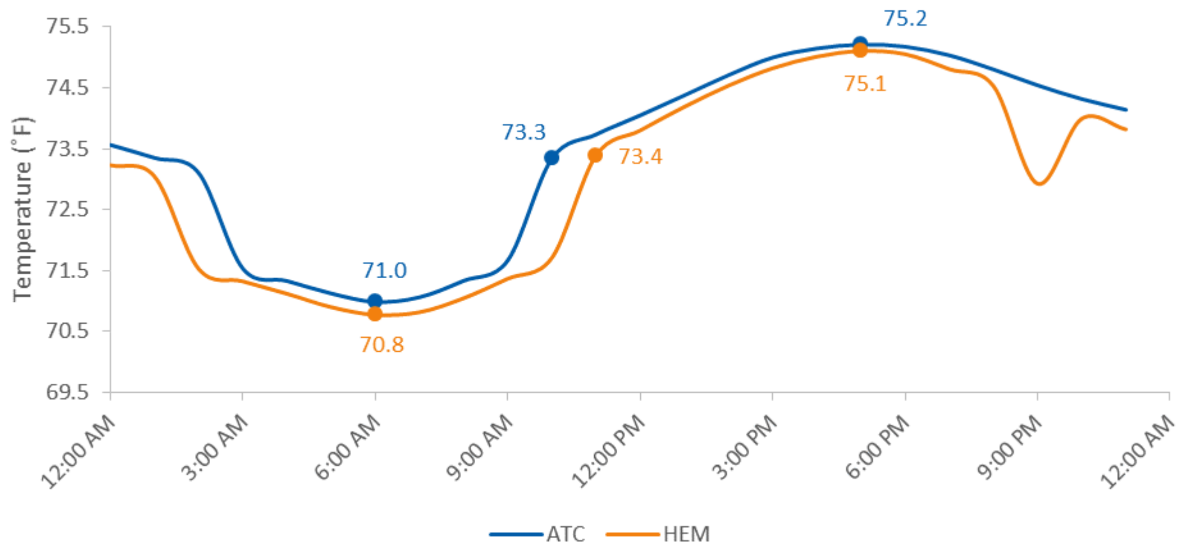


Figure 32 shows the hourly IAT during the week for both groups; both groups exhibit a similar, nearly sinusoidal general shape, with lowest temperatures in the morning and highest temperatures in the midafternoon.

Cadmus noted that, despite a significantly lower setpoint (70.3 degrees vs. 73.8 degrees), the HEM group had nearly the same IAT as the ATC group throughout the entire day—a finding consistent with trends seen in the heating season, where a discrepancy also occurred between the HEM group's IAT and the hourly setpoints.

Figure 33 shows hourly IAT during the weekend for both participant groups, resulting in similar profiles similar, with the curves following a rough sinusoidal waveform, with a dip in the early morning and a peak in the evening. The two primarily differed in that the HEM curve experienced an uncharacteristic dip around 9:00 p.m.

Most striking, Figure 33 shows the ATC group's IAT dropped to nearly the same level as the HEM group's IAT overnight, despite having a significantly higher setpoint. This indicates the heating load for ATC group's homes decreased at night. Intuitively, this makes sense as there would not be thermal gain from the sun, and the building's occupants sleep; so the internal heat gain would significantly decrease. This also may indicate the point at which buildings no longer store thermal energy absorbed during the day.

Cooling Season Setpoints and Indoor Temperature Comparisons

Cadmus compared participants' average cooling season setpoints to actual the IAT for each hour of the day to assess how effectively HVAC controls met setpoints. When interpreting these results, readers should note that space temperatures normally vary up to three degrees above and below the thermostat setpoint (i.e., the temperature differential), and a variety of factors impact how well a thermostat regulates space temperatures, including home insulation types, levels of solar heat gain, and HVAC system types.

Figure 34. HEM Average Cooling Season Setpoints and IAT, by Hour (n_{HEM}=52)

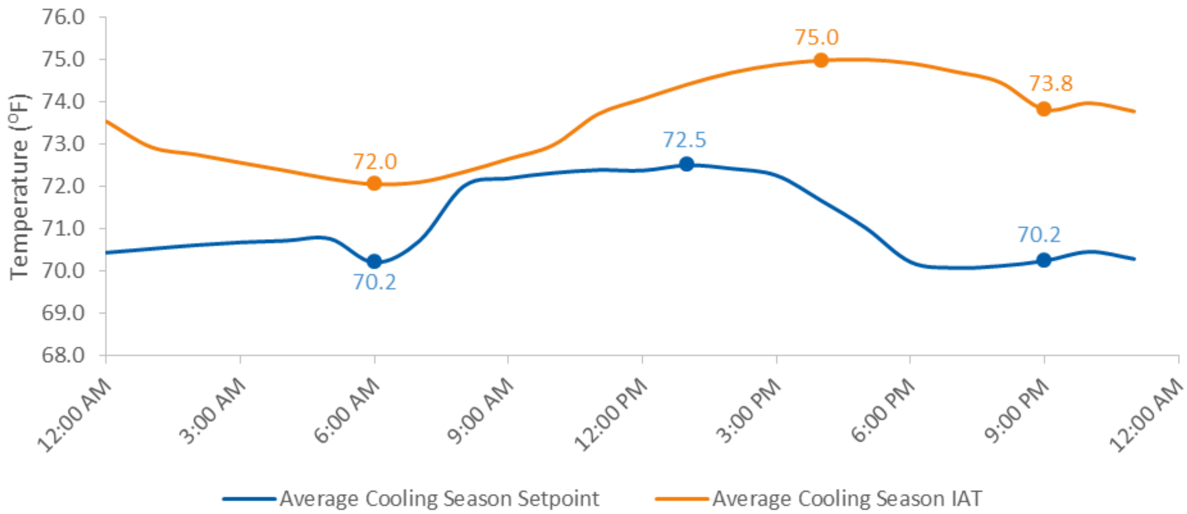
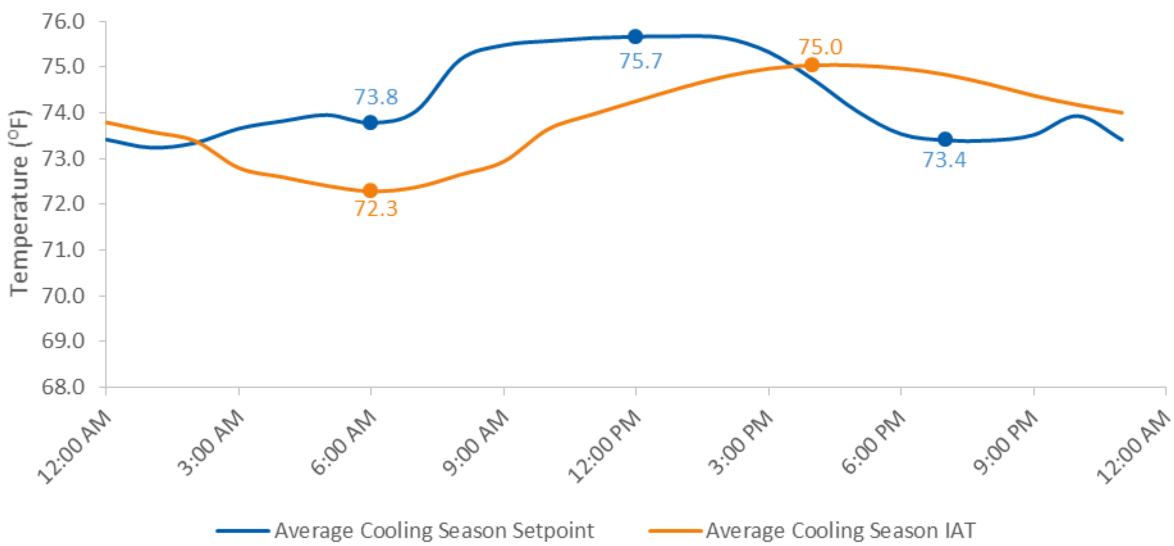


Figure 35. ATC Average Cooling Season Setpoints and IAT, by Hour (n_{ATC}=51)



In the cooling season, the ATC group IAT more closely matched setpoints than did the HEM group: the latter group exhibited an IAT on average 2.4 degrees warmer than the setpoint, compared to 0.5 degrees cooler in the ATC group. For both groups, cooling systems had the most difficulty in meeting setpoints at 6:00 p.m., when cooling setpoints had recently dropped and impacts from solar heat gained throughout the day continued to taper off. At this time, the IAT for the HEM group was 4.7 degrees warmer than its setpoint and 1.4 degrees warmer than the setpoint in the ATC group.

Unlike in the HEM group, the ATC group exhibited IATs below the setpoint for some parts of the day. From 3:00 a.m. to 3:00 p.m., the group's IAT was cooler than the setpoint by as much as 2.5 degrees. This can be explained by outdoor air temperature (OAT) conditions. Figure 36 and Figure 37 show average hourly setpoints and IATs, overlaid with average hourly OATs.

Figure 36. HEM Average Cooling Season Setpoints, IAT, OAT by Hour (n_{HEM}=52)

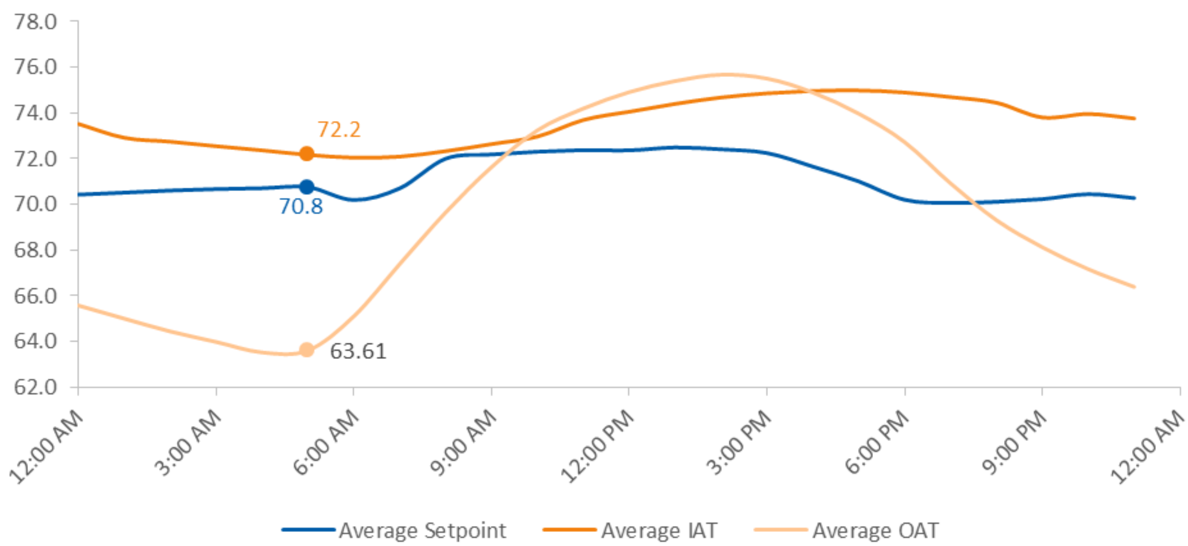
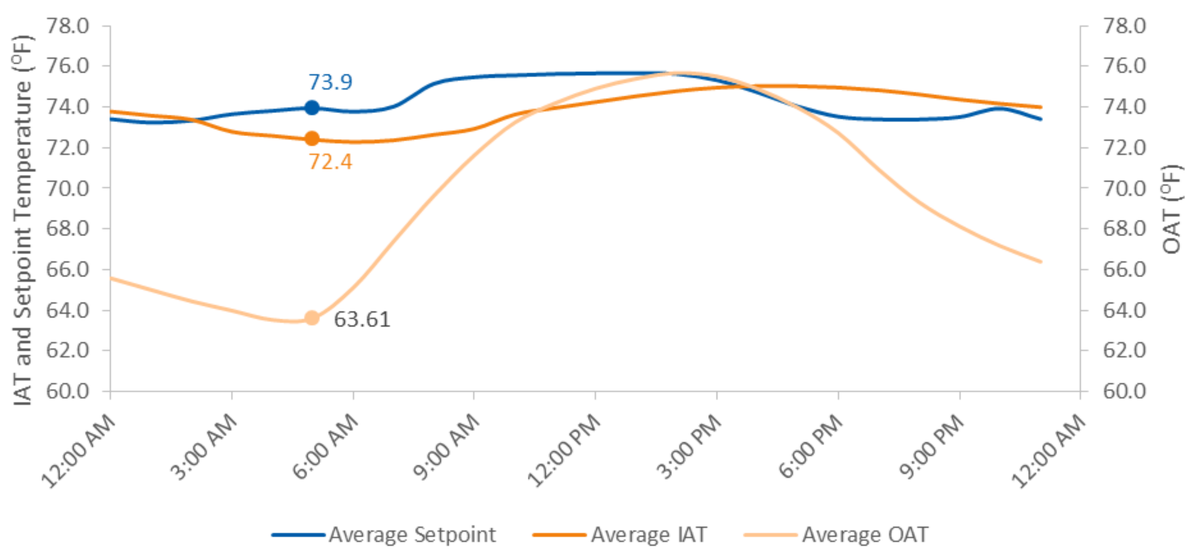


Figure 37. ATC Average Cooling Season Setpoints, IAT, OAT by Hour (n_{ATC}=51)



As OAT dropped at night, so did IAT: for the study sample, the average OAT fell to a low of 63.61 degrees at 5:00 a.m. For both groups, home temperatures dropped to approximately 72 degrees by 5:00 a.m. This IAT still remained higher than the setpoint for the HEM group, but was lower than the setpoint for the ATC group (which generally used higher setpoints in the cooling season). As this occurred during the cooling season, the heating system did not turn on to raise the IAT to the setpoint. Rather, rising OAT and solar heat gains increased the ATC group's IAT until it met the setpoint at 3:00 p.m., at which time the cooling system helped maintain the setpoint.

If solely considering hours when the cooling system was needed (4:00 p.m. to 2:00 a.m.), the ATC group's IAT averaged 0.7 degrees warmer than the setpoint (compared to 2.4 degrees for the HEM group). Although many factors can affect how well a thermostat regulates temperatures, sample results indicated cooling systems with HVAC optimization controls (i.e., the ATC group) performed better at meeting setpoints than cooling systems without HVAC optimization controls.

Cooling Season HVAC Runtimes

Cadmus assessed HVAC system runtimes by overlaying average hourly runtimes with average hourly IAT and setpoint data, as shown in Figure 38 and Figure 39.

Figure 38. HEM Cooling Season HVAC Runtime, Setpoints, IAT, by Hour (n_{HEM}=52)

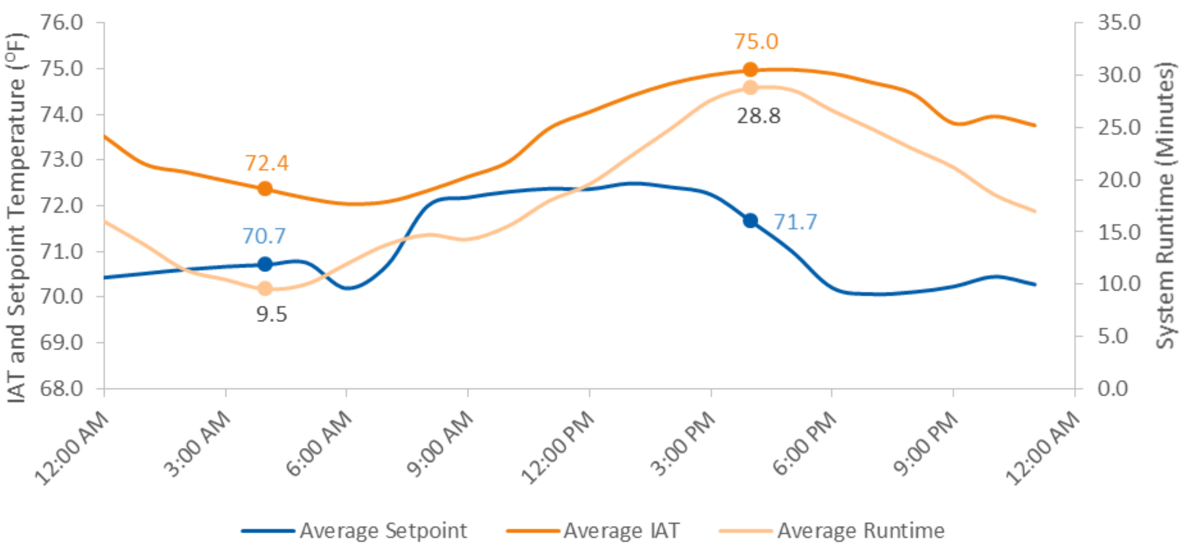
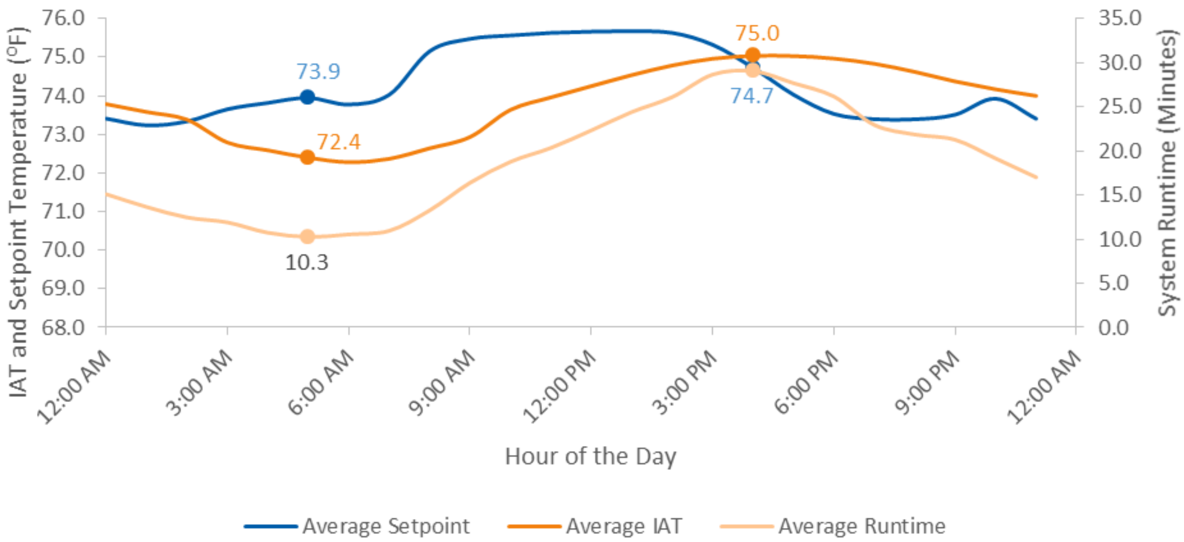


Figure 39. ATC Cooling Season HVAC Runtime, Setpoints, IAT, by Hour (n_{ATC}=51)



For both groups, daily runtimes had a pattern similar to the IAT profile—lower at night and higher during the day. This likely resulted from IAT increases due to increasing OAT and solar heat gain during the day, when cooling systems must run longer to maintain the setpoints. Alternatively, at night, when OAT drops and no solar heat gain occurs, IAT drops, and cooling systems need not work as hard.

Both groups experienced average hourly cooling system runtime peaks at 4:00 p.m., when setpoints decreased but impacts remained from solar heat gain. At this hour, both groups had average runtimes of approximately 29 minutes. Both groups experienced the lowest runtimes in the early morning (4:00 a.m. for HEM and 5:00 a.m. for ATC), when the average hourly runtime dropped to 9.5 minutes for HEM and 10.3 minutes for ATC.

Task 2. Natural Gas Billing Analysis

Cadmus received gas billing data for 52 of the 54 participants with National Grid gas accounts. Table 2 shows gas savings as a percentage of total gas usage, and Table 3 shows gas savings as a percentage of disaggregated heating gas usage for participants with available data. The evaluation team provided results for four sets of comparison groups:

- Manual vs. programmable baseline
- One thermostat vs. multiple thermostats
- ATC group vs. HEM group
- ATC participants with one thermostat vs. HEM participants with one thermostat

Table 2. Gas Savings as Percentage of Total Gas Usage

Group	Sample Size	Savings Per Customer (therms)	Average Number of Thermostats	Pre Usage (therms)	Savings Per Thermostat (therms)	% Savings Per Thermostat	Lower 90% Savings	Upper 90% Savings	Precision at 90% Confidence	Sqft	Thermostat Savings Per Sqft
Manual Baseline	9	100	2.22	1164	45	3.9%	25	65	44%	2,345	0.0192
Programmable Baseline	26	76	1.38	989	55	5.5%	40	70	28%	2,016	0.0272
1 Thermostat	19	95	1.00	1028	95	9.2%	69	121	27%	2,021	0.0470
Multiple Thermostats	16	67	2.31	1042	29	2.8%	17	41	42%	2,194	0.0132
ATC	19	81	1.58	950	51	5.4%	39	63	24%	2,035	0.0252
HEM	16	84	1.63	1134	52	4.5%	30	74	42%	2,178	0.0237
ATC 1 Thermostat	10	95	1.00	1050	95	9.1%	71	120	26%	1,984	0.0480
HEM 1 Thermostat	9	95	1.00	1003	95	9.5%	46	144	51%	2,062	0.0460
Overall	**35**	**82**	**1.60**	**1034**	**51**	**5.0%**	**39**	**63**	**23%**	**2,100**	**0.0245**

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Table 3. Gas Savings as a Percentage of Heating Gas Usage

Group	Sample Size	Savings Per Customer (Therms)	Average Number of Thermostats	Pre Heating Usage (Therms)	Savings Per Thermostat (Therms)	% Heating Savings Per Thermostat	Lower 90% Savings	Upper 90% Savings	Precision	Sqft	Thermost at Savings Per Sqft
Manual Baseline	9	100	2.22	810	45	5.6%	25	65	44%	2,345	0.0192
Programmable Baseline	26	76	1.38	720	55	7.6%	40	70	28%	2,016	0.0272
1 Thermostat	19	95	1.00	743	95	12.8%	69	121	27%	2,021	0.0470
Multiple Thermostats	16	67	2.31	742	29	3.9%	17	41	42%	2,194	0.0132
ATC	19	81	1.58	671	51	7.6%	39	63	24%	2,035	0.0252
HEM	16	84	1.63	828	52	6.2%	30	74	42%	2,178	0.0237
ATC 1 Thermostat	10	95	1	724	95	13.1%	71	120	26%	1,984	0.0480
HEM 1 Thermostat	9	95	1	765	95	12.4%	46	144	51%	2,062	0.0460
Overall	**35**	**82**	**1.60**	**743**	**51**	**6.9%**	**39**	**63**	**23%**	**2,100**	**0.0245**

Notably, participants with programmable thermostats as baselines had slightly higher savings than participants with manual thermostats as baselines (e.g., 5.5% compared to 3.9% of total gas usage; 7.6% compared to 5.6% for heating gas usage). These data suggest participants with programmable thermostats might not have used efficient setback schedules, compared to participants controlling their thermostats manually.

When considering savings from participants in both treatment groups, a large discrepancy appeared in savings between participants with one thermostat compared to those with multiple thermostats: participants with one thermostat saved 9.2% on total gas usage (12.8% of heating has usage), compared to 2.8% (3.9%) for multiple thermostats. Consequently, the comparison of ATC and HEM participants with one thermostat provided the most appropriate set of results for to consideration. Figure 40 shows a visual comparison of total gas savings results and the precision for the ATC and HEM participants with one thermostat.

Figure 40. Total Gas Savings, ATC 1 Thermostat and HEM 1 Thermostat (n_{ATC}=10, n_{HEM}=9)

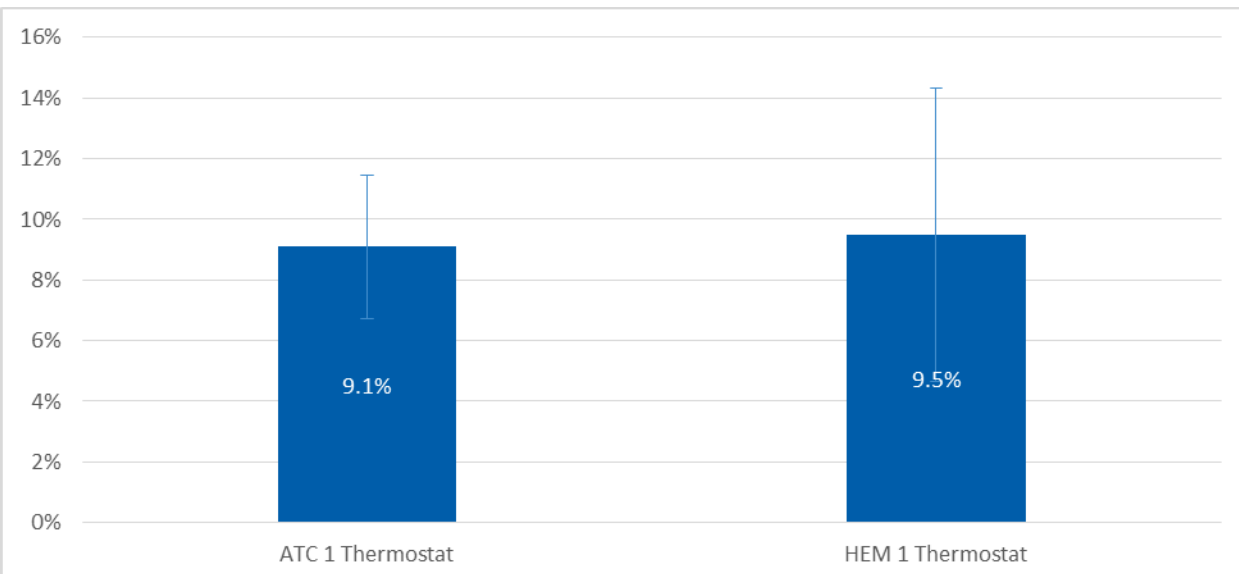
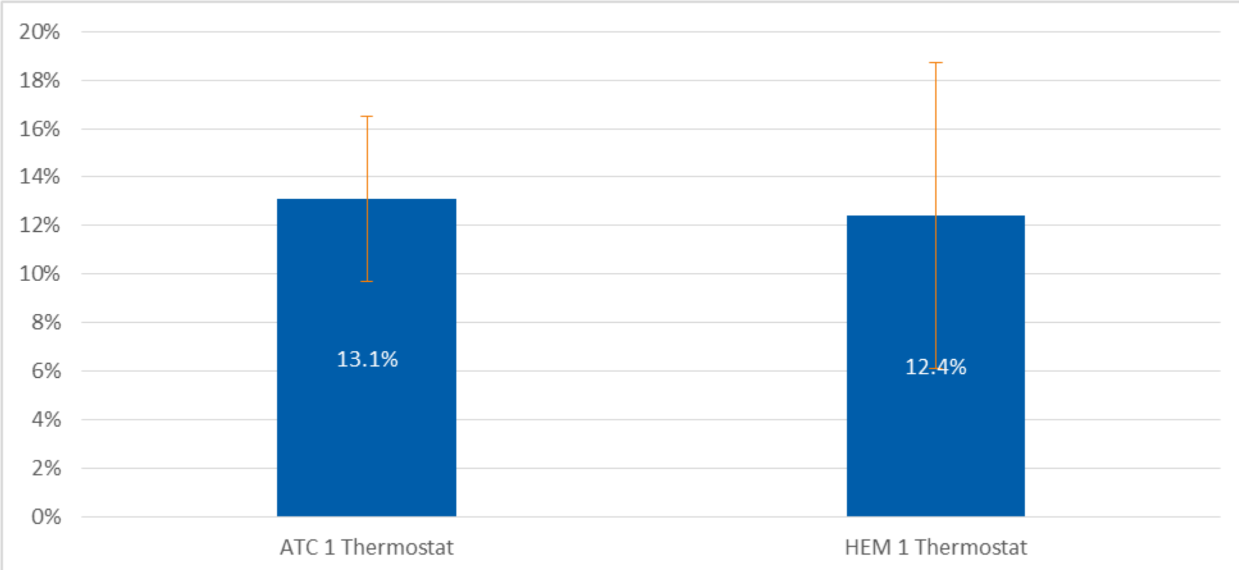


Figure 41. Heating Gas Savings, ATC 1 Thermostat and HEM 1 Thermostat (n_{ATC}=10, n_{HEM}=9)



When comparing ATC and HEM participants with just one thermostat, Cadmus found the two groups achieved about the same savings: HEM performed slightly better when considering savings as percentage of total gas usage while ATC performed slightly better when considering savings as percentage of the disaggregated heating load. As a percentage of total gas usage, the ATC group saved an average of 9.1% (compared to 9.5% for participants in the HEM group). For the disaggregated heating load, the ATC group saved an average of 13.1% of heating gas usage (compared to 12.4% for participants in the HEM group). The ATC group had slightly higher savings per square foot (0.0480 therms per square foot compared to 0.0460 therms per square foot for HEM).

Task 3. Electric Billing Analysis

Cadmus analyzed billing data for 102 participants with National Grid electric accounts. Table 4 shows electric savings as percentage of the disaggregated cooling load. Similarly the natural gas billing analysis, the evaluation team provided results in four sets of comparison groups:

- Manual vs. programmable baseline
- One thermostat vs. multiple thermostats
- ATC group vs. HEM group
- ATC participants with one thermostat vs. HEM participants with one thermostat

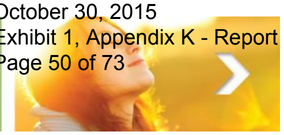


Table 4. Electric Savings as Percentage of Cooling Usage

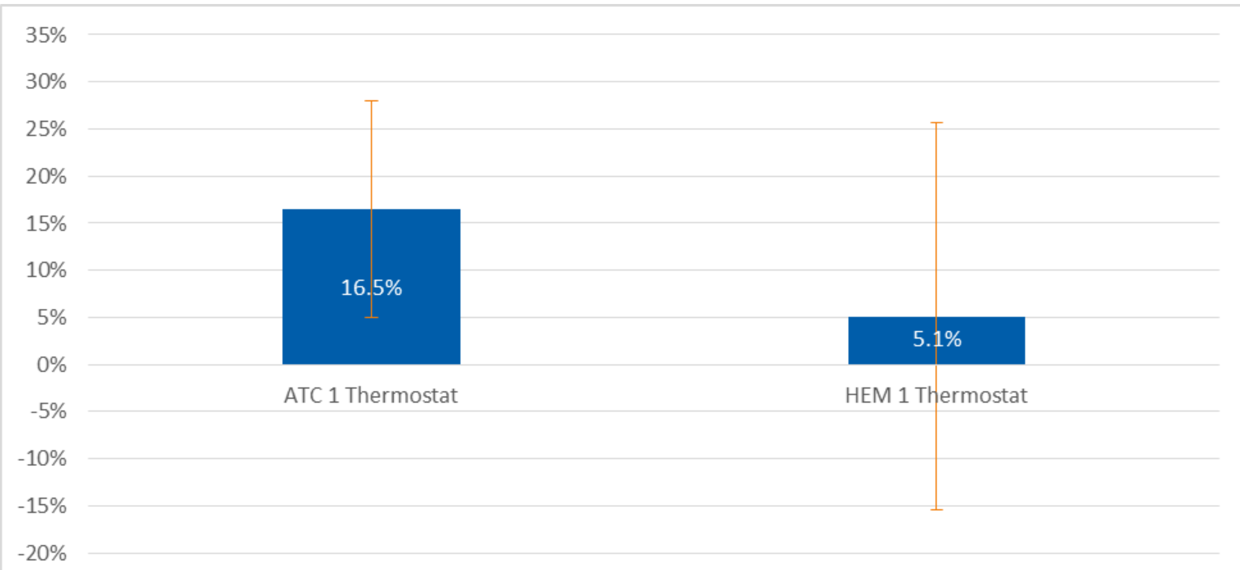
Group	Sample Size	Savings Per Customer (kWh)	Average Number of Thermostats	Pre Cooling Usage (kWh)	Savings Per Thermostat (kWh)	% Cooling Savings Per Thermostat	Lower 90% Savings	Upper 90% Savings	Precision	Sqft	Thermostat Savings Per Sqft
Manual Baseline	15	491	2.27	2,161	217	10.0%	63	370	71%	2,314	0.09136
Programmable Baseline	48	198	1.42	1,896	140	7.4%	23	257	84%	2,093	0.0669
1 Thermostat	34	215	1.00	1,755	215	12.2%	115	314	46%	1,946	0.1102
Multiple Thermostats	29	331	2.34	2,199	141	6.4%	80	203	44%	2,378	0.0593
ATC	29	384	1.45	2,379	265	11.1%	103	426	61%	2,100	0.1261
HEM	34	170	1.76	1,601	96	6.0%	-16	208	117%	2,184	0.0440
ATC 1 Thermostat	18	341	1.00	2,066	341	16.5%	104	579	70%	1,888	0.1808
HEM 1 Thermostat	16	72	1.00	1,405	72	5.1%	-218	362	403%	2,013	0.0358
Overall	**63**	**268**	**1.62**	**1,959**	**166**	**8.5%**	**72**	**260**	**57%**	**2,145**	**0.0772**

Unlike gas savings results, participants with manual thermostats as baselines had slightly better savings (10.0% compared to 7.4%), which may indicate participants with manual thermostats operated them more efficiently than those with programmable thermostats during the heating season, but not during the cooling season.

As with the gas savings analysis, a large savings discrepancy occurred between participants with one thermostat compared to those with multiple thermostats: participants with one thermostat saved 12.2% of cooling electric usage, compared to 6.4% of cooling electric usage for participants with multiple thermostats.

The ATC group reduced almost twice the electric usage for the cooling load compared to the HEM group, saving an average of 11.1%, compared to 6.0% for all group participants. When comparing ATC and HEM participants with just one thermostat, the ATC group outperformed the HEM group by more than three times, as shown in Figure 42. The ATC group saved 16.5%, compared to 5.1% for the HEM group. On a per-square-foot level, the ATC group achieved approximately five times the savings than the HEM group (0.1808 compared to 0.0358 kWh/sqft).

Figure 42. Cooling Electric Savings, ATC 1 Thermostat and HEM 1 Thermostat (n_{ATC}=18, n_{HEM}=16)



Task 4. Verification of DR Impacts

Cadmus analyzed participants' integrated energy meter data to assess the DR event impacts, with the regression analysis results shown in Table 5. The table flags statistically significant results in red. Figure 43 and Figure 44 show the runtime and demand impacts of the DR events, respectively. Bars with data labels indicated statistically significant results.

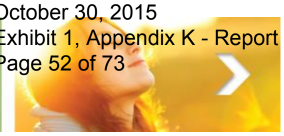


Table 5. DR Impacts: Runtime and Demand (n=30)

Event	Parameter	Runtime Analysis (Dependent Variable: Minutes of Cooling Runtime Per Hour)		Demand Analysis (Dependent Variable: kWh-Per-Hour or Average Hourly Demand in kW)	
		Change in Runtime (Minutes)	Significance (Pr > ChiSq)	Change in Demand (kW)	Significance (Pr > ChiSq)
Event 1: No pre-cooling	event1hour1	**-8.2118**	**0.0003**	0.0024	0.9973
	event1hour2	**-6.5476**	**0.0035**	-1.0334	0.1418
	event1posthour1	**12.2605**	**<.0001**	**2.6463**	**0.0002**
Event 2: Standard pre-cooling	event2prehour1	**9.7713**	**<.0001**	0.7301	0.2995
	event2hour1	-3.2271	0.1508	-0.3703	0.5992
	event2hour2	-1.3784	0.5390	-0.3215	0.6478
	event2posthour1	**6.3180**	**0.0048**	0.2816	0.6887
Event 3: Smart pre-cooling	event3prehour1	-0.0572	0.9799	-0.3542	0.6191
	event3hour1	**-8.4825**	**0.0002**	**-1.2641**	**0.0759**
	event3hour2	**-4.7597**	**0.0361**	-0.3865	0.5874
	event3posthour1	-0.7203	0.7513	0.5596	0.4325
Event 4: Smart pre-cooling	Event4prehour1	-2.4008	0.2873	-0.6529	0.3562
	event4hour1	**-11.6958**	**<.0001**	-0.4291	0.5449
	event4hour2	-1.7977	0.4266	-0.1467	0.8361
	event4posthour1	0.5383	0.8121	-0.5418	0.4456

Figure 43. DR Event Impacts: Runtime (n=30)

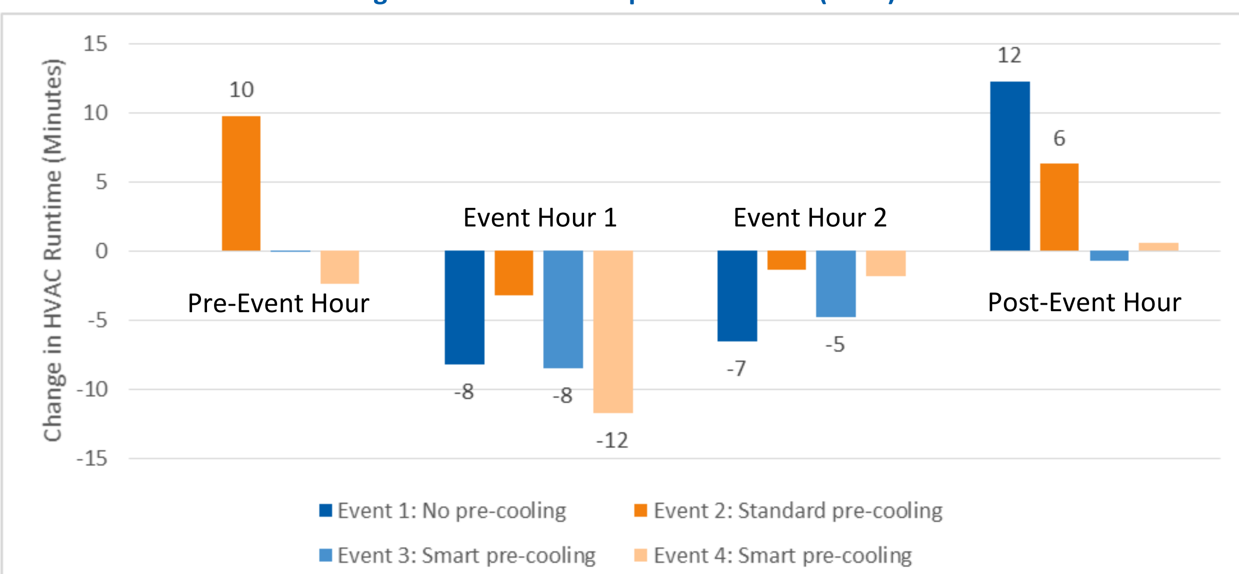


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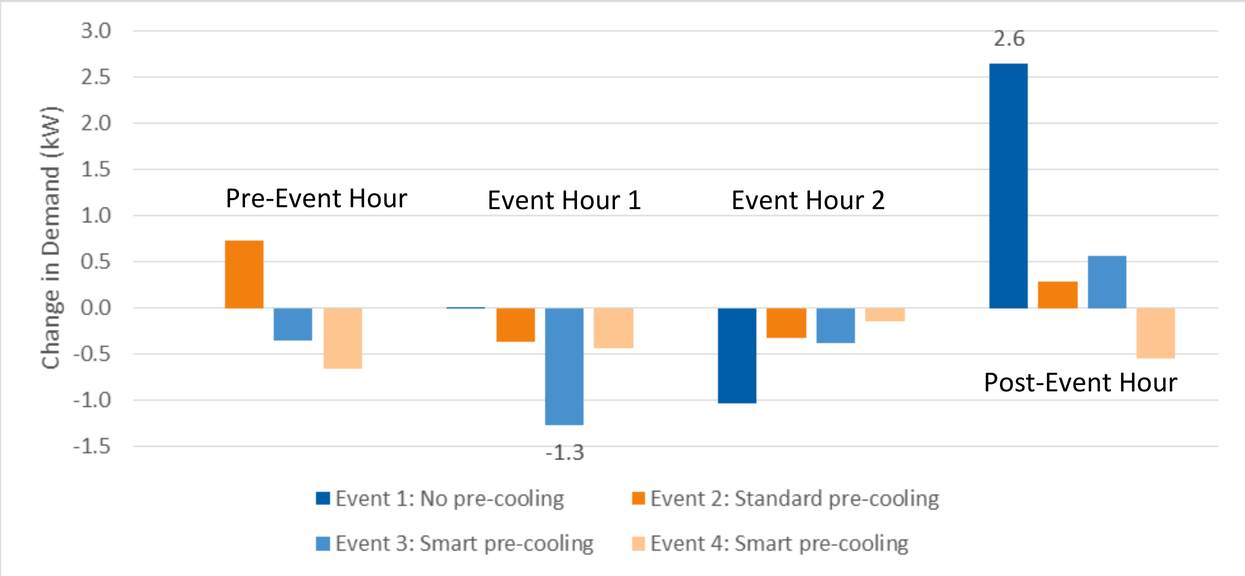
Figure 44. DR Event Impacts: Demand (n=30)



Across all four events, Cadmus found average estimated demand reductions of 0.520 kW in the first event hour and 0.472 kW in the second event hour. During smart pre-cooling events, average estimated demand reductions were 0.847 kW and 0.267 kW, respectively. The largest estimated impact—1.264 kW per home—was achieved in the first hour of the third event: an estimate statistically significant at the 10% level. None of the other event hour impact estimates, however, differed statistically from zero at the 10% significance level.

In the first hour after the DR events (eventposthour1), an average estimated increase in demand of 0.736 kW occurred. During smart pre-cooling events, an average estimated demand increase of 0.009 kW occurred due to the opposite effects estimated between Event 3 and Event 4 (both with approximately 0.5 kW, but opposite signs). Cadmus expected to observe an *increase* in demand during the first hour after a DR event (as in Event 3), but Event 4 demand decreased during that hour. Neither result, however, proved statistically different from zero. The only statistically significant post-event impact that Cadmus estimated followed Event 1 (no pre-cooling), where demand increased by 2.646 kW after the DR event.

Cadmus also estimated the same regression model using AC runtimes for comparison against whole-home demand impacts. As expected, runtime impacts were more precisely estimated than demand impacts due to the absence of all other residential end uses in the data. Across all events, an average estimated runtime reduction of 7.9 minutes occurred in the first event hour and 3.6 minutes in the second hour. The average increased runtime in the first hour after the event was 4.5 minutes. No statistically significant increase in runtime occurred after the smart pre-cooling events (Events 3 and 4). Before all three pre-cooling events, a 2.4-minute average estimated runtime increase resulted from pre-cooling, though no statistically significant impact occurred for the smart pre-cooling events, and point estimates were negative (i.e., a *reduction* in runtime during the pre-cooling hour).

Given the wide variation in the magnitude and statistical significance of Cadmus' runtime and demand impact estimates, the evaluation team sought to compare runtime impacts with demand impacts to determine if they were consistent with one another. When the EER and tonnage of an AC is known, the hourly runtime of that AC (minutes) can be approximately converted to average hourly demand (kW) using a simple engineering equation.[2]

To this end, Cadmus requested nameplate data for smart thermostat program participants. National Grid provided the evaluation team with AC makes, models, ages, and tonnage for 60 AC units in the program. Though EER was not available in these data, among these the 60 ACs averaged 4 tons, much more than Cadmus expected. (In other DR programs the average tonnage was closer to 2.5 tons. In addition, 4 tons is large for the average size of homes reported in the survey).

Assuming an average EER of 11, the average demand of each unit while running would be 4.36 kW. During the first hour of Event 3, Cadmus' estimated a runtime reduction of 8.4825 minutes and demand reduction of 1.2641 kW, as shown in Table 5. Using the average tonnage of 4 and an assumed average EER of 11, the expected kW reduction associated with an 8.4825 minute runtime reduction was approximately 0.617 kW.

However, Cadmus' statistically significant estimate of the demand reduction in this hour was 1.2641 kW, or almost twice the value expected, given the runtime reduction and the average tonnage of ACs in the program. Similarly, in the first hour after Event 1, the expected kW reduction, given the runtime reduction of 12.2605 minutes, was 0.892 kW, yet Cadmus' estimated demand reduction was 2.6463 kW—almost three times larger than expected. This suggests a number of possible problems, some of which could indicate the evaluated demand impacts are overstated.

First, the selection of AC nameplate data that National Grid provided to Cadmus may not reflect average characteristics of the true DR program population, or Cadmus' assumption of an average EER of 11 may be incorrect. This conclusion, however, suggests actual program populations ACs were even larger than 4 tons or extremely inefficient. If true, Cadmus' estimated event impacts may not be overstated, but the evaluation team finds this scenario unlikely, given observations of average AC characteristics in other DR programs.

Rather, Cadmus suspects measurement or data management errors occurred in the energy consumption data, and these errors resulted in demand impact estimates much larger than expected from the runtime impacts. As noted in the DR methods section, Cadmus identified and removed many suspicious outliers from the energy consumption data before performing the regression analysis. These outliers, however, may suggest widespread measurement error resulted in overstated demand impacts.

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2 $Average\ kW = \frac{12*tonnage}{EER} * (\frac{Hourly\ Runtime\ in\ Minutes}{60\ Minutes})$

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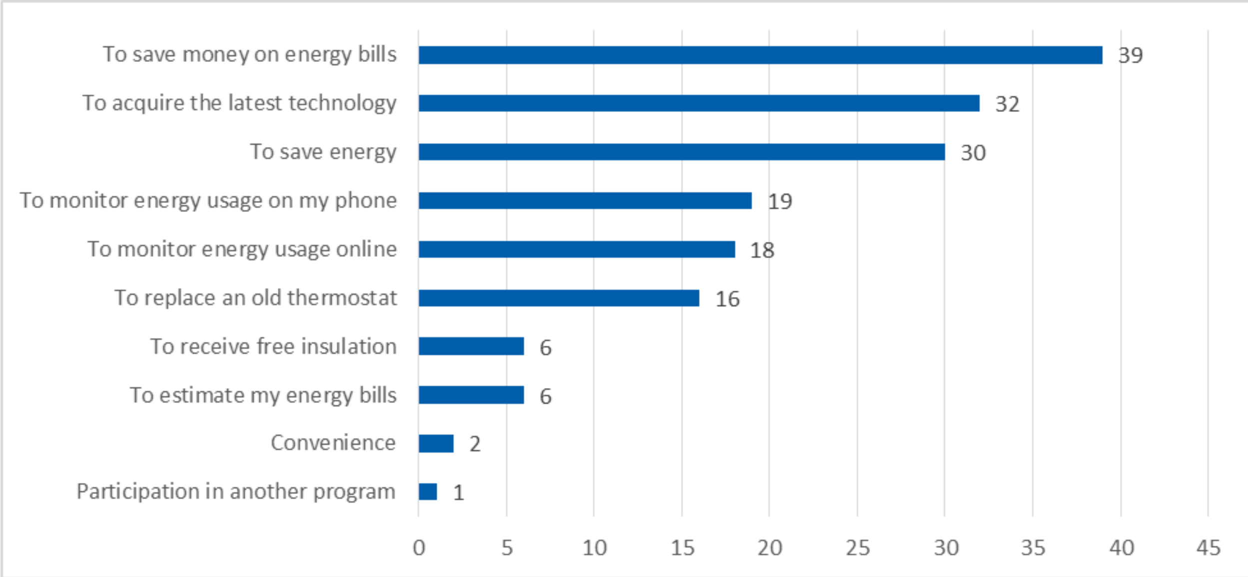
Task 5. Analysis of Participant Surveys

Motivations and Previous Thermostat Usage

Cadmus asked participants their motivations for signing up for the pilot program, with responses shown Figure 45.

Figure 45. Motivations for Signing up for the Pilot Program (n=47; multiple responses permitted)

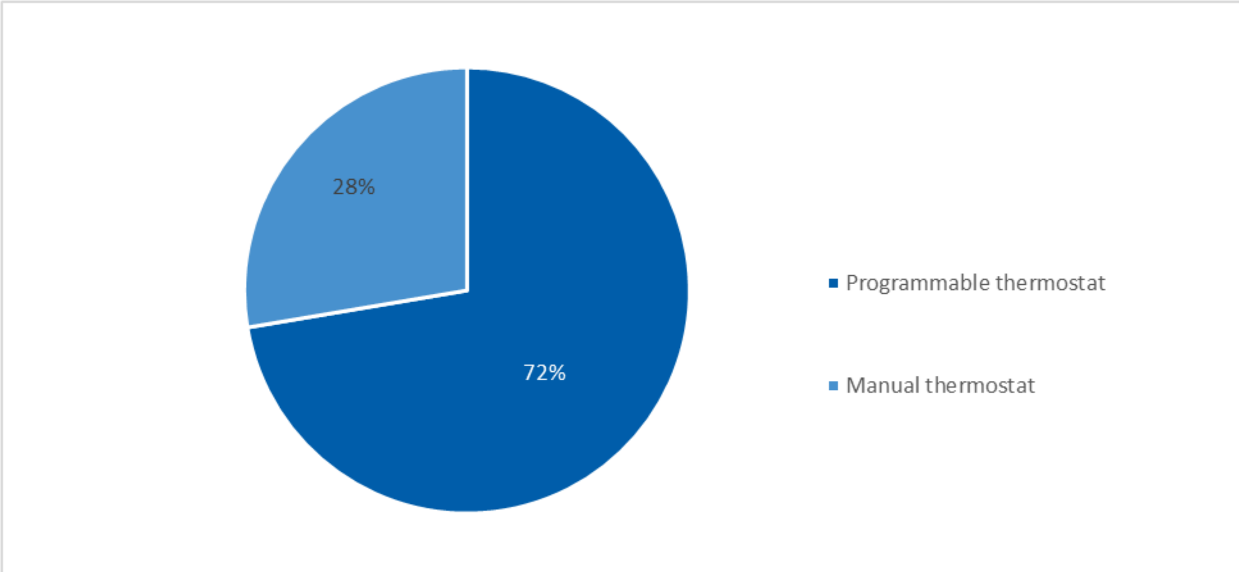


Source: 2014 Ecobee Thermostat Pilot Program Survey

The majority of participants (39 of 49) reported signing up for the pilot program to save money on electric bills. Participants cited acquiring the latest technology as their second most common motivation (32 of 49), followed by saving energy (30 of 49). Nineteen participants cited monitoring energy usage on their phones as a motivating factor, and 18 participants cited monitoring their energy usage online as a motivation. Respondents also found obtaining a new thermostat also highly motivating, with 16 citing this. When asked about the single most important factor in their decision-making process, saving money on energy bills remained the most important factor, followed by acquiring the latest technology.

Cadmus also asked participants to confirm their baseline thermostat type, with responses shown in Figure 46.

Figure 46. Participants' Previous Thermostat (n=47)

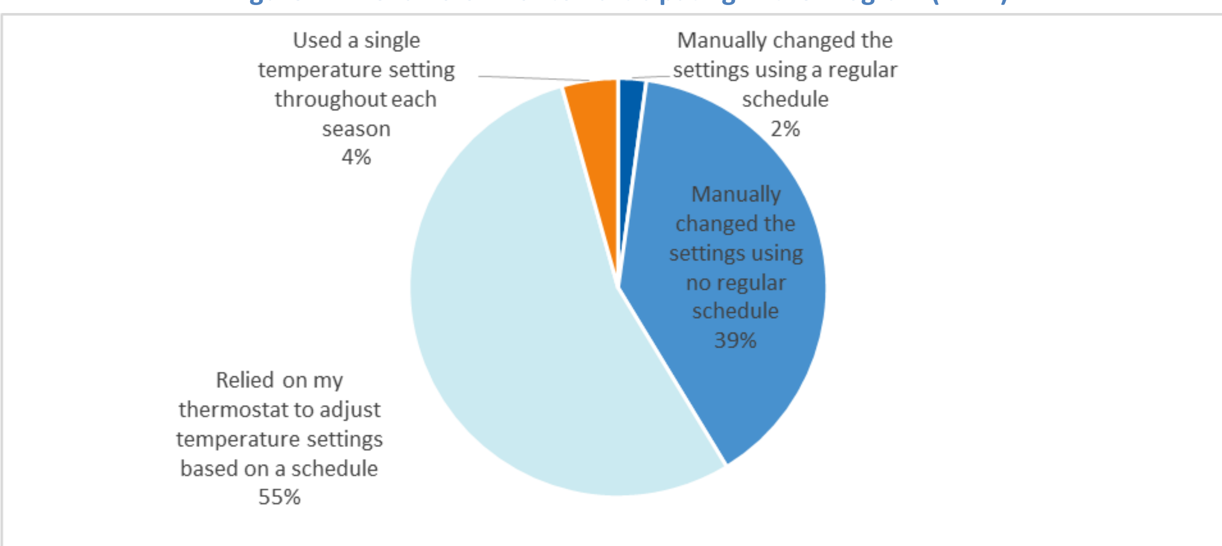


Source: 2014 Ecobee Thermostat Pilot Program Survey

A majority of participants used a programmable thermostat prior to participating in the program (72%). None of the program participants reported using an Internet-connected or smart thermostat prior to participation.

To understand participants' baseline behavior, Cadmus asked participants to describe how they operated their previous thermostats, with results shown in Figure 47.

Figure 47. Behaviors Prior to Participating in the Program (n=47)



Source: 2014 Ecobee Thermostat Pilot Program Survey

The majority of program participants (53%) set their thermostat to a schedule prior to participating in the program; 39% manually changed their thermostat settings without using a regular schedule; 4% manually changed their settings using a regular schedule; and 4% used a single temperature setting throughout each season.

Post-installation Behavior

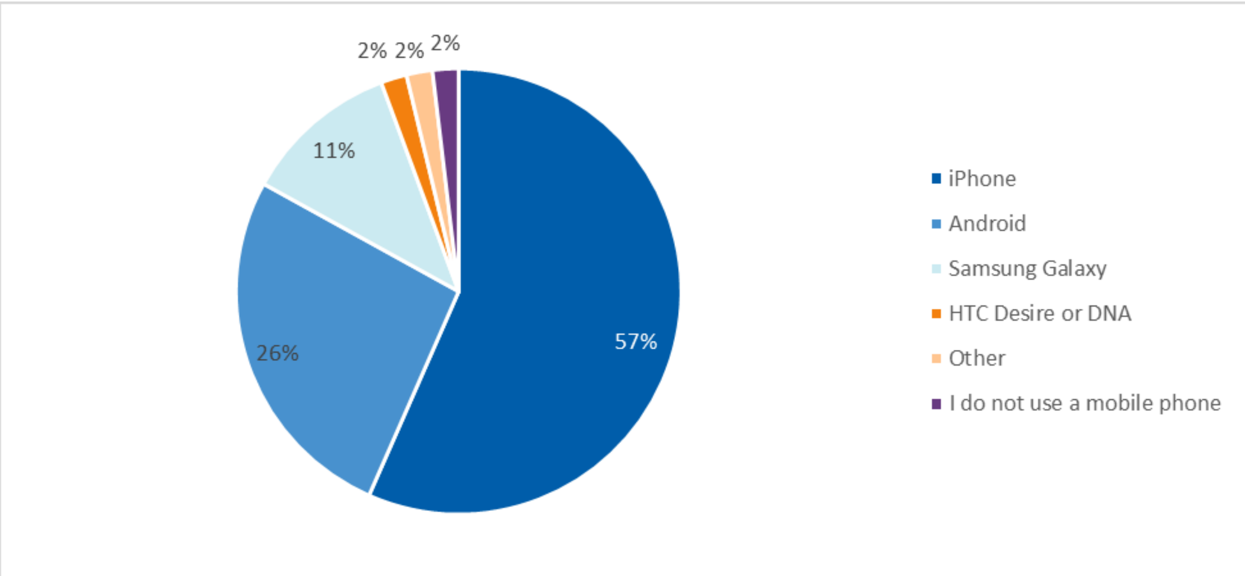
During the program, participants could access the following features:

1. Change the temperature
2. View energy usage
3. Estimate their bill by using three technologies:
    a. The thermostat itself
    b. A web portal from a computer
    c. A smartphone app

All program participants used the thermostat itself (100%) for at least one of these tasks, followed by the smartphone app (72%) and the web portal (70%).

Notably, smartphone app usage was slightly higher than web portal usage. This may be explained, as discussed further in the *Satisfaction and Willingness to Pay* section, through the appeal of mobile access through a smartphone, opposed to more stationary access afforded by web portals. Figure 48 shows participants' types of smartphones.

Figure 48. Customer Type of Phone (n=47; multiple responses allowed)



Source: 2014 Ecobee Thermostat Pilot Program Survey

The majority of participants used an iPhone (57%), followed by an Android phone (26%), and a Samsung Galaxy (11%). Only 2% of customers did not use a smartphone (Other), and only 2% of customers did not use a mobile phone. An app running on iPhone, Android, and the Samsung Galaxy worked for 94% of the pilot program population. As the pilot program population may have been more motivated by having the "latest" technology than the general population, these percentages may not apply to the general population, but the high percentage of iPhone and Android users provides a smartphone platform baseline on which to base future planning.

Cadmus asked participants to rank the usefulness of the three key features, with results shown in Table 6.

Table 6. Ranking of Usefulness by Feature (n=47)

#	Answer	Min Value	Max Value	Average Value	Responses
1	Change the temperature feature	5	10	9.27	45
2	View energy usage	1	10	7.22	37
3	Bill estimation feature	1	10	5.24	30

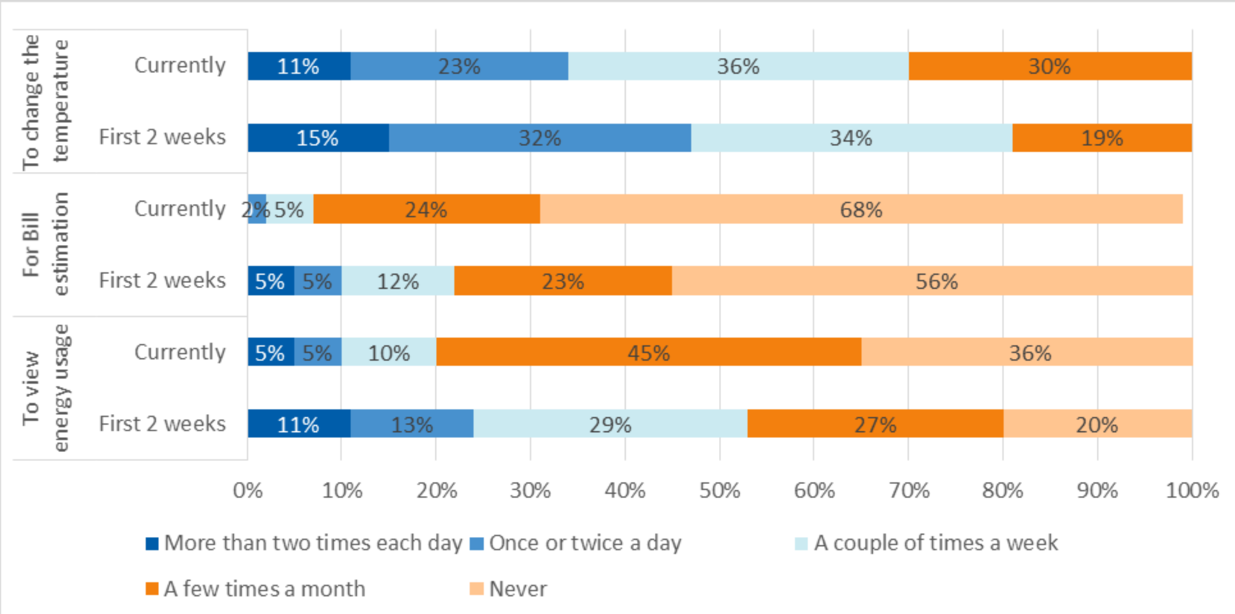
Respondents cited the top ranked feature as the ability to change temperatures: an average, participants ranked this feature a 9.27/10.00. Viewing energy usage was ranked a 6.84/10.00, and bill estimation a 4.75/10.00.

Twelve respondents offered verbatim responses received for the question: "Do you have any suggestions for any of the features above?" Three customers suggested a simpler user interface. Other comments and suggestions included the following:

> "Maybe an alert when the usage is higher and lower than your normal use."
>
> "Bill estimation and View energy usage features stopped working after installing Net Meter (for Solar)."
>
> "I don't think that the energy usage includes gas used for heat, that would be more helpful if it did!"
>
> "[I] never really got any initial instructions or feedback from National Grid on how to make the most of the unit's features."
>
> "Ability to change the schedule from the phone."

To assess these features' usefulness, Cadmus asked participants to rate their frequency of use for the first two weeks of the program, compared to the present. Figure 49 shows the results.

Figure 49. Thermostat Usage Frequency Phases (n=47)



Source: 2014 Ecobee Thermostat Pilot Program Survey

Customer interactions with their thermostats changed over time. During the first two weeks of the program, customers reported viewing their energy usage more frequently, with the majority viewing energy usage a couple times each week. Several weeks in, the majority of customers viewed their energy usage a few times each month.

Use of the bill estimation feature also declined over time, with 10% of participants using the bill estimation feature multiple times per day in the first two weeks of the program, then losing interest after the initial period, with only 2% continuing to use the feature daily.

All customers continued using the thermostats to change their home temperatures, with some additional activity occurring in the first two weeks of the pilot.

Comfort

Customers reported maintaining average home temperatures of 72.3°F during the summer cooling season, with a minimum value of 65 degrees and a maximum of 81°F. Cadmus asked participants to rate their comfort levels during the cooling season. Table 7 shows results for the HEM group.

Table 7. Summer Cooling Season Comfort Ratings (HEM Group)

Answer	Responses	%
Did not notice a change in comfort level	14	61%
The house is warmer but the comfort level is acceptable	6	26%
The house is considerably less comfortable	2	9%
Other: "House was more comfortable"	1	4%
Total	23	100%

The majority of participants (61%) did not notice changes in comfort levels. One respondent found levels more comfortable. Approximately one-quarter (26%) found the house was warmer but acceptably comfortable. Only two respondents found the house considerably less comfortable. Overall, the program's curtailment settings proved acceptable to 91% of participants.

All 47 participants were asked if they had done taken different actions to manage comfort levels in their homes during the program, with 57% using a ceiling fan or other fan to manage their comfort, 49% percent shutting blinds, 13% not taking different actions, one participant (2%) turning on a window-unit AC, and one participant (2%) leaving their house more frequently.

Participants reported the average temperature settings of 67.7°F for the 47 homes during the heating season, with a minimum value of 58°F and a maximum value of 78°F. Table 8 shows winter season comfort ratings during program participation, as compared with the season before participation.

Table 8. Heating Season Comfort Ratings (Both DR and HEM Groups)

Answer	HEM Participants		ATC Participants	
	Responses	%	Responses	%
Did not notice a change in comfort level	13	57%	15	65%
The house is cooler but the comfort level is acceptable	6	26%	5	22%
The house is considerably less comfortable	1	4%	2	9%
Other	3	13%	1	4%

The majority of participants in both groups (57% of HEM and 65% of ATC) did not notice changes in comfort levels, while 26% of HEM and 22% of ATC found their homes cooler but acceptably comfortable. Only one HEM participant (4%) and two ATC participants (9%) found their homes considerably less comfortable. These findings mirror those of summer cooling comfort levels, with most participants acceptably comfortable during the program.

Actions participants took to manage comfort levels included: 26% closing off unused rooms, 19% using a woodstove or fireplace, 11% turning on a space heater, 4% wearing extra layers of clothing, one participants (2%) using a door draft stopper, and one participant (2%) leaving their house more frequently, indicating discomfort.

DR Events

Cadmus asked DR participants an additional battery of survey questions specific to their experiences with DR events. Understanding DR events for a larger population requires determining how many participants remained home in respect to event timing. In the pilot program, 14 to 16 of 24 participants (about two-thirds) reported staying home for each of the four events. Cadmus asked these participants additional questions about comfort, as discussed further below. All participants reported receiving an e-mail notification of the events beforehand; 71% preferred to receive notification 24-hours in advance.

Notably, 17% reported that advance notification was not important for them. The remaining 13% preferred receiving notification the evening before.

If participants' records indicated they had opted-out of events, they were asked: "What was the main reason for deciding to opt-out of this event?" (for each event they opted out of). Of four opt-out respondents, only one respondent offered a clear reason for their choice: they had family visiting. Two participants reported they "don't know" or one respondent thought they had not opted out of that event.

Cadmus asked respondents if they changed their temperature setting during a DR event, and, if so, why. The majority did not change their temperature settings; the one respondent who did said it became too warm in the home. Table 9 shows overall comfort level ratings for each event.

Table 9. DR Event Comfort Ratings

Date	Did not Notice a Change in Comfort Level	The House is Warmer but the Comfort Level is Acceptable	The House is Considerably Less Comfortable	Total Responses
August 26th	79%	14%	7%	14
August 27th	77%	15%	8%	13
July 9th	64%	29%	7%	14
September 5th	80%	20%	0%	15

The majority of participants who remained home for the event did not notice a change in comfort levels (64% to 80%, depending on the event date). Between 14% and 29% found the home warmer, but still acceptably comfortable. Less than 9% in each event found the home "considerably less comfortable" during DR events.

When asked if they had taken actions to manage comfort *during* events, nine of 24 participants reported turning on ceiling fans or other fans, and eight of 24 participants reported shutting the blinds. One "other" response explained that the respondent ran the furnace fan to move air around the house during the events. When asked for additional comments on the events, the nine responses ranged from "they were fine, barely noticed," to "my wife was not happy that someone else was controlling her comfort level...." Some verbatim responses follow:

> "I didn't notice a big change which has led me to not having the AC on quite as much."
>
> "I am very happy with the thermostat. It is very convenient to adjust the temp from my smart phone and tablet."
>
> "Was prepared to adjust temperature if required, but it was not necessary."
>
> "The e-mail notifications were very informative. I had questions about the events and customer service was very prompt in answering my questions and responding to my concerns."

Behaviors and Attitudes

Cadmus asked participants if they participated in any other National Grid program in the past year. Twelve respondents had participated in another program. Two specifically reported participating in MassSave, five mentioned an insulation program, three mentioned lighting rebates, and three mentioned rebates for measures such as a new boiler, a dehumidifier, and a Nest Thermostat. The majority of respondents (73%) had not participated in another program.

Cadmus also asked participants for their agreement levels regarding a series of statements designed to better understand participant attitudes towards energy conservation, saving money, trust in the utility, and preferences for having the latest technology. Table 10 shows the results.

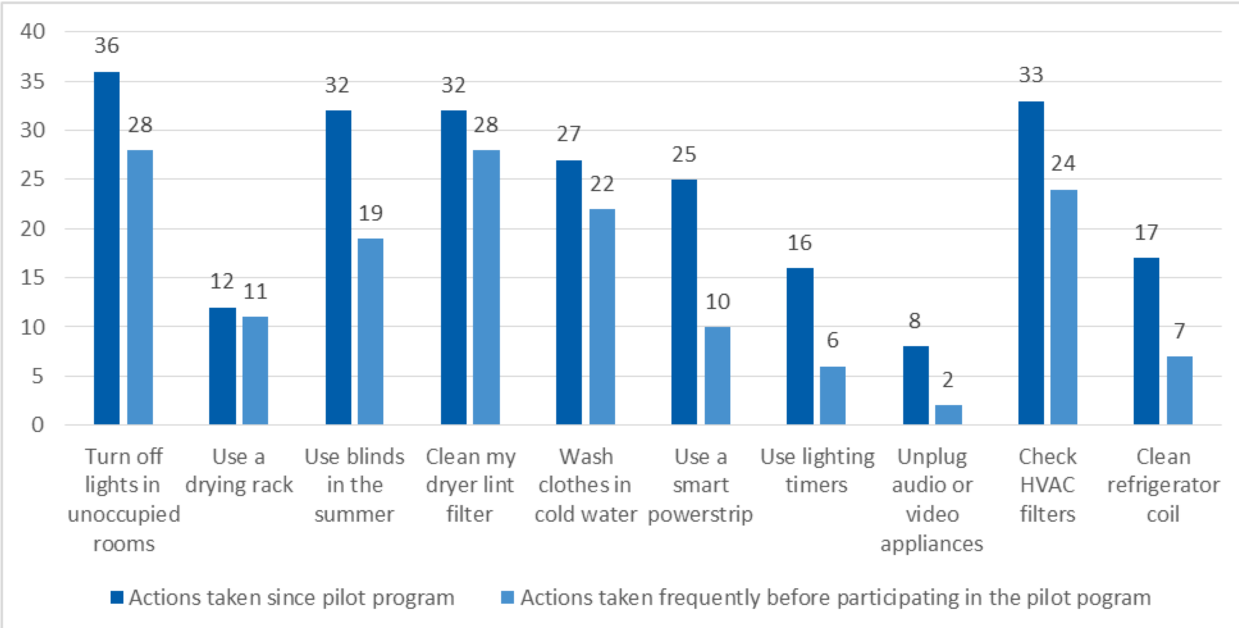
Table 10. Attitude Statements and Level of Agreement

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Total Responses	Mean
Conserving energy is important to me	2%	0%	4%	23%	70%	47	4.6
I like to have the latest technology	2%	4%	11%	28%	55%	47	4.3
Saving money is important to me	2%	0%	0%	15%	83%	46	4.76
In general, I trust my utility company as an expert in energy-saving opportunities	2%	2%	15%	62%	19%	47	3.94

Most participants strongly agreed with statements such as “conserving energy is important to me” and “saving money is important to me.” The majority of program participants also considered having the latest technology important. While most participants strongly agreed that saving energy and money were important, trust in the utility showed more ambivalence, with seven participants neither agreeing nor disagreeing, and the majority (29/47) expressing agreement, but not strong agreement. This finding may be a useful in planning future program messaging focused on the convenience and value of personal control over temperature settings.

The majority of participants took additional actions or changed the frequency in which they performed behaviors since participating in the program. Figure 50 shows these actions.

Figure 50. Comparison of Participants' Current Actions as Compared to Before Program (n=46; multiple responses allowed)



Source: 2014 Ecobee Thermostat Pilot Program Survey

The greatest changes from pre-program participation to post-program participation regarding using a smart powerstrip, cleaning refrigerator coils, using lighting timers, using blinds in the summer, and checking HVAC filters. While use of smart power strips showed a large increase post-participation, other behaviors may have been influenced by monitoring electricity consumption, as these had not been practiced prior to program participation.

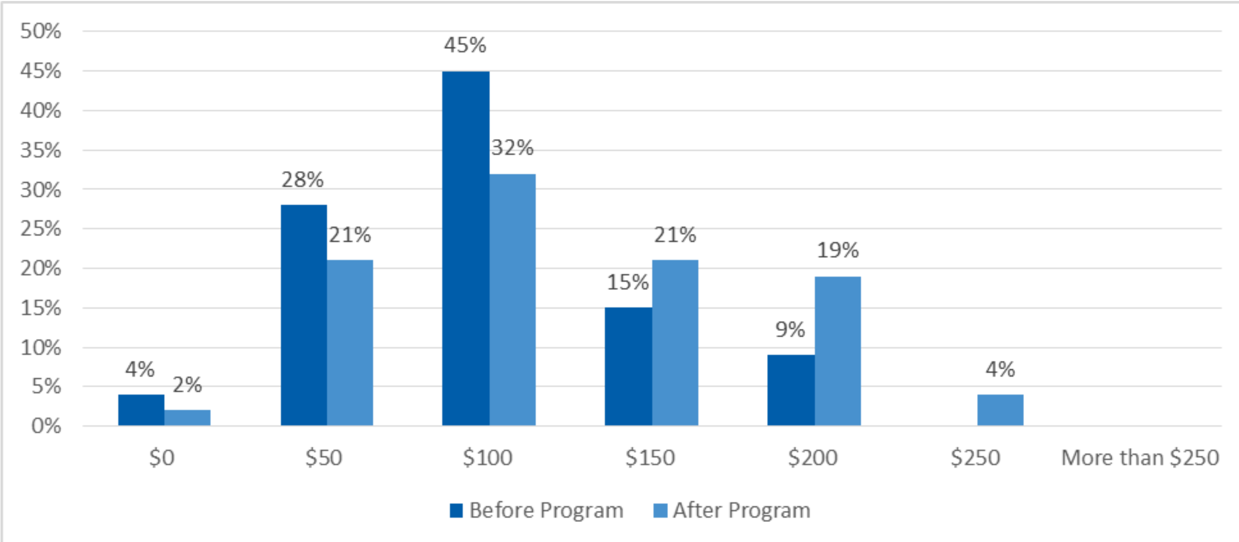
Participants also made home improvements to save energy after participating in the program, with 42% percent of respondents (19 of 45) making improvements. Such improvements included insulation, exterior door improvements, draft stopping tape, new boilers, furnaces, windows, installing a solar PV system, and lighting improvements or LED purchases.

Satisfaction and Willingness to Pay

Participants expressed overall satisfaction with National Grid, awarding an average satisfaction ratings of 7.87/10.00, with a 10 as "very satisfied." On the same scale, participants rated the Ecobee thermostat an average of 8.72/10.00. Participants also were asked: "Given the opportunity, how likely would you be to recommend this program to a friend?" Respondents rated this question an average of 9.02/10.00, or very likely to recommend the program. Participants also were asked how likely they would be to recommend the thermostat to a friend, with an average value of 8.65/10.00. These findings indicate the program was well received.

Respondents also indicated if they were inclined to pay an average of 25% more for a smart thermostat after participation in the study. When asked how much they would be willing to pay before and after the study, the average amount before was $98 and the average amount after was $123. Figure 51 shows the distribution of responses.

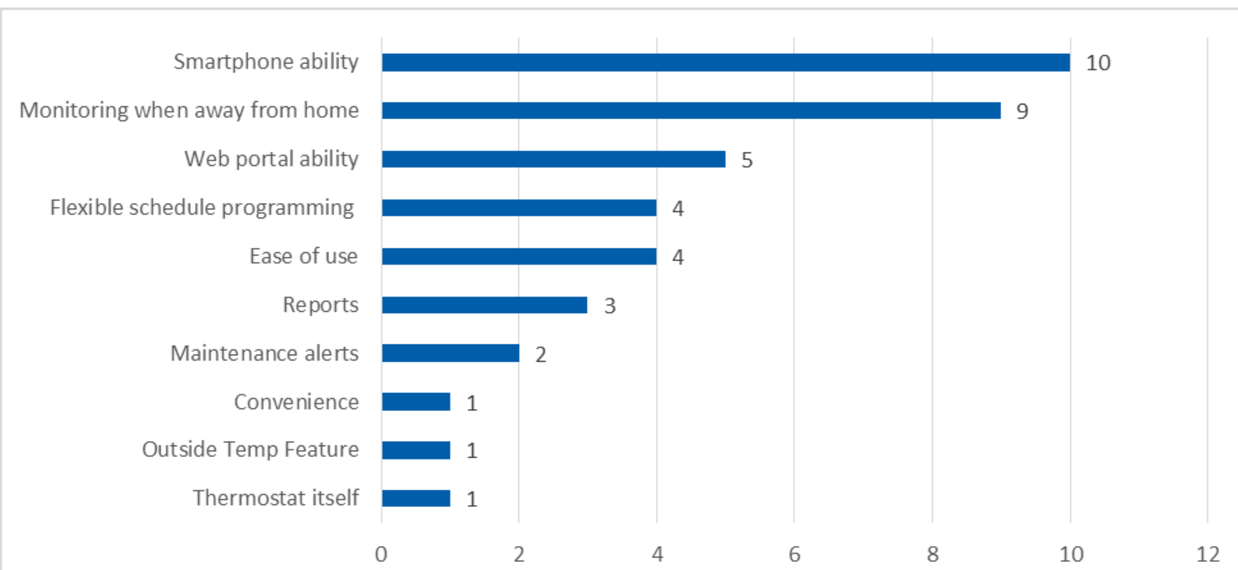
Figure 51. Willingness to Pay (n=47)



Source: 2014 Ecobee Thermostat Pilot Program Survey

Cadmus asked participants what they liked the most about the program. Figure 52 shows their responses.

Figure 52. What Program Features Did You Find Most Valuable? (n=47; multiple responses allowed)



Source: 2014 Ecobee Thermostat Pilot Program Survey

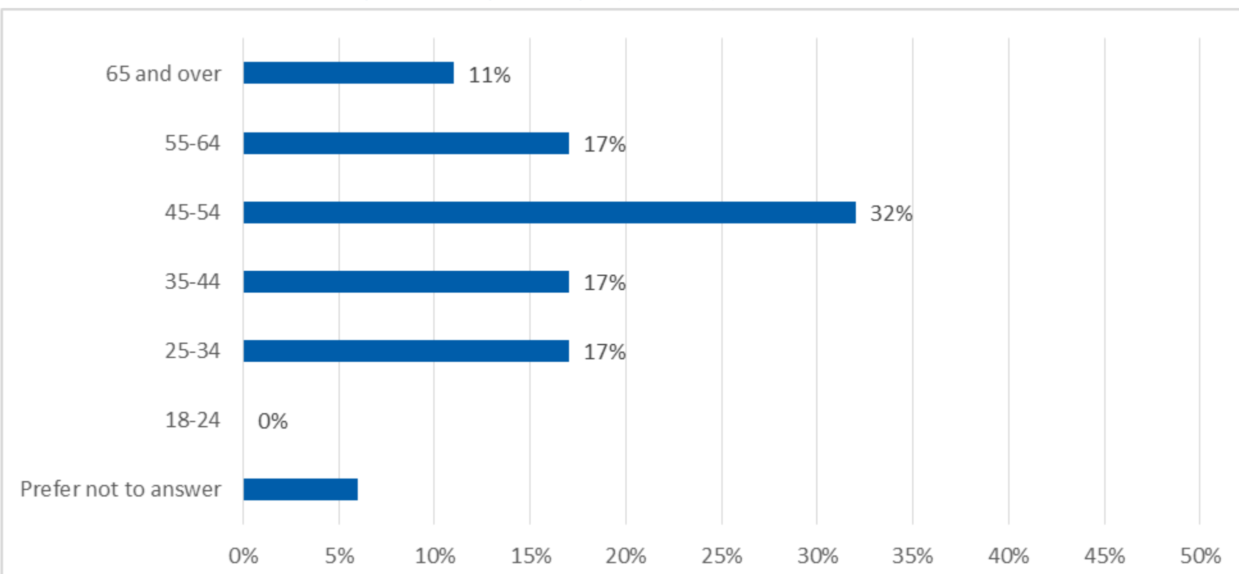
Many respondents found the smartphone app the most valuable aspect of the program. Comments included: "the ability to adjust my temp from my smartphone" and "access from my iPhone." Many participants also found the ability to monitor their home while away valuable. Comments included: "checking on the heat while out of town" and "loved the remote access and ability to monitor the home while away." Five participants cited the web portal as valuable. Some verbatim comments follow:

> "I liked the online features and details the website provided regarding usage rates and trends."
>
> "The ability to check status on a smartphone as well as set maintenance alerts (i.e. changing the filter)"
>
> "Remote and mobile controls worked out awesome when I was not home."
>
> "With my old thermostat, I could only program 3 changes per day. With Ecobee, I could program many more, and thus could be more efficient. I also really liked the ability to change temperature from my phone in case I needed to change it after leaving the house."

Demographics

Cadmus collected demographics regarding participant age, home square footage, education, and income. The following figures detail their responses.

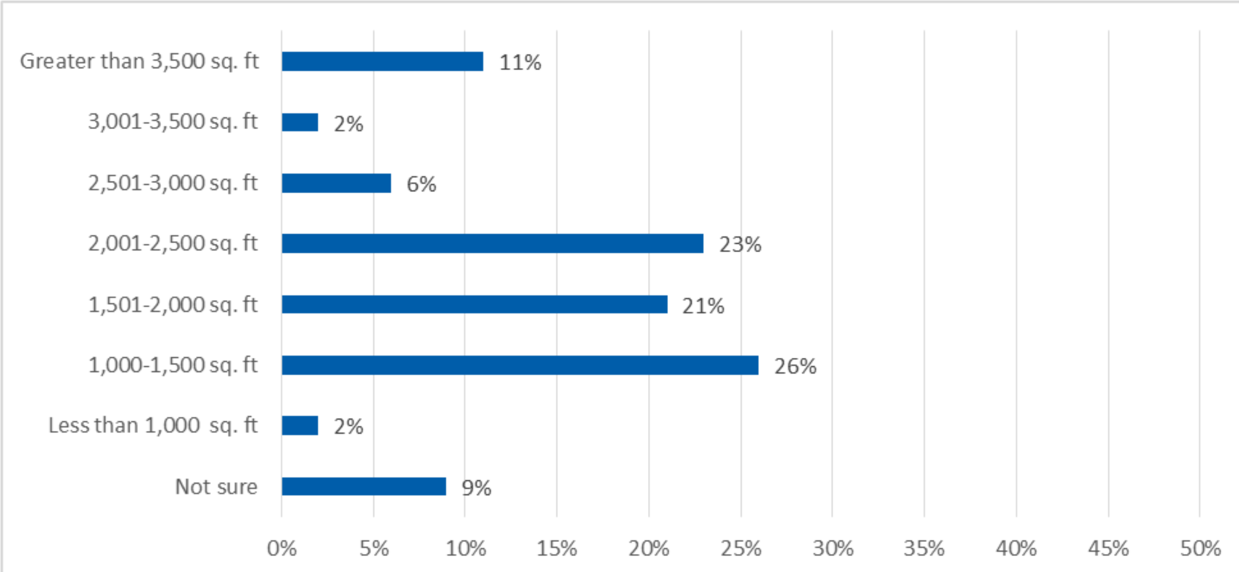
Figure 53. Age Category of Respondents (n=47)



Source: 2014 Ecobee Thermostat Pilot Program Survey

The majority of survey respondents were male (66%). Most survey respondents were in the 45 to 54 age category (32%), with 17% in the 25 to 34 age category, 17% in the 35 to 44 age category, 17% in the 55 to 64 age category, and 11% in the 65 and older category. No survey respondents were in the 18 to 24 age category (possibly due to lower homeownership rates in that age category).

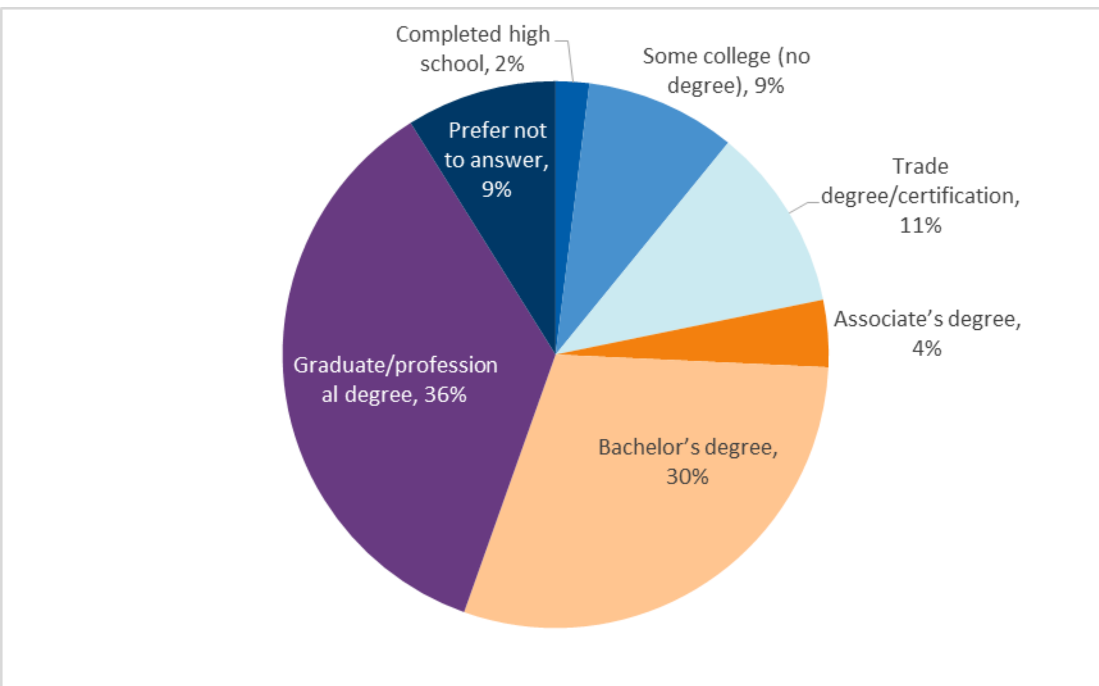
Figure 54. Home Size, in Square Feet (n=47)



Source: 2014 Ecobee Thermostat Pilot Program Survey

Most survey respondents live in a home between 1,000 to 2,500 square feet, with the majority (26%) falling into the 1,000 to 1,500 square foot home category. Specific categories are detailed below.

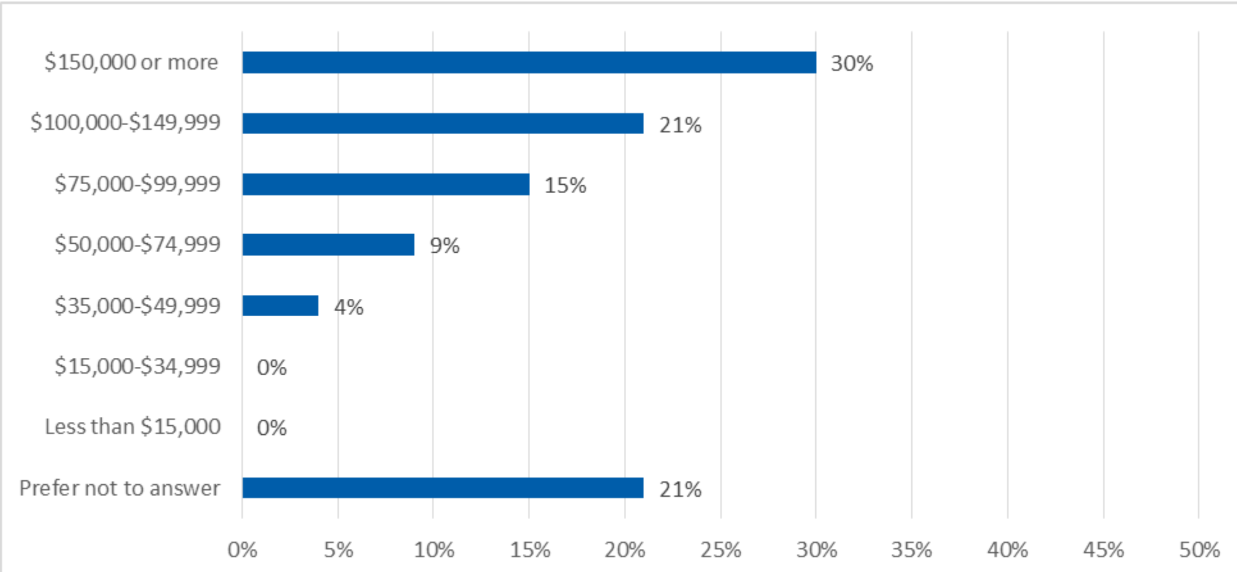
Figure 55. Education Levels (n=47)



Source: 2014 Ecobee Thermostat Pilot Program Survey

The majority of survey respondents have a graduate or professional degree (36%), followed by those with a bachelor's degree (30%). See below for the breakout by education level.

Figure 56. Income Categories (n=47)



Source: 2014 Ecobee Thermostat Pilot Program Survey

While a large percentage preferred not to answer, most survey respondents were in the $150,000 or more income category. Overall, survey respondents were highly educated and financially well off, which likely extends to the program population as a whole. The program reaches multiple income groups.

Findings and Recommendations

Objective 1: Value of Ecobee Smart Thermostat and Integrated Energy Meter

Participants found having the ability to remotely control their thermostat using the smartphone app or the web portal as the most valuable feature of the Ecobee Smart Thermostat. Although some participants used the integrated energy meter features, including energy monitoring and bill estimation tools, interest in these features decreased significantly after two weeks.

Usefulness of Features

Participants found the Ecobee Smart Thermostat's basic functions more valuable than the integrated energy meter. Participants awarded the thermostat's temperature changing feature an average usefulness rating of 9.27/10.00, compared to 7.22/10.00 for the viewing energy usage feature and only 5.24/10.00 for the bill estimation feature.

Participants found the ability to remotely control and monitor their thermostats to be the most valuable feature of the thermostat. Flexible schedule programming, ease of use, and energy reports were considered about one-half as valuable. Participants found convenience, checking the outside temperature, and the thermostat itself to be the least valuable features/characteristics.

Persistence in Use of Features

Participants' interactions with their thermostats declined over time. During the program's first two weeks, participants reported viewing their energy usage more frequently, with the majority viewing their energy usage a couple of times each week. Several weeks into the program, the majority of customers viewed their energy usage only a few times each month. Use of the bill estimation feature also declined over time, with 10% of participants using the bill estimation feature multiple times per day for the first two weeks of the program, then losing interest after the initial period, with only 2% continuing to use the feature daily. All customers continued using the thermostat to change their home's temperature, with some additional activity occurring during the pilot's first two weeks.

Recommendations

An area for further research may address methods for keeping customers engaged with the energy usage and bill estimation information, perhaps by updating it regularly with new facts or comparisons to the past week's usage or to neighborhood averages.

Objective 2: Impact of HVAC Control Optimization

The HVAC optimization controls provided energy savings during the heating and cooling seasons, while regulating temperature setpoints more accurately than the comparison participant group without HVAC optimization controls. In terms of energy savings, the HVAC optimization controls outperformed the comparison group significantly in the cooling season, but provided similar savings in the heating season.

Temperature Regulation

During the heating and cooling seasons, HVAC systems with HVAC optimization controls more effectively regulated temperatures than HVAC systems without HVAC optimization controls. Indoor air temperatures for the group with HVAC optimization controls (the ATC group) more closely matched setpoints compared to the group without HVAC optimization controls (HEM group):

- In the heating season, indoor air temperatures (IAT) in the ATC group averaged 1.8 degrees warmer than setpoints, compared to 5.1 degrees warmer than setpoints in the HEM group.
- When cooling was required in the cooling season, IAT in the ATC group averaged 0.7 degrees warmer than the setpoint, compared to 2.4 degrees warmer than the setpoint in the HEM group.

Heating Season Energy Savings

Heating systems with HVAC optimization controls saved about the same in natural gas as heating systems without HVAC optimization controls. When comparing ATC and HEM participants with just one thermostat, Cadmus found natural gas savings to be about the same between the two groups. The HEM group performed slightly better when considering savings as a percentage of total gas usage, while the ATC group performed slightly better when considering savings as percentage of the disaggregated heating load and savings per square foot:

- As a percentage of total gas usage, the HEM group saved an average of 9.5%, compared to 9.1% for participants in the ATC group.
- As a percentage of the disaggregated heating load, the ATC group saved an average of 13.1% of heating gas usage, compared to 12.4% for participants in the HEM group.
- On a per-square-foot level, the ATC group saved 0.0480 therms/sqft compared to 0.0460 therms/sqft for the HEM group.

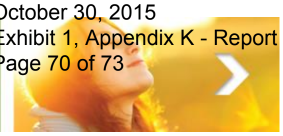
Cooling Season Energy Savings

Cooling systems with HVAC optimization controls saved significantly more electricity than cooling systems without HVAC optimization controls. When comparing ATC and HEM participants with just one thermostat, Cadmus found the ATC group outperformed the HEM by three times when considering the disaggregated cooling load and five times when considering savings per square foot:

- As a percentage of the disaggregated cooling load, the ATC group saved 16.5%, compared to 5.1% for the HEM group.
- On a per-square-foot level, the ATC group saved 0.1808 kWh/sqft, compared to 0.0358 kWh/sqft.

Recommendations

HVAC optimization controls show promise as an effective measure for reducing heating and cooling energy usage while improving temperature regulation, but energy savings calculations should be updated with larger sample sizes to improve the precision of estimates.



Objective 3: Impact of DR

Overall, DR events reduced participants' HVAC system runtimes without creating discomfort for participants.

Demand Impacts

DR events occurred and affected runtimes. The runtime impacts confirmed DR events occurred. Across all events, an average estimated runtime reduction of 7.9 minutes occurred in the first event hour and 3.6 minutes occurred in the second hour.

Evaluated kW impacts are likely overstated. Cadmus found statistically significant estimates of demand reductions were almost twice the value expected, given runtime reductions and the average tonnage of air conditioners (AC) in the program. This suggests a number of possible problems, some of which could indicate the study's demand impacts are overstated. Cadmus suspects this resulted from quality issues with the integrated energy meter dataset.

Smart cooling-style DR events had the largest impact on savings. During the two smart pre-cooling events, average estimated demand reductions of 0.847 kW and 0.267 kW resulted. Across all four events, average estimated demand reductions were 0.520 kW in the first hour and 0.472 kW in the second event hour.

Comfort

Participants in general did not find events uncomfortable. The majority of ATC participants (65% - 80%, depending on DR event) did not notice a change in comfort level during the DR events. Fourteen to 29% noticed the house was warmer but found the comfort level to be acceptable. Only 0-8% (depending on the DR event) found the house to be considerably less comfortable.

Recommendations

Cadmus recommends improving the estimated demand impacts by completing the actions that follow. However, if necessary to use this year's results for program planning, runtime impact results can be used with the average population EER and tonnage data to calculate estimated demand impacts.

To improve the estimated demand impacts:

- Improve the quality of the integrated energy meter data used to estimate DR impacts. For example, missing data should be clearly differentiated from true zeroes, and the source of high and low outliers should be investigated and corrected (for instance, readings over 40 kWh per hour).
- If possible, AC energy efficiency rating (EER) and tonnage data should be collected for new program participants at the time of thermostat installation. Better AMI data and a bigger sample of AC nameplate data will improve the accuracy of the DR program's demand impact estimates.

CADMUS

Appendix A: Demand Response Notification E-mails

From: Miller, Keith
Sent: Tuesday, July 08, 2014 6:53 PM
To: Miller, Keith
Subject: National Grid Temperature Optimization Event Tomorrow

Temperature Optimization Event: July 9, 2014

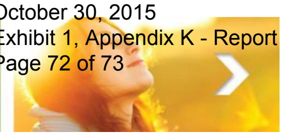
Time of event: 1:00 – 3:00 PM EST

National Grid will be conducting a temperature optimization event tomorrow as part of your participation in the **Automatic Temperature Control Pilot**. Temperature Control is automatic and no effort will be needed on your part. You will have the ability to adjust your thermostat if you desire to make any type of temperature adjustment during the event. We appreciate your participation and our goal is to keep you comfortable while reducing electricity demand.

Please let me know if you have any questions,

Regards, Keith

Keith Miller | Products/Energy Services
national**grid** | Energy Efficiency
40 Sylvan Road | Waltham, MA 02451
keith.miller2@nationalgrid.com | (781) 907-2241



From: Miller, Keith
Sent: Monday, August 25, 2014 12:23 PM
To: Miller, Keith
Subject: National Grid Temperature Optimization Event Tomorrow and Wednesday - August 26 and August 27 from 1-4 PM EST

Temperature Optimization Event: August 26 and August 27, 2014

Time of event: 1:00 – 4:00 PM EST

National Grid will be conducting a temperature optimization event tomorrow August 26, and Wednesday August 27 as part of your participation in the **Automatic Temperature Control Pilot**. Temperature Control is automatic and no effort will be needed on your part. You will have the ability to adjust your thermostat if you desire to make any type of temperature adjustment during the event. We appreciate your participation and our goal is to keep you comfortable while reducing electricity demand.

Please let me know if you have any questions,

Regards, Keith

Keith Miller | Products/Energy Services
national**grid** | Energy Efficiency
40 Sylvan Road | Waltham, MA 02451
keith.miller2@nationalgrid.com | (781) 907-2241

From: Miller, Keith
Sent: Thursday, September 04, 2014 3:26 PM
To: Miller, Keith
Subject: Temperature Optimization Event: September 5, 2014. Time of event 1-4 PM EST

Temperature Optimization Event: September 5, 2014

Time of event: 1:00 – 4:00 PM EST

National Grid will be conducting a temperature optimization event tomorrow September 5, 2014 as part of your participation in the **Automatic Temperature Control Pilot**. Temperature Control is automatic and no effort will be needed on your part. You will have the ability to adjust your thermostat if you desire to make any type of temperature adjustment during the event. We appreciate your participation and our goal is to keep you comfortable while reducing electricity demand.

Please let me know if you have any questions,

Regards, Keith

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national**grid** | Energy Efficiency
40 Sylvan Road | Waltham, MA 02451
keith.miller2@nationalgrid.com | (781) 907-2241

Heat Pump Clothes Dryer Technical Demonstration

August 7, 2015

National Grid
40 Sylvan Road
Waltham, MA

Eversource Energy
One NSTAR Way
Westwood, MA

The Cadmus Group, Inc.
An Employee-Owned Company • www.cadmusgroup.com

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CADMUS

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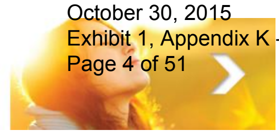
Cadmus



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Introduction

Heat pump dryers (HPDs) are a plug-and-play alternative to conventional electric resistance dryers (ERDs) and can reduce clothes dryer energy consumption and electrical demand without changing consumer habits. A heat pump dryer reduces energy consumption by recycling the warm air that it produces. Rather than venting heat and moisture to the outside of the house like a conventional electric resistance dryer, the HPD extracts heat and moisture from the air leaving the dryer drum and adds that heat to the airstream entering the drum.

National Grid and Eversource Energy (the Companies) contracted Cadmus to examine HPDs as a potential product offering for their energy-efficiency programs. Cadmus conducted a technology demonstration to achieve these objectives:

1. Measure the energy consumption and performance of the heat pump dryer in participant single-family households;
2. Estimate the energy and demand impacts of the heat pump dryer compared to various baseline scenarios;
3. Examine the interactive impacts of the heat pump dryer on cooling and heating energy consumption;
4. Survey participants regarding their experience and satisfaction with the new dryer; and
5. Identify the energy impacts of different user settings to support educational material about optimizing equipment performance.

Between November 2014 and January 2015, Cadmus conducted data collection and analysis on six *in situ* heat pump dryer installations in Massachusetts and Rhode Island and two *ex-situ* installations in Cadmus' testing laboratory. Cadmus then performed additional *ex situ* performance testing on a second HPD model. In total, Cadmus analyzed 102 *in situ* loads of laundry to establish the baseline (pre-replacement) conditions, 191 *in situ* loads of laundry to establish the technological impact (post-replacement) conditions, and 36 to 40 *ex situ* loads of laundry for each of the two HPD models to establish the lab testing segment of this demonstration. Cadmus also conducted surveys for the *in situ* participants to examine the user experience and satisfaction with the HPD technology.

This report describes the methods, results, and Cadmus' findings and recommendations from this HPD technology demonstration.

Methods

To examine the energy performance of heat pump dryers (HPDs), potential energy and demand savings compared to electric resistance dryers, and customer satisfaction, Cadmus completed pre- and post-installation *in situ* metering at six single-family households, *ex situ* or laboratory testing on two HPD models, and surveys with the six *in situ* participants.

In this report, we refer to the original HPD model, for which we performed both *in situ* and *ex situ* testing, as "Model A" or "HPD-A" and to the second HPD model, for which we performed *ex situ* testing only, as "Model B" or "HPD-B."

In Situ Pre/Post Data Collection

Cadmus completed pre-installation and post-installation *in situ* metering at six single-family households (participants) in Massachusetts and Rhode Island to (1) examine and compare the energy performance of existing electric resistance dryers (ERD) and new HPDs and (2) collect information on the typical laundry load characteristics and user settings.

Figure 1 describes the *in situ* data collection process for each participant. All six participants were recruited by National Grid and received a new front-loading washing machine and HPD for their participation in six weeks of performance testing. To maintain the comparability of post-installation performance, we used the same washer and HPD models for all participants.

Figure 1. Process for *In Situ* Data Collection

Install Metering Equipment

To start the *in situ* activities, Cadmus visited each participant home to collect information on the existing appliances, install our data collection equipment, and instruct participants on the pre-installation data collection process. We provided each participant with a laundry basket, scale, and a pre-installation data collection form (Appendix A).

Table 1 lists the information Cadmus collected for each appliance.

Table 1. Data Collection Points – Equipment Specifications

Equipment	Clothes Washer	Clothes Dryer	Water Heater
Make/Model	X	X	X
Age or Manufacture Date	X	X	X
Vented to Outside (Y or N)	n/a	X	n/a
ENERGY STAR® Label (Y or N)	X	n/a	X
Front- or Top-Loading	X	n/a	n/a
Fuel	X	X	X

Table 2 lists the data collection points and metering equipment that Cadmus installed for each home. Figure 2 (page 11) shows the metering equipment installed on the new clothes washer and HPD.

Table 2. Data Collection Points – Metering

Equipment	Parameter (Units)	Measurement Equipment	Data Logger	Logging Interval and Type
Dryer	Power (W)	kWh transducer*	Onset Hobo U30	1-min, average
Washer	Power (W)	(Integrated into data logger)	Onset Plug Load Data Logger (UX120-018)	1-min, average
Washer	Hot water temperature (°F)	Onset S-TMB*	Onset Hobo U30	1-min, average
Washer	Cold water temperature (°F)	Onset S-TMB*	Onset Hobo U30	1-min, average
Washer	Hot water flow (gpm)	Omega FTB-8000*	Onset Hobo U30	1-min, average
Washer	Cold water flow (gpm)	Omega FTB-8000*	Onset Hobo U30	1-min, average
Ambient air	Temperature (°F) and relative humidity (%)	Temp/RH logger	Onset Hobo U30	1-min, average

* Cadmus custom meter

Collect Pre-Installation Data

Over two weeks in October and November, our installed data loggers recorded data on the homeowners' existing clothes washer and ERD. During this period, the participants recorded laundry weights (dirty, wet, and dry), machine settings, and date/time of load using Cadmus' laundry log.

One site (Newton) did not operate its existing washer or dryer during this period so we could not collect pre-installation data at this site.

Install New Washer and Heat Pump Dryer

At the end of the pre-installation period, the HPD manufacturer's technicians installed a new clothes washer and new HPD at each participant household. A Cadmus technician accompanied the manufacturer technician to download the pre-installation data and ensure correct placement and operation of the logging equipment on the new appliances. Figure 2 displays the metering equipment installed on the new washer and heat pump dryer.

Figure 2. Metering Equipment with New Washer and Heat Pump Dryer

We observed several installation or user requirements unique to the HPD installation and use:

- **HPD condensate line:** The HPD contains a condensate line to purge the moisture removed from the dryer air. The condensate line is typically connected to the same drain used by the clothes washer discharge or a nearby utility sink. For two sites with the appliances located in the basement, the existing drain was higher than allowed by the design of the HPD condensate pump. To solve this issue at one site, the manufacture used a pedestal to increase the height of the machine relative to the existing plumbing (Figure 2). At the second site, the manufacturer temporarily used a five-gallon bucket to receive the HPD condensate with a submersible booster pump to connect to the existing plumbing drain. For a permanent solution, the manufacture installed an elevated condensate pump to receive the HPD condensate and pump it to the existing drain plumbing.
- **Ventless model**: Because the HPD recycles the dryer air, it does not require a vent like standard ERDs. Removing the need for a dryer vent allows for more flexibility in the location of the dryer. However, as discussed in later in this report, the location of the dryer in an open or enclosed space may have a substantial impact on the HPD energy performance.
- **Secondary lint filter**. The HPD model includes a secondary lint filter, in addition to the lint screen, located below the main dryer door. The appliance manual recommends that the user clear this additional filter after every fifth cycle or as prompted by an indicator light.

Collect Post-Installation Data

For a minimum of four weeks, our installed data loggers recorded performance data on the new washer and HPD. During the post-installation period, participants documented laundry weights, machine settings, and satisfaction ratings using an online form provided by the appliance manufacturer.

At the end of the post-installation period, Cadmus returned to each site to remove and download the data loggers. We also collected the post-installation laundry data from the manufacturer's online forms.

Conduct Participant Survey

Cadmus developed a survey to examine participant experiences with the dryer technology and to inform program design recommendations for a HPD rebate program. (The survey instrument is included in Appendix B.) At the end of the post-installation period, we e-mailed each participant a link to the online survey and asked participants to complete the survey within seven days.

Ex Situ (Laboratory) Testing for HPD-A

To supplement the *in situ* data and examine the HPD performance under controlled conditions, we performed a series of *ex situ* tests on HPD-A, the same washer and HPD equipment used in the *in situ* post-installation testing.

We installed HPD-A and the new clothes washer in our Waltham, Massachusetts laboratory and designed a testing protocol to demonstrate the impact of various parameters – such as dryness level, termination, and textile type – on dryer performance and energy consumption.

Figure 3 describes the key steps in our laboratory testing.

Figure 3. Laboratory Testing Procedure

Install Metering Equipment

We installed the same metering equipment that we used for the *in situ* testing (Table 2) on the new washer and heat pump dryer in our laboratory.

Define Control Conditions

We compiled a uniform load of laundry for the laboratory test runs, basing the load composition on the AHAM/ANSI HLD-1-2010 standard *Household Tumble Type Clothes Dryers* and the Department of Energy (DOE) Appendix D2 *Uniform Test Method for Measuring the Energy Consumption of Clothes Dryers*, with supporting information gathered from a review of publicly available literature. Our literature review included documents published in the ACEEE Summer Study on Energy Efficiency in Buildings (2014) and by the National Resources Defense Council (2011).

Condition Laundry Load

We pre-conditioned and normalized the test load based on the AHAM/ANSI HLD-1-2010 standard procedure. We then performed the subsequent bone-drying procedure within an electric resistance clothes dryer under both the AHAM/ANSI HLD-1-2010 and DOE Appendix D2 standards.

CADMUS

Define Test Load Procedure

To identify the performance and energy impacts of different load characteristics or user settings, we designed a series of test runs to modulate various parameters while holding other parameters constant. Based on guidelines in the previously noted literature, we toggled the following options on the laboratory heat pump dryer to examine performance and help guide our customer recommendations for dryer energy use minimization:

- Weight of Clothing: 4.5, 8.45, and 15 pounds;
- Cycle Type: *Normal* and *Timed Dry*;
- Energy Options: *Eco*, *Balanced*, and *Speed*;
- Temperature Options: *Extra Low*, *Low*, *Medium*, and *High*;
- Dryness Level: *Less*, *Normal*, and *More*; and
- Termination: *Auto* and *Monitored* (based on DOE Appendix D2, Section 3.3.1).

Table 3 describes the combinations of parameters we designed for this testing.

Table 3. Test Run Specifications for *Ex Situ* Testing (HPD-A)

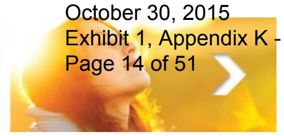
Load Size	Cloth Dimension		Cycle Type		Energy Options			Temp				Dryness Level			Termination	
	2D	3D	Normal	Timed Dry	Eco	Balanced	Speed	Extra Low	Low	Medium	High	Less	Normal	More	Auto	Timed / Monitored
4.5	■		■			■				■			■		■	
	■		■				■			■			■		■	
	■		■			■				■				■	■	
	■		■			■				■			■		■	
	■		■			■				■		■			■	
	■		■		■					■			■		■	
8.45	■			■		■					■					■
	■			■		■				■						■
	■			■		■			■							■
	■			■		■		■								■
		■	■			■				■			■		■	
15	■		■			■				■			■		■	

Conduct Iterative Test Loads

We ran each test three times to decrease the impact of external variation and with a single test load to decrease variations in cloth composition. In total, Cadmus analyzed 36 test laundry loads for HPD-A and 40 test laundry loads for HPD-B.

HVAC Interaction

We examined primary and secondary data to estimate the interactive impacts of the HPD on household cooling and heating energy consumption. We examined the measured ambient temperature at each participant's home to determine typical ambient temperatures and used laboratory air flow values to estimate expected makeup air requirements for a vented dryer.



We compared the typical ambient temperatures inside participant homes to the typical meteorological year (TMY) weather data to estimate the energy needed to condition the makeup air for a vented dryer, then used heating and cooling periods of to estimate impacts of ventless dryers on household HVAC consumption compared to typical vented dryers.

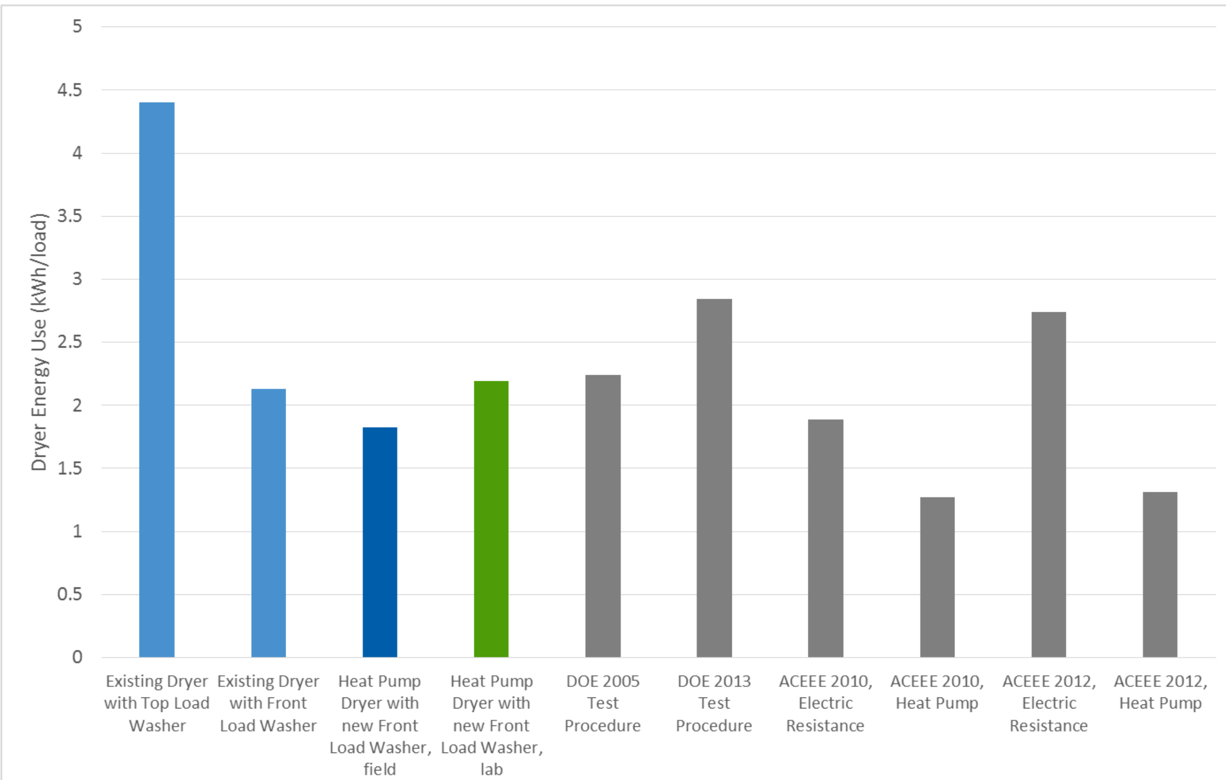
Based on this analysis, there is no significant change in the HVAC load within vented clothes dryers. The data gathered for this study confirms a marginal (2%) savings of the ventless dryer on household annual HVAC energy consumption. While heat pump clothes dryers do increase the local temperature and humidity during and shortly after a load of laundry, these effects have little impact on the home's energy use due to the duration of the laundry cycle and the variation in outside temperatures. Overall, the net of the additional heat rendered by the ventless heat pump dryer is beneficial to the household due to the offset of heating required during the winter in a heating dominated climate.

Results

In this section we compare the average *in situ* performance to the results from other studies or specifications, examine the energy and savings performance of the heat pump dryer (HPD) installations at each participant home, and discuss results of the participant satisfaction surveys.

Figure 4 compares the overall dryer performance results from this study (left four columns) to other HPD performance values available in literature (right six columns). In this figure and throughout the report, a light blue color denotes field testing of existing ERDs, a dark blue denotes field testing of HPDs, a dark green color denotes laboratory testing of the HPD, and a gray color denotes information from the literature review.

Figure 4. Comparison of Average HPD Energy Performance



Estimated Annual Energy Performance

In this study, we estimate the annual energy savings potential for heat pump dryers by comparing the per-load energy consumption of the baseline and HPD, estimating the number of dryer loads performed each year, and comparing the annual standby energy required for each model.

We calculate the annual savings using the following formula:

$$\Delta kWh = (kWh_{ERD} - kWh_{HPD}) \times Loads + (SBE_{BASE} - SBE_{HPD})$$

where:

kWh_{ERD}	= the average per-load energy consumption of the baseline ERD (kWh/load)
kWh_{HPD}	= the average per-load energy consumption of the HPD (kWh/load)
$Loads$	= the estimated total number of dryer loads performed each year (loads/year)
SBE_{BASE}	= the total annual standby energy of the baseline dryer (kWh/year)
SBE_{HPD}	= the total annual standby energy of the heat pump dryer (kWh/year)

Baseline Energy Consumption

To determine the energy savings for various replacement scenarios, we examined multiple baseline conditions. Table 4 presents baseline values from this study and literature for average ERD per-load energy consumption.

Table 4. ERD Energy Consumption

Baseline Condition (Source)	kWh_{ERD} (kWh/load)	Average Power (kW)	Max Power (kW)
This Study			
Existing ERD with top-loading (vertical axis) washer (n=2)	4.46	4.12	5.43
Existing ERD with front-loading (horizontal axis) washer (n=3)	2.17	2.07	4.76
Weighted average existing ERD in MA (n=5) [1]	3.84	3.63	5.27
Literature Review			
ACEEE 2010	2.85	UNK	UNK
ACEEE 2012	2.74	UNK	UNK
Federal minimum requirement for ERD (1994)	2.81	UNK	UNK
Federal minimum requirement for ERD (2015)	2.27	UNK	UNK
ENERGY STAR® minimum requirement for ERD (2014)	2.15	UNK	UNK

Note: These consumption results do not include standby power
[1] Weighted based on percentage of front-loading (24.75%) and top-loading (75.25%) clothes washers in MA

We calculated a weighted average energy consumption for the *in situ* existing dryers using market share information about the percentage of top-loading washers and front-loading washers from the Massachusetts Residential Appliance Saturation Survey and the Massachusetts data given in the US Residential Energy Consumption Survey.

To compare the values using consistent units (average kWh per load), we modified some values via a load-based average using the DOE's currently accepted value of 283 loads per year or converted values from an Energy Factor (pounds per kWh) using the DOE's standard weight of 8.45 lbs.

Heat Pump Dryer Energy Consumption

Table 5 shows the average HPD per-load energy consumption from this study and other sources.

Table 5. HPD Energy Consumption

HPD Condition (Source)	kWh_{HPD} (kWh/load)	Average Power (kW)	Max Power (kW)
This Study			
Average of all *in situ* HPDs (n=6)	1.83	1.74	2.76
Average of *in situ* HPDs, not including Newton site (n=5) [1]	1.71	1.63	2.74
Literature Review			
Estimate based on HPB-A performance specifications [2]	1.82	1.52	UNK
Estimate based on HPB-B performance specifications [3]	1.94	2.01	UNK
ACEEE 2010	1.27	UNK	UNK
ACEEE 2012	1.31	UNK	UNK

[1] We provide an average performance value excluding Newton due to the enclosure issues discussed on page 23.
[2] ENERGY STAR® QPL lists these ratings for HPD-A: CEF = 4.5; Annual consumption = 531 kWh/year; and average cycle time = 71 minutes. We estimated kWh/load and average kWh using 1.89 W of standby power (see page 31) and the DOE standard of 283 loads/year.
[3] ENERGY STAR® QPL lists these ratings for HPD-B: CEF = 4.3; annual consumption = 556 kWh/year; and average cycle time = 58 minutes. We estimated kWh/load and average kWh using 0.76 W of standby power (see page 31) and the DOE standard of 283 loads/year.

Annual Loads

Table 6 provides values to estimate the annual dryer loads per year. Although the six participants in this study completed an average 0.95 loads per day (346 loads per year), the DOE protocol for estimating annual energy consumption specifies 283 loads per year.

Table 6. Dryer Annual Loads

Source	Annual Loads (loads/year)
This study	**346**
DOE	283
ACEEE 2010	285

In Situ Dryer Performance

Over six weeks of *in situ* data collection, Cadmus measured the performance of 293 ERD (pre-installation) loads and HPD (post-installation) loads. Table 7 shows the ERD existing washer type and install location for the clothes dryer for each site.

Table 7. *In Situ* Testing Locations and Notable Characteristics

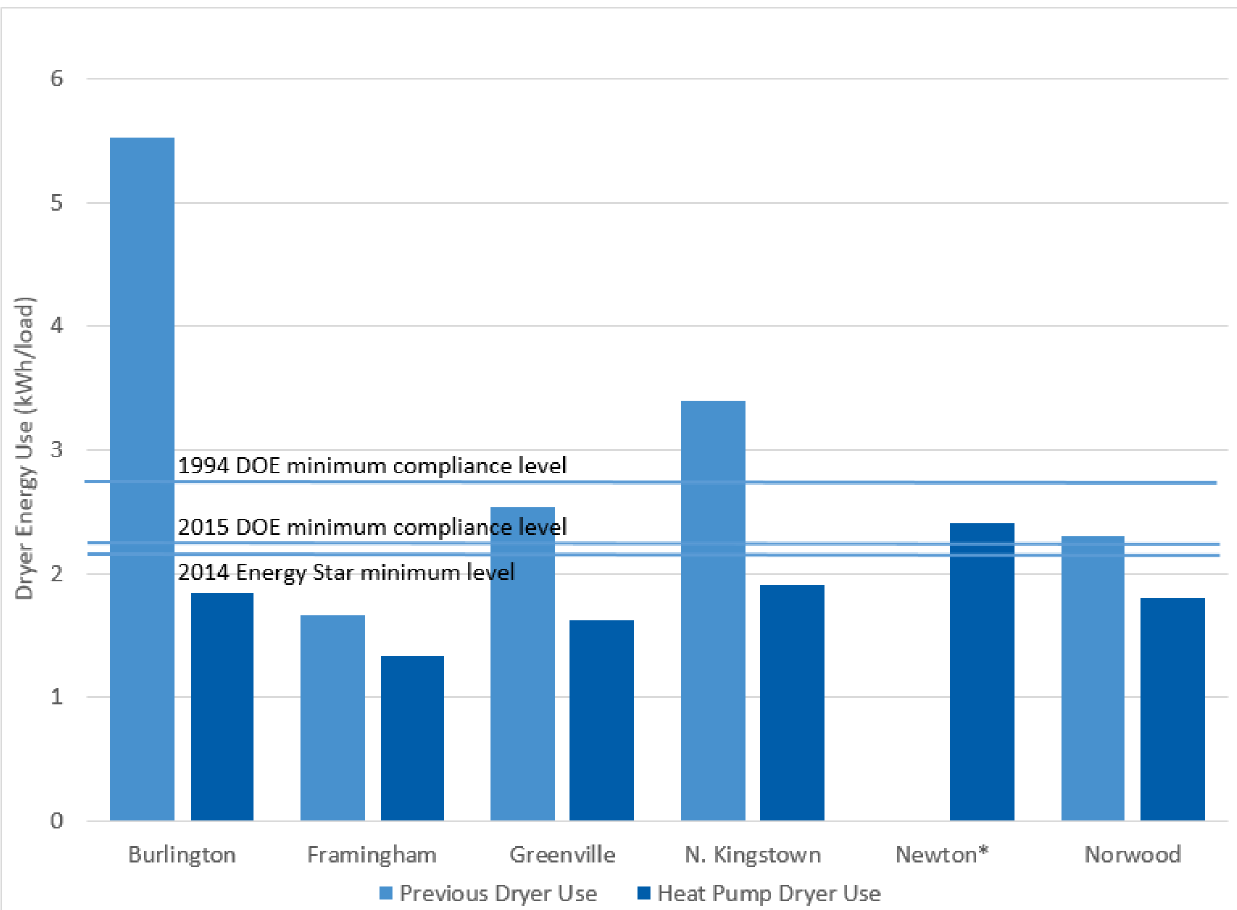
Site	Existing Washer Type	Clothes Dryer Location
Burlington, MA	Top-Loading	Open Area
Framingham, MA	Front-Loading	Open Area
Greenville, RI	Front-Loading	Open area
N. Kingstown, RI	Top-Loading	Open Area
Newton, MA [1]	Front-Loading	Closed Area
Norwood, MA	Front-Loading	Open Area

[1] The participant did not operate the washer or dryer during the pre-installation period, so we do not have baseline ERD measurements for this site.

Average Load Performance per Site

Figure 5 shows the average per-load kWh consumption and savings for each participant site.

Figure 5. Average Per-Load Dryer Energy Use and Savings



* The participant did not operate the washer or dryer during the pre-installation period.

All sites demonstrated a reduction in dryer energy consumption between the existing ERD and the new HPD, but the magnitude of the savings varied.

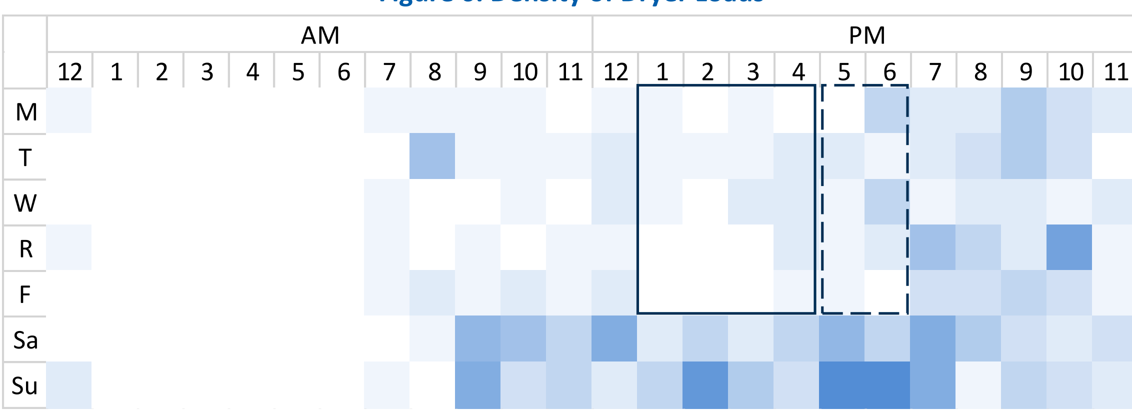
We observed the largest reductions in dryer energy consumption at the Burlington and N. Kingstown sites, the two households with top-loading, vertical-axis clothes washers. Although the HPDs at these sites performed similarly to the other sites, the Burlington and N. Kingstown ERDs demonstrated the highest average ERD consumption and operated above the 1994 DOE minimum compliance level. The high ERD consumption is likely due to high moisture content in the loads washed with the existing top-loading clothes washers. Similarly, the large reduction in dryer energy use (compared to other sites) is likely due to the replacement of the existing top-loading washer with the new front-loading washer.

At all sites except for the Newton site, the HPD performance exceeded 2014 ENERGY STAR® compliance levels. (We discuss possible reasons for the higher average HPD consumption observed at the Newton site on page 23.) The average HPD consumption ranged from 1.34 kWh/load (Framingham) to 2.41 kWh/load (Newton) with the varied performance due to varied load conditions (e.g., load material and weight) and operating settings (e.g., dryer modes and dryness setting) at participant homes.

Time of Day Operation

Figure 6 shows a frequency map illustrating the time-of-day operation of the *in situ* clothes dryers. The darker colors indicate more frequent dryer operation during that hour.

Figure 6. Density of Dryer Loads



Note: Data include dryer operation during both the pre-installation and post-installation periods. Solid line box is summer peak period (1-5 p.m. M-F). Dash line box is winter peak period (5-7 p.m. M-F).

Participants completed more than half of all dryer loads (152 of the 293 recorded loads) on Saturdays and Sundays, with the most frequent operation between 5:00 and 7:00 p.m. on Sundays. During the weekdays, Thursday evening had the most loads (23 of the 293 loads).

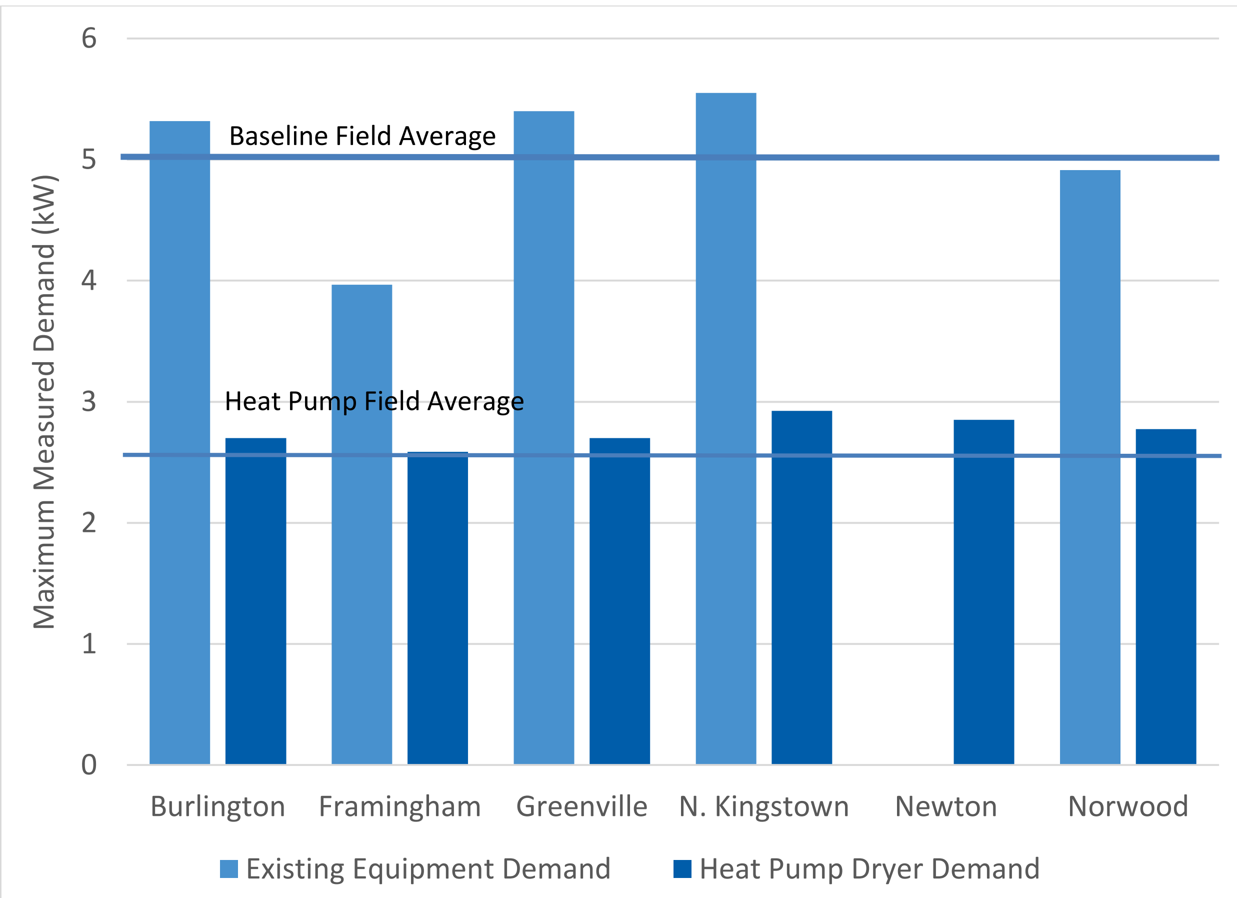
For the purposes of energy-efficiency program reporting in Massachusetts and Rhode Island, the summer on-peak period is defined as 1:00 to 5:00 p.m. Monday through Friday during summer months. The winter on-peak period is defined as 5:00 to 7:00 p.m. Monday through Friday during winter months. Assuming the use pattern measured does not change throughout the year, the data show infrequent operation during the summer and winter on-peak periods. Most loads occur on the weekends outside of both the summer and winter peak periods.

These frequency and coincidence data are based on the usage of the six program participants, all of whom work at National Grid and may not represent a future energy-efficiency program population. Still, the low coincidence results are consistent with previous research studies that indicate low usage during system peak periods.

Maximum Power Demand

Figure 7 illustrates the maximum measured demand for both the existing ERDs and the new HPDs at each site.

Figure 7. Maximum Measured Demand (kW)



Note: The Newton site did not operate its ERD during the pre-installation period.

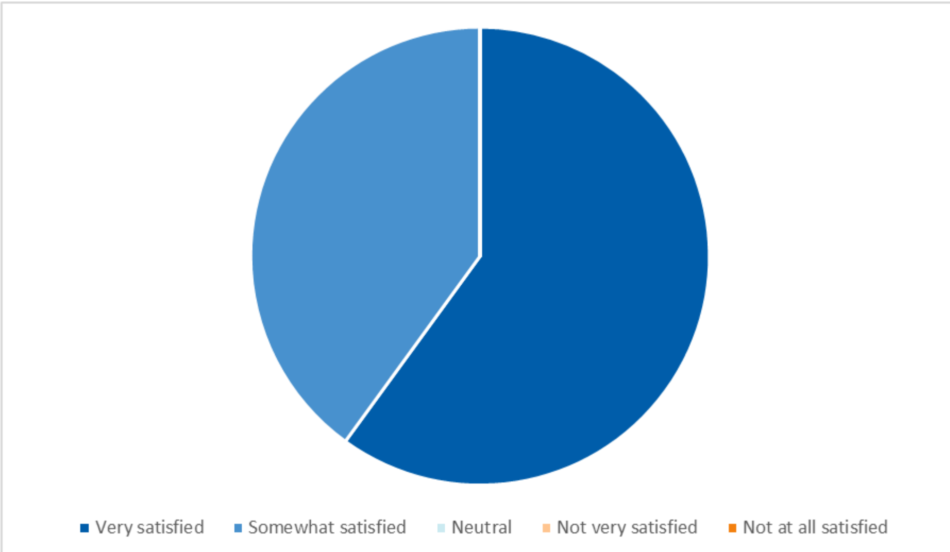
Compared to the existing electric resistence dryers, the *in situ* HPDs achieved an average maximum measured demand reduction of 2.79 per unit (up to a 50% reduction).

Customer Satisfaction

Cadmus examined the survey data from Cadmus' post-installation online survey (see Appendix B) and the manufacture's laundry logs to assess the participant experience and satisfaction with the new heat pump dryer. Five of the six participants responded to our survey.

All survey participants indicated that they were satisfied with their heat pump clothes dryer (Figure 8).

Figure 8. Participant Satisfaction Levels



The survey also assessed participant satisfaction with differences between both of the technologies (old electric and new HPDs) in areas relating to functionality, ease of use, and additional characteristics of HPDs.

Principal complaints arise from the presence and perceived integrity of the secondary lint filter. One participant also noted concerns regarding the durability of the external condensate water pump required in some installations, particularly in basements.

Despite these concerns, participants' overall satisfaction with the new HPD outweighed that of any changes in drying duration, dryness levels, or ergonomics from participants' previous models.

Factors Influencing Energy Savings

In this section, we describe the factors that influence dryer energy use based on findings from the *in situ* and laboratory testing of the same HPD model. The next chapter presents the results of laboratory testing on a different HPD model (not included in the *in situ* testing) and compares the laboratory results of the two lab-testing HPD models.

Clothes Washer Axis

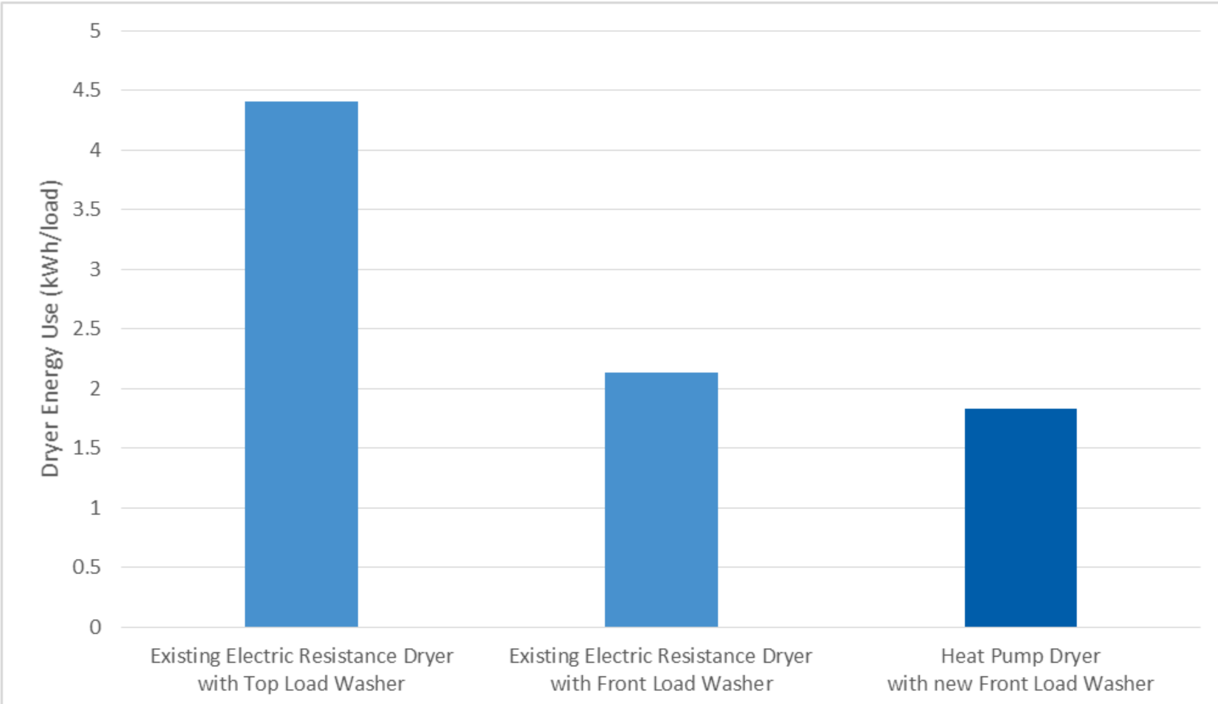
A majority of the dryer energy savings may be attributable to a change in washer orientation. A top-loading or vertical-axis clothes washer historically has been the dominant design in the United States. However, a front-loading or horizontal-axis clothes washer design is more common for commercial washers and today's high-performance residential washers. A horizontal-axis washer has higher spin speeds than a vertical-axis machine, removing more residual water from the clothes.

Figure 9 illustrates the impact of the clothes washer axis on clothes dryer energy consumption by showing the average dryer energy use in the three categories:

1. The existing ERD with the existing top-loading washer,
2. The existing ERD with the existing front-loading washer, and
3. The new HPD with a new front-loading washer.

The first and second columns show the impact of a change in clothes washer orientation on dryer energy use. Comparing the second and third columns demonstrates the energy savings attributable to the change in clothes dryer technologies.

Figure 9. Impact of Washer Axis on Dryer Energy Use



The average energy savings achieved by the HPD with a new front-load washer is 2.63 kWh per load compared to an existing ERD with top-load washer, but only 0.34 kWh per load compared to an existing ERD with a front-load washer. Although the sample size for this comparison is small (293 loads of laundry at six *in situ* test sites), Cadmus' previous clothes washer studies and available literature also emphasize the influence of clothes washer axis on the energy required to dry the load.

The difference between the two washer groups used in this study comes down to the fact that a horizontal-axis, front-loading washer is able to spin more water from the clothes than a vertical-axis, top-loading washer. Furthermore, Tomlinson et al. documents that the conversion from a vertical-axis washing machine to a horizontal-axis washing machine will save, on average, 1.3 kWh per load of washer energy (58%).[1] The combination of lower water use and a higher spin rates in horizontal-axis washing machines also yields clothing with less moisture, leaving the clothes dryer to do less work (energy) on the clothes.

Dryer Location

The *in situ* HPD performance data indicate that the position of the clothes dryer within an enclosed area may degrade the performance of the HPD. The Newton participant located its dryer in an enclosed closet and, due to noise levels, operated the dryer with the closet doors closed. This placement was not in compliance with the manufacturer's installation instructions for minimum ventilation openings for a

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[1] Tomlinson, J.J. and Rizy, D.T. "Bern Clothes Washer Study." Final Report. 1998. Available online: http://dc.doi.org/10.2172/633967

closet installation. This type of operation places the unit in an enclosed operating environment, which taxes the dryer due to the non-vented nature of the appliance.

The Newton HPD averaged 2.41 kWh per load, or 41% more energy than the 1.71 kWh per load average used at the households that located the dryers in open spaces. We used load weight data to examine the impact of moisture content on dryer energy consumption and found that the Newton site used 52% more energy per weight of water removed (kWh/lb-H_2O) than the five other sites. This result indicates that higher energy use of the Newton dryer was not due higher levels of moisture removed during the dryer cycle. Because the Newton home was unoccupied during the pre-installation period, no data were available to examine the Newton baseline dryer performance.

Despite the poorest performance among other heat pump dryers, the Newton HPD (paired with the new front-load washer) still performed better than the average existing ERDs with top-load washers.

Load Weight

Figure 10 compares the frequency distribution of the *in situ* load weights (293 total loads) to the laboratory testing weights. Based on participant records, the median load weight (8.8 pounds) was similar to the main testing weight (8.45 pounds). The average participant load weight was 9.31 pounds.

Figure 10. Load Weight Frequency Distribution

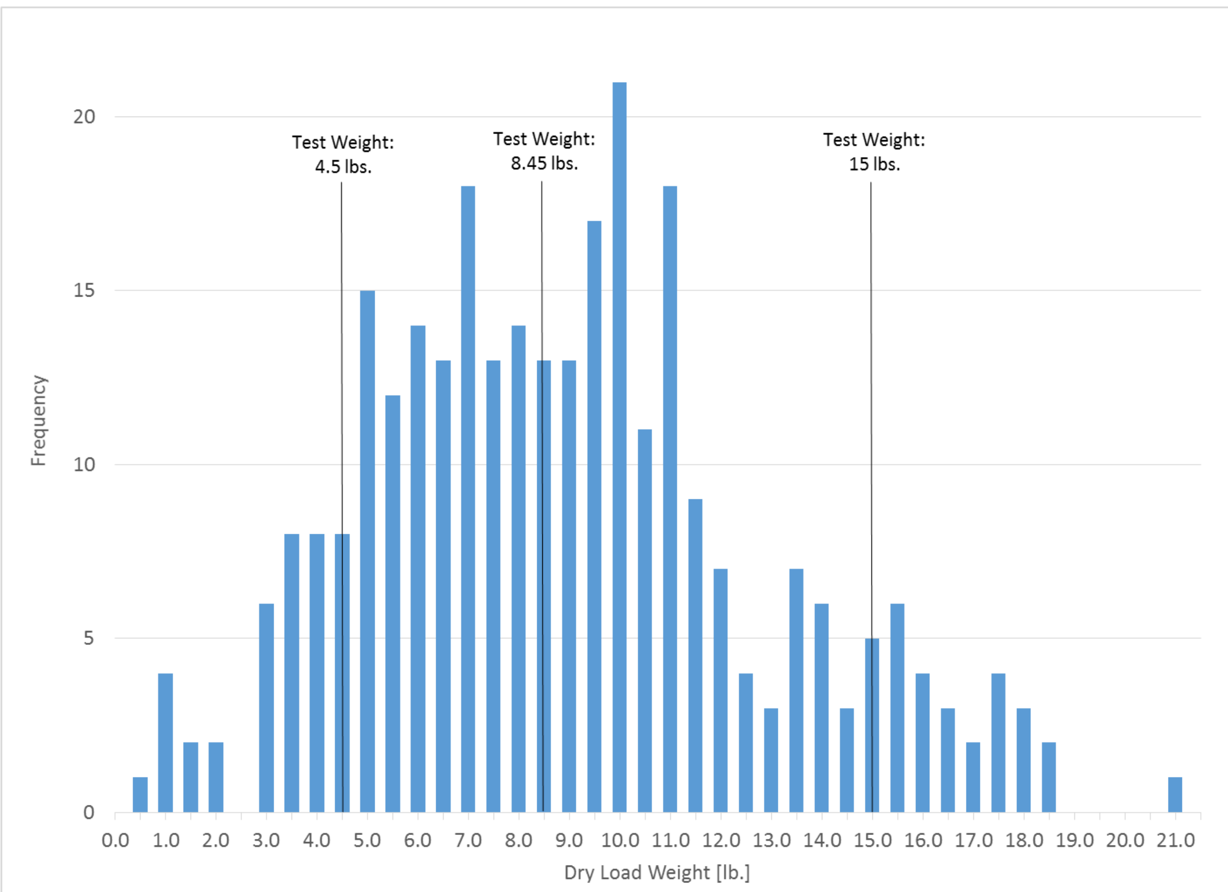
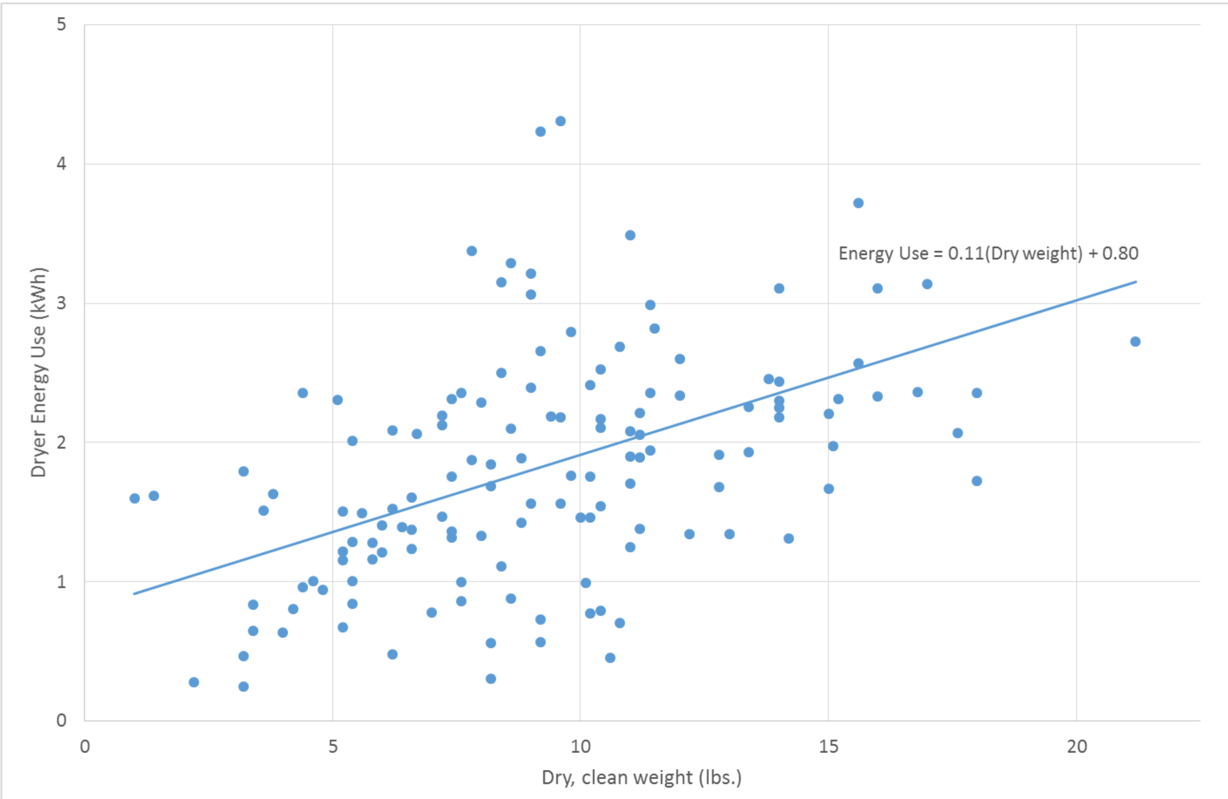


Figure 11 plots the dry load weight against the dryer energy use for the loads monitored during the *in situ* data collection period. The data indicate a wide variety of load weights and a loose correlation between load weight and dryer energy consumption.

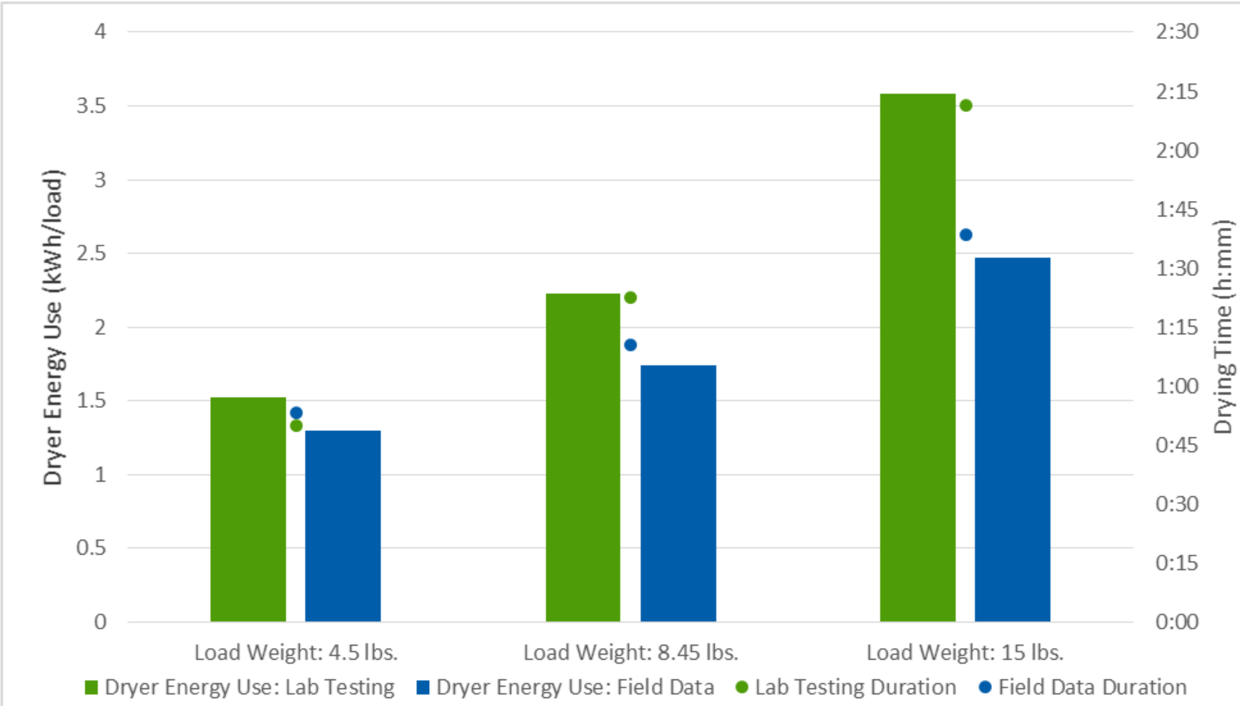
Figure 11. Dry Load Weight vs. Dryer Energy Use



Despite the scatter, the load data demonstrate that heavier laundry loads require more energy. The scatter is due to other factors that influence dryer energy consumption and are not controlled in the *in situ* environment. The data reveal that, on average and in a typical household environment, the incremental additional energy required to dry each additional pound of laundry is roughly 0.11 kWh per pound of dry load.

Figure 12 compares the average *in situ* results with the lab testing results.

Figure 12. Dryer Performance vs. Load Weight



The laboratory loads (green bars) consistently used more energy than the *in situ* loads (blue bars), with an increasing differential as the weight of the load increased. It is likely that the relative dominance of cotton towels in the test load contributed to this increasing variance. The conformity of the data at lower load weights suggests the amount of energy required to simply operate the cycle, independent of the weight of the laundry load. The linear relationship of Figure 11 suggests this amount of 0.80 kWh.

Dryness Level Setting

The HPD test model offers three dryness level settings: *Less*, *Normal*, and *More*. The *Less* setting would have a higher remaining moisture content in the clothes than the *Normal* setting. The *More* setting would have a lower remaining moisture content in the clothes than the *Normal* setting. When using automatic cycles, the dryness level can be selected. The automatic cycles are the equivalent of a macro which, given the cycle category, specifies default values such as drying temperature or energy options. The manufacturer defines automatic cycles as *Normal*, *Bulky*, *Heavy Duty*, *Towels*, *Delicates*, and *Casual*. The *Normal* setting is the default dryness level for five out of the six automatic cycles, although the user can override the dryness level to other settings.

Figure 13 shows the participant-reported values for the dryness setting selection. For the majority of the time, participants used the default *Normal* setting. Although the average load under this option takes longer than the existing equipment, none of the survey respondents stated that they were dissatisfied with the drying time of their new heat pump clothes dryer.

Figure 13. *In Situ* Dryness Level Setting Selection

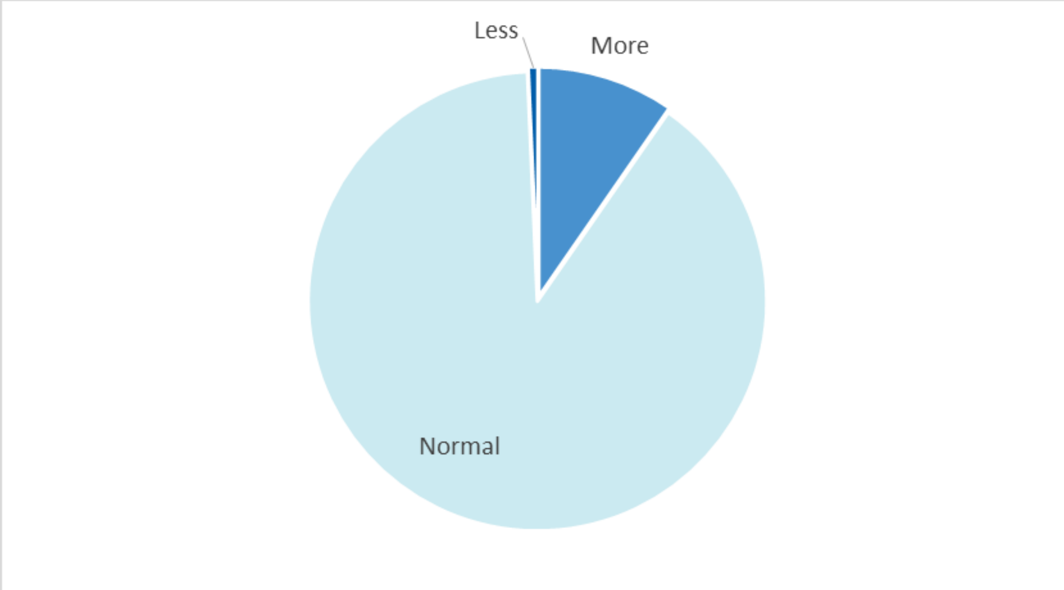
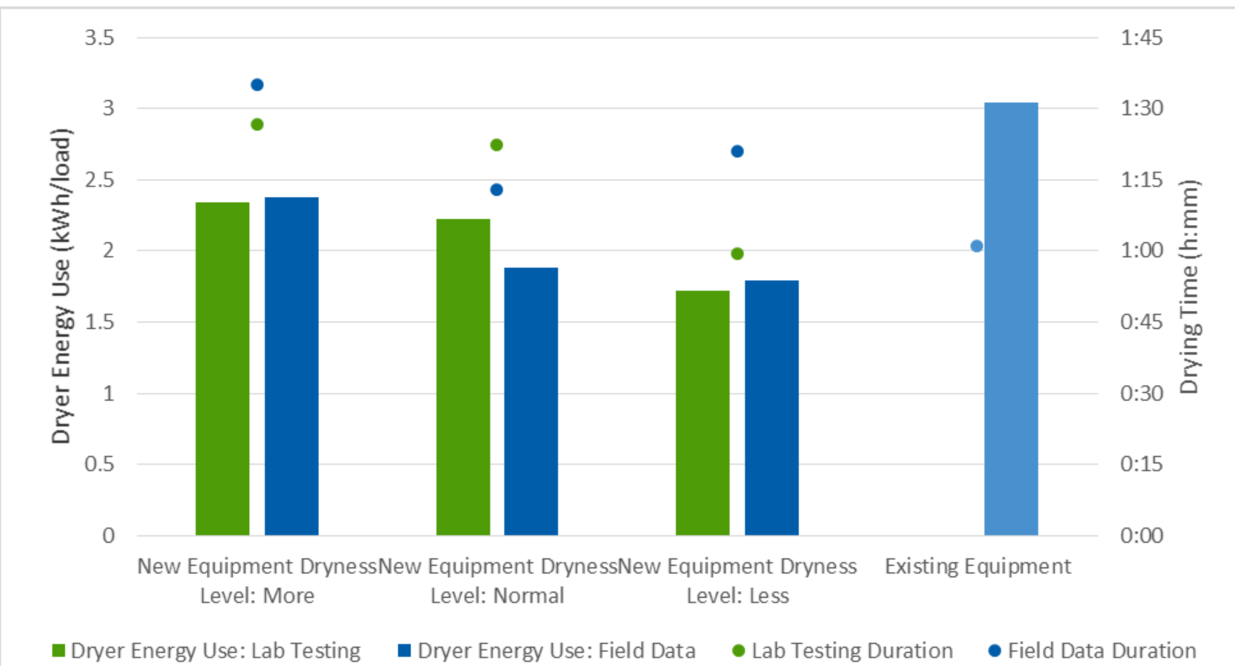


Figure 14 shows the impact of the dryness setting on dryer performance based on laboratory test loads. In each group, the left column shows the results of lab testing, and the right column shows the results of cross-referencing the field data with the participant self-reported drying logs. For comparison, the rightmost bar shows the average energy use and drying time for the *in situ* electric resistance dryers. The small circles indicate the drying time.

Figure 14. Dryer Performance vs. Dryness Level Setting



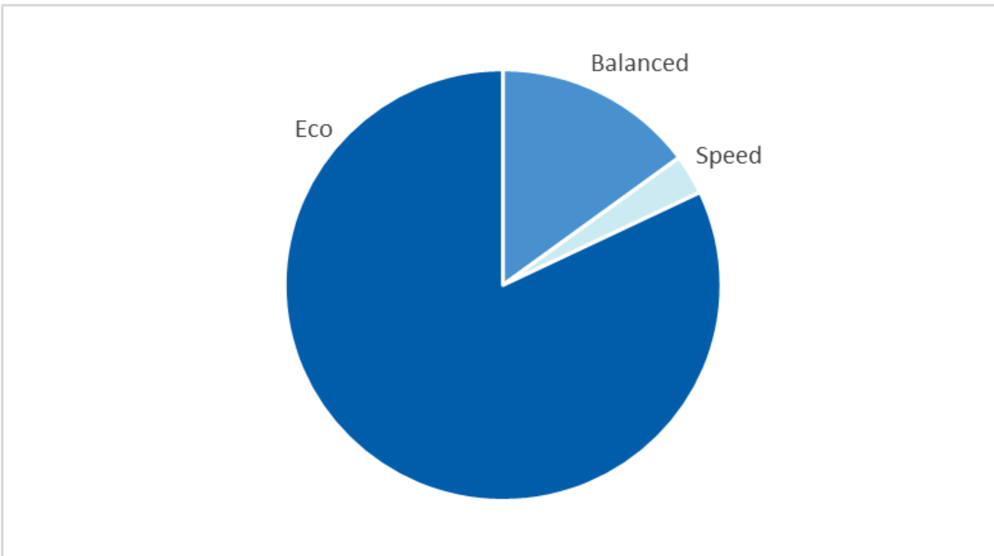
Decreasing the dryness level (i.e., decreasing the required moisture removal) reduces dryer energy use. The *More* setting consumed 3.7% (0.083 kWh) more energy and took 5.5% (four minutes) longer than the *Normal* setting, but resulted in similar residual moisture content to the *Normal* setting. In contrast, the *Less* setting saved 22.3% (0.498 kWh) of energy and 28% of drying time compared to the *Normal* setting, with an increase of 2.8% in the residual moisture content. For all tests, we used the auto-termination function of the machine.

Energy Option Setting

The HPD test model offers three energy option settings: *Eco*, *Balanced*, and *Speed*.

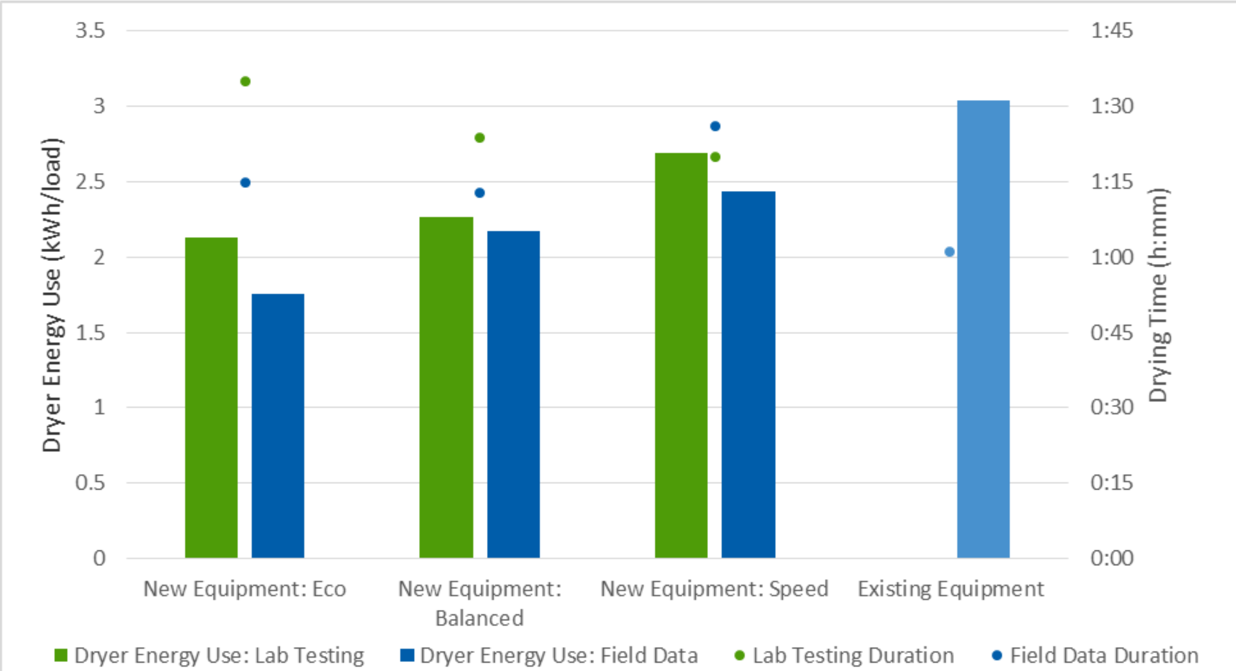
Figure 15 shows the distribution of participant-reported energy option selections. Participants reported using the *Eco* mode often (82%), followed by the *Balanced* mode (15%), and then the *Speed* mode (3%).

Figure 15. Economy Mode Selection



Cadmus ran several tests to evaluate the energy use and duration of different loads. We ran all loads with the 8.45-lb test load. Figure 16 shows the energy use and dryer times of the different economy settings both in the field and in the laboratory.

Figure 16. Dryer Performance vs. Energy Option Setting



The laboratory tests confirmed that the *Eco* mode is the most efficient in terms of kWh used per load (2.13 kWh per load), followed by the *Balanced* mode (2.27 kWh per load), and then *Speed* mode (2.69 kWh per load). With the energy option lab tests all run with the same weight load, we confirmed the inverse relationship between drying time and energy use.

The high use of the *Eco* mode selection a good indicator of overall consumer settings that influence the duration of the drying time per load. Even though the *Eco* mode requires 25% more time than the homeowners' existing ERDs, participants favored it over the faster energy options. Since it is the manufacturer's default setting, its high *in situ* use is influenced by it being positively programmed into the design.

Cloth Dimension: 2D vs. 3D

Unlike simple fabrics, clothing is multi-dimensional. With pockets, hoods, collars, and sleeves, both sides of the fabric used in clothing are unlikely to be exposed to the rotating drum of the clothes dryer. However, the AHAM/ANSI load composition includes bed linens, pillowcases, and towels; these items are largely two-dimensional, heavily water-absorbent, and not representative of most consumers' laundry loads. The multi-dimensional aspect of consumer laundry loads has been noted in the literature, but there is not a uniform testing methodology known to the authors at the writing of this report.

To fill this gap, Cadmus conducted laboratory tests using a mix of heavyweight short-sleeved polo shirts with embroidery and long-sleeved shirts without buttons or embellishment. When we compared the results of these tests, we found the three-dimensional loads consumed 0.27 kWh (11%) less energy and took 5 minutes longer to dry the load. This helps to explain why *in situ* loads (composed of complex, 3D fabrics) consistently use less energy than the lab loads (based on a 2D load).

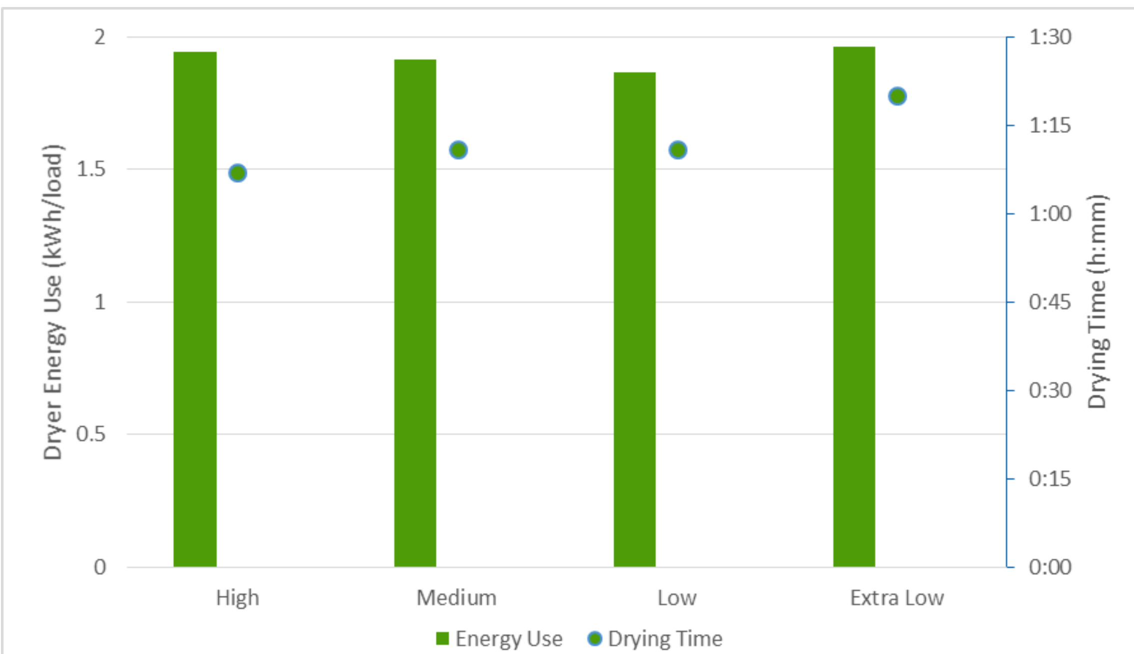
Dryer Temperature Setting

The HPD test model offers four dryer temperature settings: *High*, *Medium*, *Low,* and *Extra Low*. The owner's manual recommends using the warmest setting safe for the items in the load per the garment label instructions.

It is not immediately intuitive how the dryer temperature setting impacts dryer energy use. At a first glance, a higher temperature would seemingly require more energy, but the auto-termination feature allows for a reduced drying time. To look into this further, our lab tests varied the dryer temperature, keeping the final moisture content as a constant.

Figure 17 shows the impact of the dryer temperature setting on dryer energy use based on laboratory test loads.

Figure 17. Dryer Performance vs. Temperature Setting



The data indicate that the dryer temperature setting has little impact on dryer energy use. Switching from the *High* to *Low* temperature setting saved 0.08 kWh (or about 4%) per load. However, savings due to lower temperature settings are offset by the increased drying time. The *Extra Low* temperature setting resulted in the highest energy consumption due to the longer drying time.

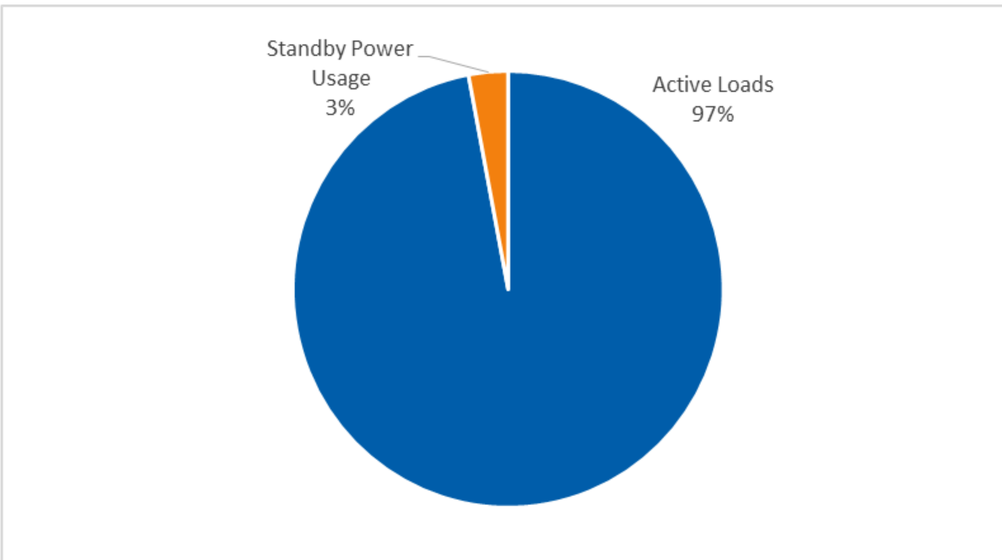
The temperature setting from the *in situ* data is more a reflection of the types of clothing in a household and is driven by participants following the garment labels instructions to "tumble dry low". It is not an opportunity to save additional energy by choosing one setting over the other as shown by our laboratory testing. An interesting finding is that the switch from *Medium* to *Low* setting saved 0.05 kWh per load, achieved the same residual moisture level in the dried load, and did not increase drying time.

Standby Energy Usage

Unlike mechanically controlled dryers with dials, electronically controlled dryers with touch pad settings consume a small amount of additional energy for the electronics. Unless the user unplugs the dryer before and after use, the electronic controls draw power even when the dryer is not operating.

Cadmus measured 1.89 Watts of standby power from the tested heat pump dryer, equal to 16 kWh per year. Figure 18 shows the portion of energy consumed by the dryer merely to provide power to the controls.

Figure 18. Standby Electric Usage Impacts



Combined Energy Factor

To include the influence of standby energy on the performance of clothes dryers, ENERGY STAR uses a metric called the Combined Energy Factor (CEF). The CEF is given in pounds per kWh and is the weight of the load divided by the average per-load energy use (including both standby and operational energy). A higher CEF represents a more energy-efficient dryer.

$$CEF = \frac{Load\ Weight\ (lbs)}{Energy_{Operation} + Energy_{Standby}}$$

The CEF of the heat pump dryer is 4.94 pounds per kWh, exceeding the ENERGY STAR® minimum criteria of 3.93 lb/kWh for a standard size, ventless electric clothes dryer.[2]

The ENERGY STAR®-rated performance for this clothes dryer lists the CEF as 4.5, yielding an energy consumption of 531 kWh per year.[3] While the energy use per load and standby usage from this demonstration are in agreement with that with the ENERGY STAR® CEF, the average weight of participants' loads was 9.31 pounds, greater than the 8.45 pound DOE assumption and increasing the resultant CEF. The annualized result of the CEF via our field data is then 533 kWh/year, very close to that from the details from ENERGY STAR®.

[2] Energy Star – *ENERGY STAR Program Requirements Product Specification for Clothes Dryers.* 2014. Retrieved from the DOE website December 12, 2014: http://www.energystar.gov/sites/default/files/specs//ENERGY%20STAR%20Final%20Version%201%200%20Clothes%20Dryers%20Program%20Requirements.pdf

[3] Energy Star – ENERGY STAR Certified Residential Clothes Dryers. Web page. Retrieved January 14, 2015. http://www.energystar.gov/productfinder/product/certified-clothes-dryers/details/2223285

Laboratory Testing Results on HPD-B (Second Model)

Cadmus performed a second round of laboratory testing on a different heat pump dryer (HPD) model provided by the Companies. Although we did not repeat the *in situ* testing with the second HPD model, we designed the laboratory test procedure similar to the procedure used for the first HPD model.

Ex Situ *(Laboratory) Testing Procedure for HPD-B*

To conduct performance testing for HPD-B, we followed the same laboratory testing procedure described in Figure 3 on page 12. We installed the same metering equipment (Step 1), defined the same control conditions (Step 2), and used the same conditioned laundry load materials (Step 3). We also used the same clothes washer for testing both HPD-A and HPD-B so that any differences in the dryer performance should not be attributable to the clothes washer performance. Although the clothes washer is from the same manufacturer and designed to be paired with HPD-A, using the same clothes washer model ensures that key factors influencing dryer energy performance—load weight and moisture content—remain constant for similar tests on both dryer models.

Because the HPD models have different operating options, we designed a unique test load procedure (Step 4) for HPD-B. The HPD-B procedure is similar to the procedure for HPD-A (shown in

on page 13) but uses the unique options available on the HPD-B equipment:

- Cycle Type: *Normal* and *Timed Dry*;
- Energy Options: *EcoHybrid* and *Normal*;
- Temperature Options: *Ultra Low*, *Low*, *Medium*, *Mid High*, and *High*;
- Dryness Level: *Damp Dry*, *Less Dry*, *Normal*, *More Dry*, and *Very Dry*; and
- Termination: *Auto* and *Monitored*.

We used information from the *in situ* participant survey to determine the combinations of dryer settings most likely to occur in customer households. For example, we did not include the *Damp Dry* option and designed only one test each with the *Less Dry, More Dry,* and *Very Dry* options due to participants' frequent use of the Normal dryness setting with HPD-A (Figure 13).

Table 8 describes the thirteen combinations of parameters we designed for testing HPD-B. As we did for HPD-A, we ran each HPD-B test combination three times for a total of 40 test loads (including a fourth run for test #13, which exhibited high variation) and used the average performance in our analysis.

Table 8. Test Run Specifications for *Ex Situ* Testing (HPD-B)

Test ID	Load Size	Cloth Dimension		Cycle Type		Energy Options		Temp					Dryness Level					Termination	
		2D	3D	Nor-mal	Timed Dry	Eco-Hybrid	Nor-mal	Ultra Low	Low	Med.	Mid High	High	Damp Dry	Less Dry	Nor-mal	More Dry	Very Dry	Auto	Timed/ Moni-tored
1	4.5	■		■			■			■					■			■	
2		■		■		■				■					■			■	
3		■		■			■			■							■	■	
4		■		■			■			■						■		■	
5		■		■			■			■					■			■	
6		■		■			■			■				■				■	
7	8.45	■			■		■					■			■				■
8		■			■		■				■				■				■
9		■			■		■			■					■				■
10		■			■		■		■						■				■
11		■			■		■	■							■				■
12			■	■			■			■					■			■	
13	15	■		■			■			■					■			■	

Results for HPD-B

The following sections describe how the various load characteristics or dryer settings impact dryer performance, based on the results of 40 loads of *ex situ* testing. In each figure, we provide three performance metrics:

- Dryer energy use is the total electric energy consumed for the load (kWh/load);
- Drying time is the total time required for the dryer to dry the load (minutes/load); and
- Remaining moisture content (RMC) indicates the final dryness level of the load.

Load Weight

Figure 19 shows the impact of load weight on dryer energy performance.

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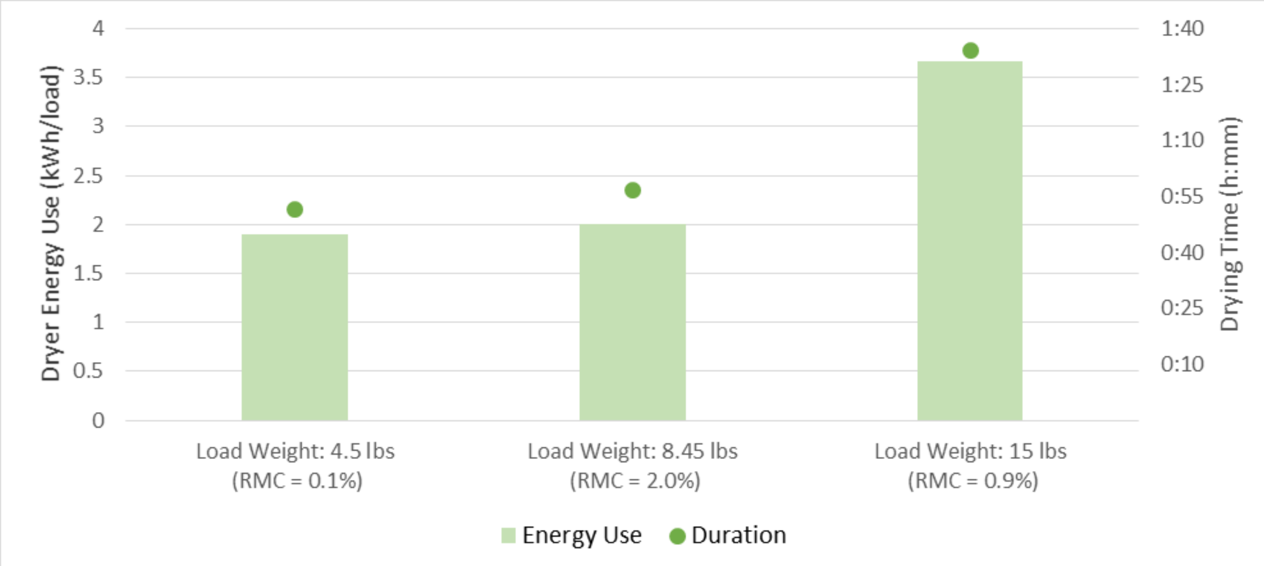
Figure 19. Dryer Performance vs. Load Weight (HPD-B)



The HPD performs similarly to dry the 4.5-lb load (1.90 kWh and 52 minutes per load) and the 8.45-lb load (2.00 kWh and 57 minutes per load) but requires significantly more energy and time to dry the 15-lb load (3.66 kWh and 1 hour, 35 minutes per load).

However, when normalized by pound of laundry, the dryer is more efficient serving the 8.45-lb and 15-lb loads (0.24 kWh/lb) than the smaller 4.5-lb load (0.42 kWh/lb).

Dryness Level Setting

HPD-B offers five dryness level settings: *Damp Dry*, *Less Dry*, *Normal*, *More Dry*, and *Very Dry*.

Figure 20 shows the impact of dryness level setting on dryer energy performance. (Due to the tendencies of participants to use the *Normal* dryness setting, we did not include the *Damp Dry* option in our testing).

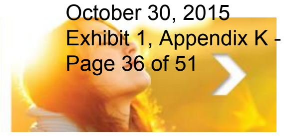
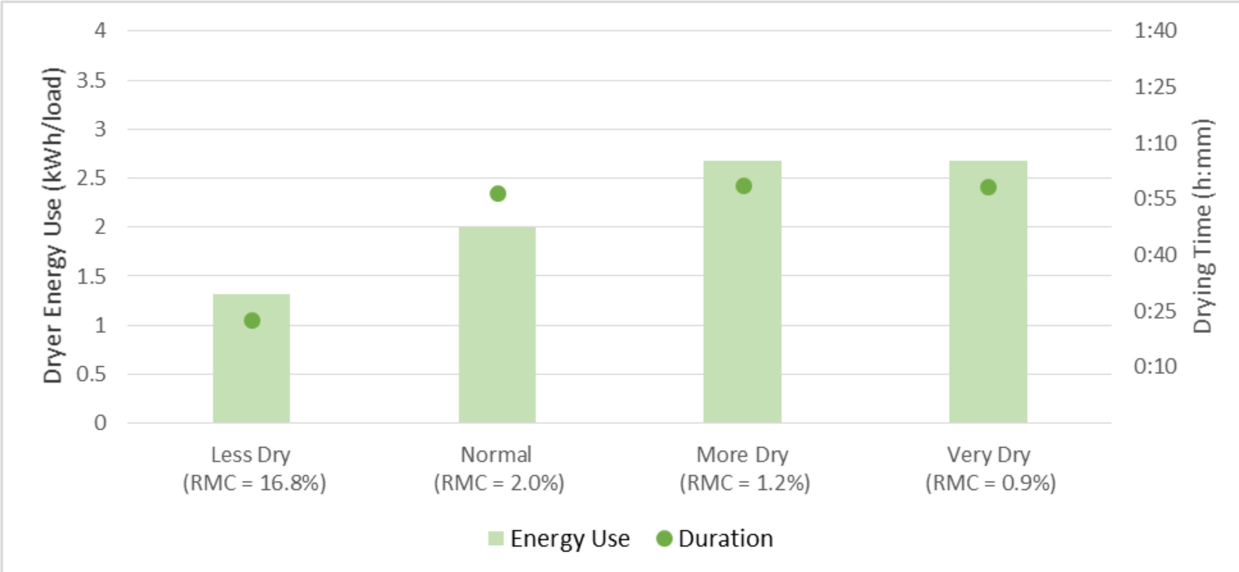


Figure 20. Dryer Performance vs. Dryness Level Setting (HPD-B)



As expected, increasing the dryness level setting increased both the dryer energy consumption and the drying time. The *Less Dry* option used much less energy than the other options (1.31 kWh per load) but, with a remaining moisture content of 16.8%, is unlikely to satisfy most customers.

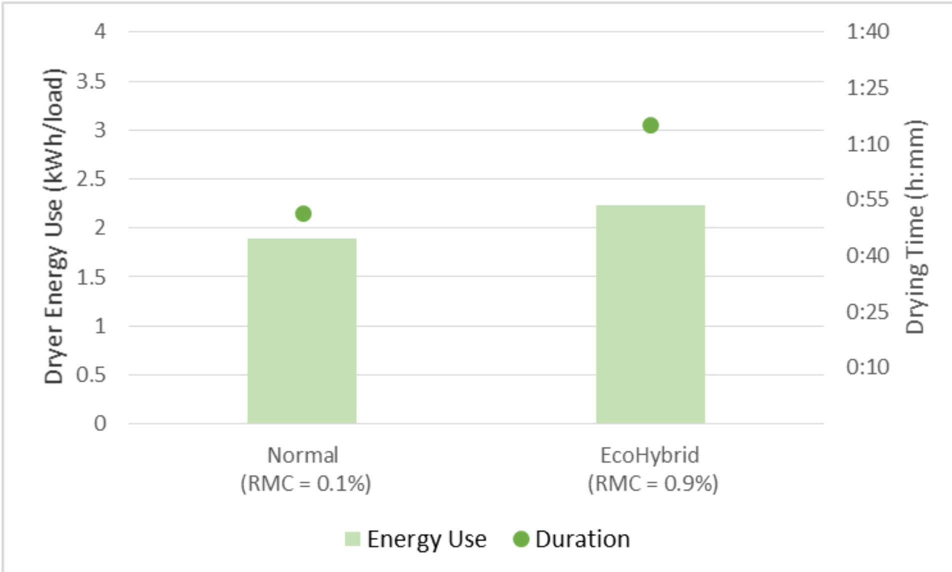
The *Normal* setting most efficiently achieves a satisfactory RMC value. The *More Dry* and *Very Dry* settings use 34% more energy compared to the *Normal* setting to produce dryer loads with insignificant drying time penalties.

Energy Option Setting

HPD-B offers two energy options: *Normal* and *EcoHybrid*.

Figure 21 shows the impact of the energy option setting on dryer performance.

Figure 21. Dryer Performance vs. Energy Option Setting (HPD-B)

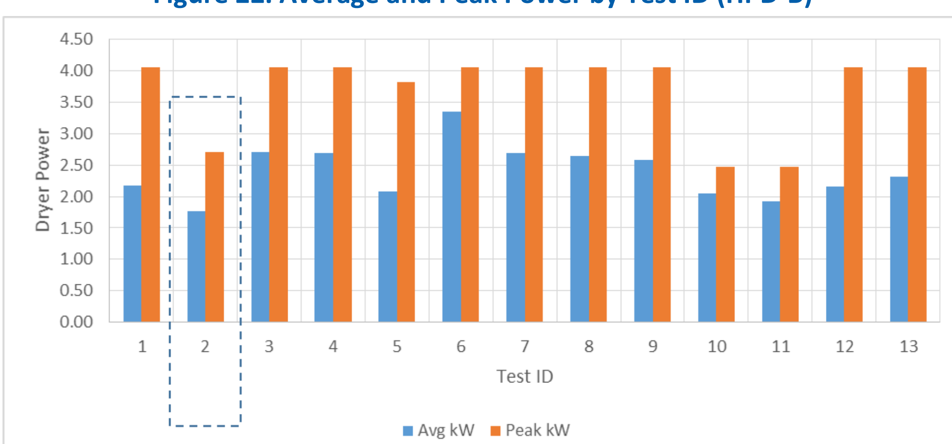


The data suggest that there are no advantages to the customer for selecting the *EcoHybrid* option. Compared to the *Normal* setting, the *EcoHybrid* setting used 18% more energy, took 23 minutes longer, and had a higher RMC in the finished load.

The benefit of the *EcoHybrid* option is to reduce both maximum and average power to complete the dryer cycle. Compared to the *Normal* setting, the *EcoHybrid* setting reduces average power by 18% and reduced maximum power by 33%.

As shown in Figure 22, the *EcoHybrid* option (Test ID #2) offers the lowest average demand compared to all other test runs and the lowest peak demand compared to all but two test runs. (Tests 10 and 11 use the *Ultra Low* and *Low* temperature settings and result in the lowest peak power values.)

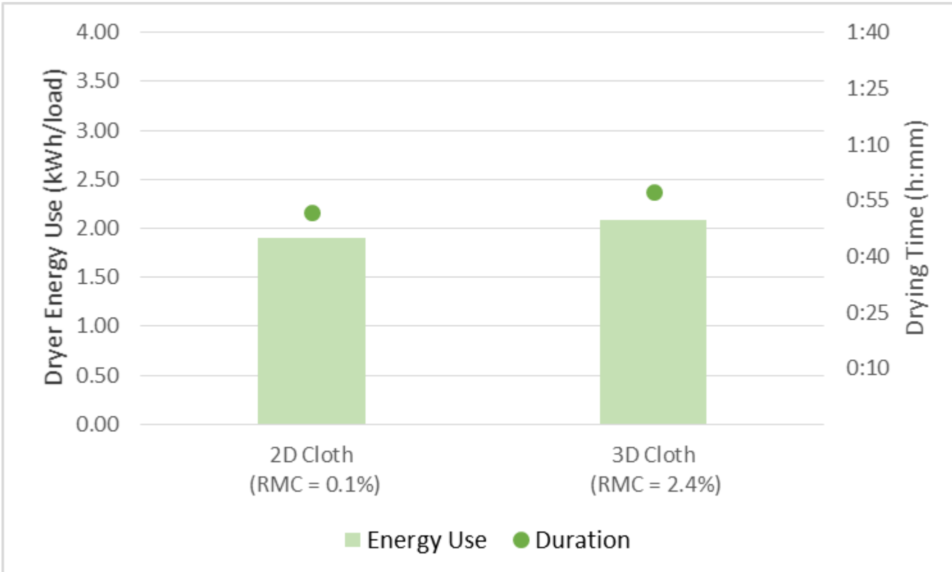
Figure 22. Average and Peak Power by Test ID (HPD-B)



Cloth Dimension: 2D vs. 3D

Figure 23 shows the impact of the cloth dimension on dryer performance by comparing two test runs with the same dryer settings but different laundry load compositions.

Figure 23. Dryer Performance vs. Cloth Dimension (HPD-B)



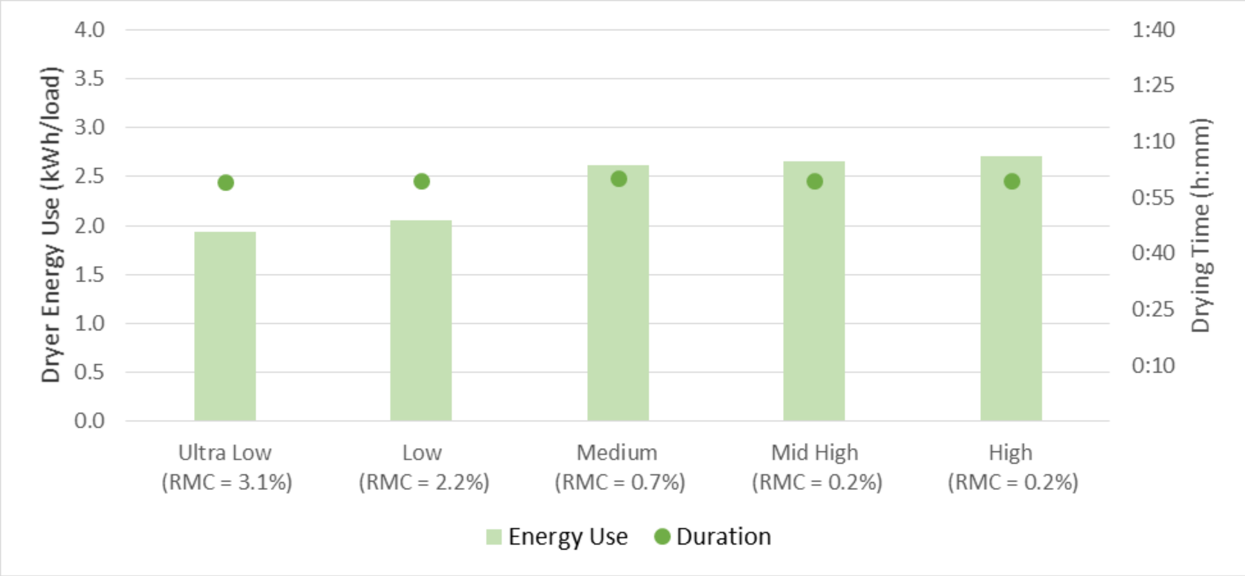
The data indicate only a marginal increase in energy use and drying time with the more complex load. However, the dryer also left the 3D load less dry than the 2D load. (Both test runs used the auto termination feature).

Dryer Temperature Setting

HPD-B offers five dryer temperature settings: *Ultra Low*, *Low*, *Medium*, *Mid High*, and *High*.

Figure 24 shows the impact of the dryness setting on dryer performance.

Figure 24. Dryer Performance vs. Temperature Setting (HPD-B)



As expected, increasing the dryer temperature setting increases the dryer energy consumption. The data indicate modest energy differences between to two lower settings and among the three medium and high settings, with a significant energy different between the two groups. Although a user can save 27% energy consumption by using the *Low* setting instead of the *Medium* setting, the user sacrifices final dryness, with remaining moisture content (RMC) values above 2% for the low energy loads.

The data also demonstrate that changes in the dryer temperature setting had no impact on the drying time. All test loads at all settings averaged exactly one hour in duration.

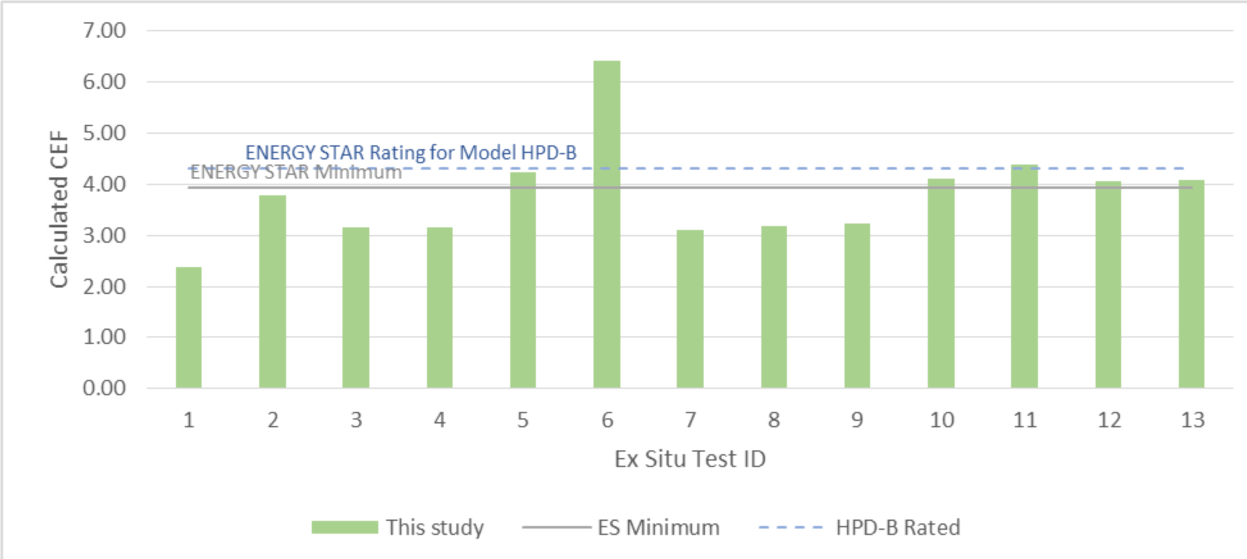
Standby Energy Usage

Cadmus measured 76 Watts of standby power from HPD-B, less than half of the 1.89 Watts of standby power measured for HPD-A. Assuming the dryer operates at one hour per load and served 283 loads per year, the annual standby energy for HPD-B is 6.5 kWh when the dryer is not operating.

Combined Energy Factor

HPD-B has a rated combined energy factor (CEF, defined on page 31) of 4.3. Cadmus' testing (which does not strictly follow the standard test procedures) found the CEF for HPD-B ranges from 2.37 (Test 1) to 6.43 (Test 6) for the tested combinations of load characteristics and dryer settings (Figure 25).

Figure 25. Calculated CEF Values for HPD-B



Only six of the thirteen ten runs exceed the ENERGY STAR® minimum performance value of 3.93 pounds per kWh for electric clothes dryers, and only two of the test runs exceed the rated CEF for the specific make and model of HPD-B. However there are differences in the laboratory performance conditions for this study and the conditions through which the ENERGY STAR® ratings are measured.

Recommendations

Cadmus offers the following recommendations based on the findings from this study:

- **Encourage replacement of top-load (vertical axis) clothes washers with front-load (horizontal axis) clothes washers.** The moisture content of the laundry entering the clothes dryer has a major impact on energy use, and literature confirms that the rotation of the washer drum extracts moisture more efficiently than evaporation in the clothes dryer. This study confirmed that the majority of energy savings achieved at each participant site is attributable the change in washer axis configuration.
- **Discourage customers from installing non-vented heat pump dryers enclosed areas (e.g., a closet).** Although it still performed better than the average existing ERD, the HPD located and operated in an enclosed closet consumed 41% more energy per load than the other *in situ* HPDs, illustrating the impact of enclosure on energy performance.
- **Encourage users to operate appliances with full loads to optimize energy performance, and educate customers on the inverse relationship between energy and drying time.** Heavier loads were more energy efficient per pound of dry laundry, but also took longer to dry. Increasing the load weight from 4.5 pounds to 8.45 pounds decreased the energy consumption from 0.30 kWh per pound to 0.26 kWh per pound (13.3% reduction), but required an additional 32 minutes over the 50 minutes required for 4.5-pound load (total drying time of 82 minutes).
- For the HPD model in this study:
  - The most common user settings—the *Eco* energy mode and the *Normal* dryness level—are efficient and practical. The laboratory data showed that using the *Eco* energy option setting and the *Less* dryness level setting results in the most energy-efficient dryer performance; however, compared to the user-preferred *Normal* setting, the *Low* dryness level results in a higher residual moisture content. Compare to *Eco* and *Normal*, the *Speed* mode increases energy but only reduced drying time by 3 minutes and the *More* dryness setting increases energy but does not impact residual moisture content.
  - With the exception of the *Extra Low* option, temperature settings had little impact on the energy use and drying time. Users should avoid the *Extra Low* setting, which consumed more energy and resulted in longer drying cycles compared to other options.

Appendix A. Pre-Installation Participant Laundry Log

Instructions: For each load of laundry please record start data/time, laundry weight before wash, laundry weight after wash/before dryer, and laundry weight after dry. Also please circle washer and dryer settings that best match your machine.

Cycle #	Date	Start Time	Dirty Laundry Weight (w/basket)	Washer: Please Circle All That Apply						Wet, Clean Laundry Weight (w/ basket)	Dryer: Please Circle One				Dry, Clean Laundry Weight (w/ basket)
				Washer Settings:		Wash Water Temp	Rinse Water Temp	Spin Cycle	Soil Level		Dryer Settings:			Amount of Laundry from Washer to Dryer	
				Hand wash	Delicate	Hot	Hot	High Extra High	Light		Accudry	Delicate	Tumble Press	All	
				Perm press	Whites	Warm	Warm	Medium	Normal		Perm press	Whites	if Time Dry	Most	
				Express	Normal	Cold	Cold	Slow Extra Slow	Heavy		Express	Normal	Minutes:_______	Some	
				Heavy Duty	Sanitary	Tap cold	Tap cold	No spin			Heavy Duty	Air only	Hours:_______	Other:_________	
				Hand wash	Delicate	Hot	Hot	High Extra High	Light		Accudry	Delicate	Tumble Press	All	
				Perm press	Whites	Warm	Warm	Medium	Normal		Perm press	Whites	if Time Dry	Most	
				Express	Normal	Cold	Cold	Slow Extra Slow	Heavy		Express	Normal	Minutes:_______	Some	
				Heavy Duty	Sanitary	Tap cold	Tap cold	No spin			Heavy Duty	Air only	Hours:_______	Other:_________	
				Hand wash	Delicate	Hot	Hot	High Extra High	Light		Accudry	Delicate	Tumble Press	All	
				Perm press	Whites	Warm	Warm	Medium	Normal		Perm press	Whites	if Time Dry	Most	
				Express	Normal	Cold	Cold	Slow Extra Slow	Heavy		Express	Normal	Minutes:_______	Some	
				Heavy Duty	Sanitary	Tap cold	Tap cold	No spin			Heavy Duty	Air only	Hours:_______	Other:_________	
				Hand wash	Delicate	Hot	Hot	High Extra High	Light		Accudry	Delicate	Tumble Press	All	
				Perm press	Whites	Warm	Warm	Medium	Normal		Perm press	Whites	if Time Dry	Most	
				Express	Normal	Cold	Cold	Slow Extra Slow	Heavy		Express	Normal	Minutes:_______	Some	
				Heavy Duty	Sanitary	Tap cold	Tap cold	No spin			Heavy Duty	Air only	Hours:_______	Other:_________	

Appendix B. Participant Survey

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National Grid Heat Pump Dryer Program: Participant Survey

This survey consists of one group of participants:

- National Grid Heat Pump Dryer Group (6 participants)

The group received a new Whirlpool heat pump clothes dryer and a new matching Whirlpool front-loading clothes washer. The purpose of this survey is to use participant feedback to examine participant experiences with the dryer technology and to inform program design recommendations for a heat pump dryer rebate program. Cadmus will administer the survey online by e-mailing each participant link to the survey website. We will ask participants to complete the survey within seven days. Cadmus will follow up by phone with any participants who have not completed the survey.

Researchable Questions
• What was the participant's experience with the new technology? • Were participants satisfied with the heat pump dryer? • Would participants recommend the heat pump dryer? • What would participants be willing to pay for a heat pump dryer?

Thank you for your participation in this survey. This survey will ask questions about the new heat pump clothes dryer and matching clothes washer you received. The survey should take approximately 10 minutes to complete.

A. *Equipment Performance: Clothing Washer*

The first five questions will ask about your old and new **clothes washer**s.

A1. How old was your previous clothes washer? (in years) [Record: ________________]

A2. Compared to your previous clothes washer, would you say that the performance of your new **clothes washer** is:

1. Much better
2. Somewhat better
3. About the same
4. Somewhat worse
5. Much worse

-98. Don't know

A3. Do you operate your new washer or do you wash loads differently in any way compared to your previous dryer? **[Record: ________________]**

A4. Overall, how satisfied are you with the **clothes washer** you received?

1. Very satisfied
2. Somewhat satisfied
3. Neutral
4. Not very satisfied
5. Not at all satisfied

-98. Don't know

A5. Please provide any additional comments on the **clothes washer** you received in the space below: [Record: ________________]

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B. Equipment Performance: Heat Pump Dryer

The next set of questions will ask about your old dryer and new **heat pump dryer**.

B1. How old was your previous clothes **dryer**? (in years) **[Record: ________________]**

B2. Compared to your previous clothes **dryer**, would you say that the performance of your new **dryer** is:

1. Much better
2. Somewhat better
3. About the same
4. Somewhat worse
5. Much worse

-98. Don't know

B3. Do you operate your new dryer or do you dry loads differently in any way compared to your previous dryer? **[Record: ________________]**

B4. Overall, how satisfied are you with the heat pump dryer you received?

1. Very satisfied
2. Somewhat satisfied
3. Neutral
4. Not very satisfied
5. Not at all satisfied

-98. Don’t know

B5. **[If “Not very satisfied” or “Not at all satisfied]** Why are you dissatisfied with the heat pump dryer you received? **[Record: _______________]**

B6. In the table below, please rate your level of satisfaction with each aspect of the heat pump dryer.

	Very satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Not very satisfied	Not at all satisfied	N/A or Don't know
Appearance						
Ease-of-use						
Noise level						
Dryness level						
Drying time						
No need for a dryer vent						
Hose for water drain on dryer						
Secondary lint filter						
Overall drying performance						

B7. How frequently do you clean the secondary filter on the dryer?

1. Before or after each load
2. About once a week
3. About once a month
4. I have not cleaned the secondary filter on the dryer.
5. I am not aware of a secondary filter on the dryer.
6. Other **[Record: _______________]**

B8. What do you like best about the heat pump dryer? **[Record: _______________]**

B9. What do you like least about the heat pump dryer? **[Record: _______________]**

B10. Please provide any additional comments in the space below: **[Record: _______________]**

C. Willingness to Pay and Likelihood of Recommending

C1. **Before** participating in this pilot, what is the most you would have paid for a new heat pump clothes dryer?

1. $1,500 to $1,999
2. $1,000 to $1,499
3. $500 to $999 to
4. Less than $499
5. I would not purchase a heat pump dryer.

-98. Don't know

C2. **After** participating in this pilot, what is the most you would have paid for a new heat pump clothes dryer?

1. $1,500 to $1,999
2. $1,000 to $1,499
3. $500 to $999 to
4. Less than $499
5. I would not purchase a heat pump dryer.

-98. Don't know

C3. How likely would you be to recommend a **heat pump dryer** to a friend?

1. Very likely
2. Somewhat likely
3. Neutral
4. Not very likely
5. Not at all likely

-98. Don't know

C4. Which of the following are most influential reasons to purchase a heat pump dryer? **[Multiple choices possible]**

1. To save money on energy bills
2. To save energy
3. To acquire the latest technology
4. To acquire eco-friendly technology
5. To replace an old clothes dryer and washer
6. To have a dryer that does not require venting
7. Other **[Record:________________]**

-98. Don't know

D. Additional Information

D1. How many people currently live in your household full time (at least 9 months of the year)?
[Specify:________________________]

D2. About how many laundry loads do you perform per week? **[Specify:________________________]**

End

Thank you for completing our survey. Your feedback will be used to help National Grid plan future program offerings.

Appendix C. References

2009 EIA Residential Energy Consumption Survey. Retrieved from EIA on February 3, 2015: http://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/ma.pdf.

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nationalgrid

Technical Assistance Study

Vacuum Steam Heating

ID Number(s): RIS-87-14-0110

Igor Zhadanovsky, PhD.
36 Falmouth RD
Newton, MA

Date: 10/17/2014
Conducted By: Jean-Paul Vandeputte

I. Contents

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III. Introduction

Keith Miller with National Grid (NGrid) requested engineering services from RISE Engineering. The intent of this study is to quantify the savings potential and market applicability of a new residential steam distribution system which operates under vacuum to deliver heat.

RISE Engineering conducted multiple site visits to perform a series of measurements in order to determine the overall system efficiency changes through different operating modes. These visits were performed at major system changes to download data from the monitors before each new test began.

IV. Executive Summary

Igor Zhadanovsky, PhD., the President of Applied Engineering Consulting, contacted Keith Miller of National Grid to request that his method to steam distribution be assessed for energy savings. Through this process, RISE Engineering was requested to perform measurement and verification of the energy savings potential of the vacuum distribution system approach. Based upon the collected data, the vacuum system retrofit produced favorable energy savings as a percentage of on-site fuel consumption. This technology could be installed at facilities which currently utilize single pipe steam to heat or those new construction facilities which are being designed with single pipe steam.

V. Facility Overview

The property that was utilized is a two story colonial that serves as both a day care and living quarters. Each floor has its own steam boiler and distribution system which are controlled by programmable thermostats. The first floor (noted as Unit #38), the day care, was not monitored in this study although it was stated that the thermostat was maintained at a constant setting. The top floor, Igor's home (Unit #36), was the focal point of the evaluation.

The residency is the 2nd floor of 1910 colonial, and is 1,150 square feet in floor area. Eight (8) radiators were utilized to heat the space. To ensure consistency between testing scenarios, two (2) of the cast iron radiators were disconnected from the system so that both the VSH and the single pipe steam system used the same number of radiators. The home's insulation level is low with most walls having no insulation. Fourteen (14) out of seventeen (17) windows are new, with the three (3) old windows being attached to a screened porch (each of which having storm windows). A forced air system in the attic space provides cooling only.

Radiator Location	Steam Delivery Order
Kitchen	1
Bedroom #1	2
Dining Room	3
Bedroom #2	4
Office	5
Living Room	6

A basic floor plan of Unit #36 is shown below. This lays out the various rooms, original and new radiators, and the space thermostat. The order in which the radiators receive steam is chronologically noted and shown in the table to the right.

VI. Vacuum Steam Heating

a. Technology

Residential homes constructed in the early 1900s with steam systems generally utilize one-pipe (SPS) or two-pipe steam distribution. In the scenario at Unit #36 (single pipe steam), gravity returns condensate back to the boiler through steam piping in a counter-flow manner[1]. The single pipe steam radiators are all high-mass cast iron units with air vents. These vents allow air within the system to purge during the "warm-up" cycle while preventing valuable steam from escaping. While this system is very easy to install, only one set of pipes, it generally lacks the maintenance necessary to keep it running properly.

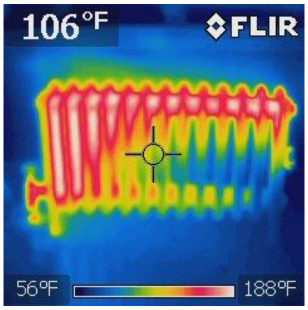


Figure 1: Single Pipe Steam Radiator (High mass cast iron)

Vacuum heating technology has been successfully utilized in both residential and commercial applications. Systems generally operate between 5 to 10 inches of mercury vacuum. The specific application being studied utilizes a deeper vacuum and modern plumbing / distribution replacement to further increase savings potential.

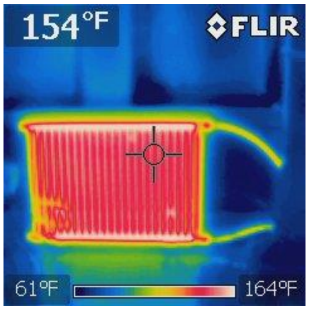


Figure 2: Vacuum Steam Heating system radiator (Low mass steam)

Modifying a standard single pipe steam system to a Vacuum Steam Heating system reduces operating temperatures while maintaining a high differential pressure across the system. In this specific scenario the single pipe steam system was abandoned in place. Tests were conducted in back-to-back weeks utilizing various scenarios to quantify the potential efficiency gain of switching to the VSH system. The VSH system utilized a supply and return hose to each radiator. The distribution system did not use a metal pipe but rather copper tubing and temperature-resistant clear plastic tubing. The VSH distribution system was attached to new low mass hydronic radiators. A vacuum pump maintained the vacuum in the system to between 20 and 24 inches of mercury vacuum.

Common practice within the industry generally calls for complete steam to hot water conversions. While this may be optimal for efficiency, costs to do so generally prohibit a customer from moving forward. The VHS may be a feasible alternative to obtain those savings.

[1] Two-pipe systems utilize a separate pipe to return condensate back to the boiler.

b. Analysis Methodology and Results

To quantify efficiency gains between the VSH system and the single pipe steam system a number of data monitors supplied both by RISE Engineering and Applied Engineering Consulting were utilized to track and trend the operational parameters of the various test scenarios. The monitors recorded data in increments of as little as 10 second intervals and up to 15 min intervals. Pulse meters were utilized to monitor the vacuum pump and the gas meter. A list of RISE Engineering's installed meters is as below.

Sensor #	Model	Use Description
1	Fyrite Tech Analyzer Model 60	Used to determine the combustion efficiency of the base case boiler
2	Flir Systems i7	Infrared camera utilized to document the heat output of the radiators
3	HOBO U12-011 Temp/RH	Used to monitor the basement temperature
4	HOBO UX100-011 Temp/RH	Used to monitor the temperature at the control thermostat
5	HOBO UA-002-64 Pendant Temperature/Light, 64K	Outdoor air and ambient solar conditions
6	HOBO UX120-017 4-Channel Pulse Input	Data recorded to measure time gaps in On/Off pulses from the CSV-A8
7	HOBO CSV-A8 AC Current Switch	The current switch which monitored run time on the vacuum pump

The meters that were deployed by Applied Engineering Consulting included the following.

Sensor #	Model	Use Description
1	Pulse Meter	Recorded Pulse output from Gas meter to record fuel consumption
2	Presure Sensor	Measure the Vacuum in the system
3 - 7	Temperature Sensors	Condensate return, Kitchen, Bedroom 1, Bedroom 2, Dining Room, Living Room, Office

The data from these meters was imported into a spreadsheet calculation to determine the savings for the following scenarios.

System Comparison
Old Boiler - Single Pipe Steam
Old Boiler - Vacuum System
New Boiler - Single Pipe Steam
New Boiler - Vacuum System
Old Boiler - Single Pipe Steam
New Boiler - Single Pipe Steam
Old Boiler - Vacuum System
New Boiler - Vacuum System
New Boiler - Vacuum System
New Boiler - Balanced Vacuum
Old Boiler - Single Pipe Steam
New Boiler - Balanced Vacuum

The first steps in determining the energy impact of the VSH system were to generate plot and trend lines from relevant data that would potentially impact the consumption of the facility. The two major independent variables for this project were the outdoor ambient conditions and the amount of potential solar heat gain. These two variables were identified as the independent variables because the thermostat was set to a specific load profile and was monitored to ensure that it held those conditions.

A plot of the outdoor air temperature vs. the fuel consumed by the boiler to heat the apartment is shown below.

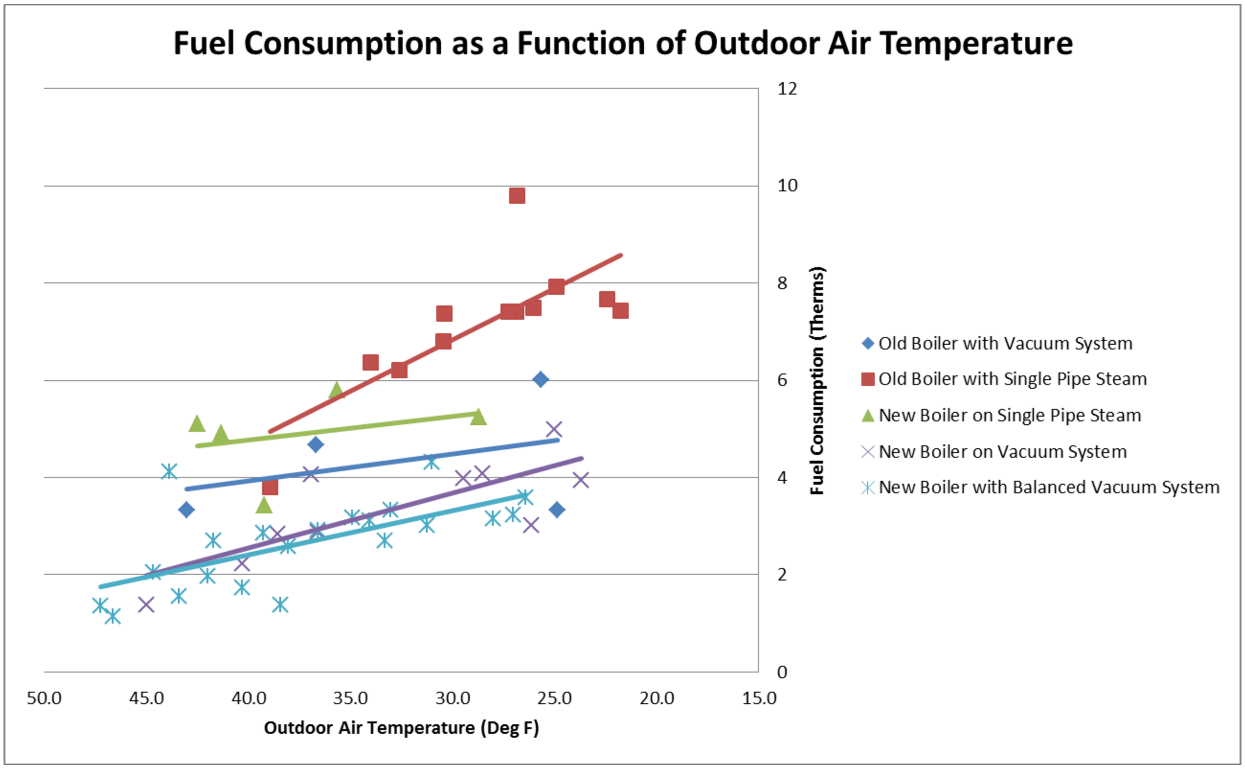


Figure 3: Fuel consumption as a function of outdoor air temperature per day

This graph (Figure 3) shows a direct relationship between the outdoor air temperature and fuel consumption of the facility. Note that the various tests took place across similar weather conditions despite taking multiple weeks to complete. Each data set represents its own test with the least efficient (Old Boiler with Single Pipe Steam (Red Squares)) being highest up the scale. Conversely, the most efficient test that was performed is lowest on the graph (New Boiler with the Balanced VSH System).

The second independent variable, the solar heat gain or in this case the lumens of light recorded by the light sensor, is plotted against the fuel consumption to determine the effect of solar heat gains on the property.

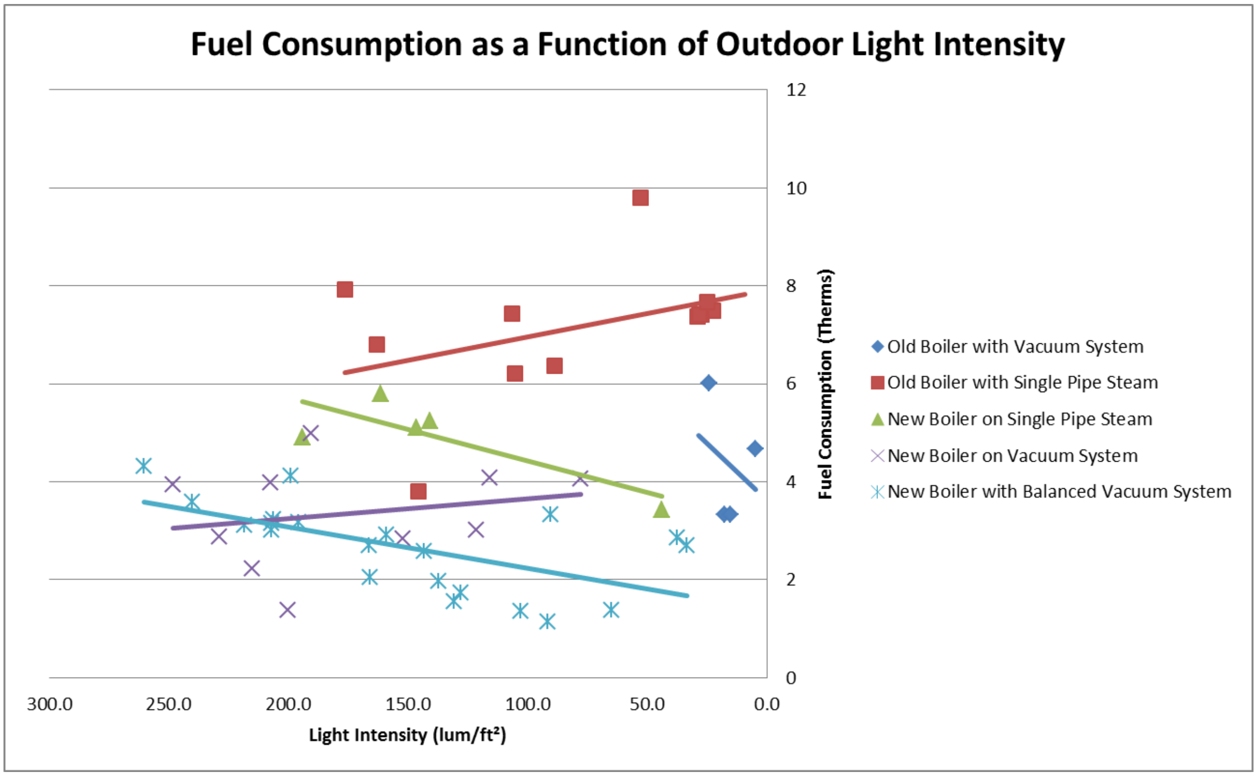


Figure 4: Fuel consumption as a function of outdoor light intensity per day

Figure 4 shows that the outdoor light intensity does not have the same linear effect on the fuel consumption as the outdoor air temperature (Figure 3) does. We can make this correlation because on days that have significantly different light intensities the fuel consumption can remain constant because the outdoor temperature was the same.

Since there is such a strong linear relationship between the fuel consumption and outdoor air temperature, a linear regression analysis was performed on the couplet of information to develop an equation for each test set. These equations were utilized to quantify average predicted daily fuel consumption values across a bin data set of Boston, MA compiled from the most recent TMY3 data[2].

[2] BinMaker® PRO Version 3.0.2 – Climatic Design Data © licensed from ASHRAE

daily average temperature as a predictor for heating consumption							
Mid-pts	Min DB (F)	Max DB (F)	Old Boiler - Single Pipe Steam	Old Boiler - Vacuum System	New Boiler - Single Pipe Steam	New Boiler - Vacuum System	New Boiler - Balanced Vacuum System
			(Therms)	(Therms)	(Therms)	(Therms)	(Therms)
107.5	105	110	-9.49	0.17	4.82	-5.12	-3.75
102.5	100	105	-8.43	0.45	4.82	-4.55	-3.29
97.5	95	100	-7.38	0.73	4.81	-3.98	-2.84
92.5	90	95	-6.33	1.01	4.80	-3.42	-2.38
87.5	85	90	-5.28	1.28	4.79	-2.85	-1.92
82.5	80	85	-4.22	1.56	4.79	-2.28	-1.47
77.5	75	80	-3.17	1.84	4.78	-1.71	-1.01
72.5	70	75	-2.12	2.12	4.77	-1.14	-0.56
67.5	65	70	-1.06	2.40	4.77	-0.58	-0.10
62.5	60	65	0.00	2.67	4.76	0.00	0.36
57.5	55	60	1.04	2.95	4.75	0.56	0.81
52.5	50	55	2.09	3.23	4.74	1.13	1.27
47.5	45	50	3.15	3.51	4.74	1.70	1.73
42.5	40	45	4.20	3.79	4.73	2.26	2.18
37.5	35	40	5.25	4.06	4.72	2.83	2.64
32.5	30	35	6.31	4.34	4.72	3.40	3.10
27.5	25	30	7.36	4.62	4.71	3.97	3.55
22.5	20	25	8.41	4.90	4.70	4.54	4.01
17.5	15	20	9.46	5.17	4.69	5.10	4.46
12.5	10	15	10.52	5.45	4.69	5.67	4.92
7.5	5	10	11.57	5.73	4.68	6.24	5.38
2.5	0	5	12.62	6.01	4.67	6.81	5.83
-2.5	-5	0	13.68	6.29	4.67	7.38	6.29
-7.5	-10	-5	14.73	6.56	4.66	7.94	6.75

Figure 5: Midpoints of 5 degree temperature bins to predict average daily fuel consumption

Figure 5 shows us the average predicted fuel consumption at the midpoints for 5 degree temperature bin data. The data above the midpoint temperature of 62.5°F is grayed out as the heating system should be operating above 65°F outdoor air temperature. The cells below negative 2.5°F are grayed out because there were no hours recorded in the TMY3 bin data for Boston, MA that met those conditions.

Once the daily average consumption values were determined for the midpoint conditions a generic heating profile for a building of 1,150 square feet was utilized to determine that there were approximately 4,271 heating hours over the course of a TMY3 year. Based on that information, annual fuel consumption for heating the facility was generated.

Yearly heating therm consumption based upon daily average temperature and heating consumption									
Mid-pts	Min DB (F)	Max DB (F)	Assumed Heating Hours	Old Boiler - Single Pipe Steam	Old Boiler - Vacuum System	New Boiler - Single Pipe Steam	New Boiler - Vacuum System	New Boiler - Balanced Vacuum System
			(Hours)	(Therms)	(Therms)	(Therms)	(Therms)	(Therms)
72.5	70	75	0	0.00	0.00	0.00	0.00	0.00
67.5	65	70	0	0.00	0.00	0.00	0.00	0.00
62.5	60	65	0	0.00	0.00	0.00	0.00	0.00
57.5	55	60	83	3.60	10.21	16.43	1.93	2.81
52.5	50	55	227	19.81	30.55	44.87	10.66	12.01
47.5	45	50	428	56.13	62.55	84.47	30.23	30.78
42.5	40	45	714	124.97	112.61	140.70	67.34	64.93
37.5	35	40	956	209.26	161.85	188.11	112.79	105.12
32.5	30	35	655	172.11	118.47	128.69	92.78	84.48
27.5	25	30	551	168.95	106.04	108.09	91.09	81.54
22.5	20	25	344	120.57	70.19	67.38	65.01	57.45
17.5	15	20	234	92.28	50.45	45.76	49.76	43.53
12.5	10	15	37	16.21	8.41	7.23	8.74	7.59
7.5	5	10	38	18.32	9.07	7.41	9.88	8.51
2.5	0	5	4	2.10	1.00	0.78	1.13	0.97
-2.5	-5	0	0	0.00	0.00	0.00	0.00	0.00
-7.5	-10	-5	0	0.00	0.00	0.00	0.00	0.00
Totals			4,271	1,004.34	741.40	839.92	541.35	499.74

Figure 6: TMY3 bin hours are used to predict yearly fuel consumption for heating

Figure 6 breaks down the predicted fuel consumption of each heating system based upon its midpoint temperature estimated and the hours in that temperature band. As the test data showed there is a significant improvement between the base case existing single pipe steam and very old steam boiler and the VSH system and a new higher efficiency steam boiler. Again cells above the 62.5°F midpoint and below the 2.5°F midpoint were not relevant to the study as there are either no heating hours in the temperature bands or the heating system should be off. There is one negative value in this chart; this value is carried over from the linear regression that was performed to develop the consumption equations. Since a boiler cannot generate natural gas it was not included in the calculation.

The savings for each test case is show below.

System Comparison	Predicted Consumption (Therms)	Percent Savings
Old Boiler - Single Pipe Steam	1,004	
Old Boiler - Vacuum System	741	26.2%
New Boiler - Single Pipe Steam	840	
New Boiler - Vacuum System	541	35.5%
Old Boiler - Single Pipe Steam	1,004	
New Boiler - Single Pipe Steam	840	16.4%
Old Boiler - Vacuum System	741	
New Boiler - Vacuum System	541	27.0%
New Boiler - Vacuum System	541	
New Boiler - Balanced Vacuum	500	7.7%
Old Boiler - Single Pipe Steam	1,004	
New Boiler - Balanced Vacuum	500	50.2%

Figure 7: Study Results showing percent savings between test cases

Figure 7 shows the percent savings based upon the analysis methodology described above. The savings range from 7.7% up to 50.2% depending on what type of a system change the facility undergoes. In many cases facilities will likely either utilize the "Old Boiler – Single Pipe Steam vs. Old Boiler – Vacuum System" comparison which in this specific test showed 26.2% savings.

In conjunction with the fuel savings associated with the VSH system installation there is a small electric penalty for the run hours of the vacuum pump. The pump was monitored for 29 days to record its change of state (pump on/pump off) to determine its total run time per day. Over the course of the 29 days it averaged 1:59.54 hours of run time. Extrapolating the run time out over the course of the 178 day heating season (as per the TMY3 midpoint heating hours) the vacuum pump will consume 163.58 kWh of electricity. The cost to run this pump is approximately $24.54 per year[3].

[3] $0.15 / kWh = "all-in" electric cost

VII. Explanation of Energy Savings

The predicted energy savings varies widely based on the system installed. As each scenario is independent from one another, a number of factors contribute to a reduction in the quantity of natural gas consumed by the boiler and measured at the meter. The following section of the study may be used as verification of energy savings and dissemination of such factors.

Savings were separated into the following categories for each of the scenarios reviewed

- Combustion Efficiency
- Boiler Standby Losses
- Off-cycle Losses
- Air removal

Other considerations in the categories above include:

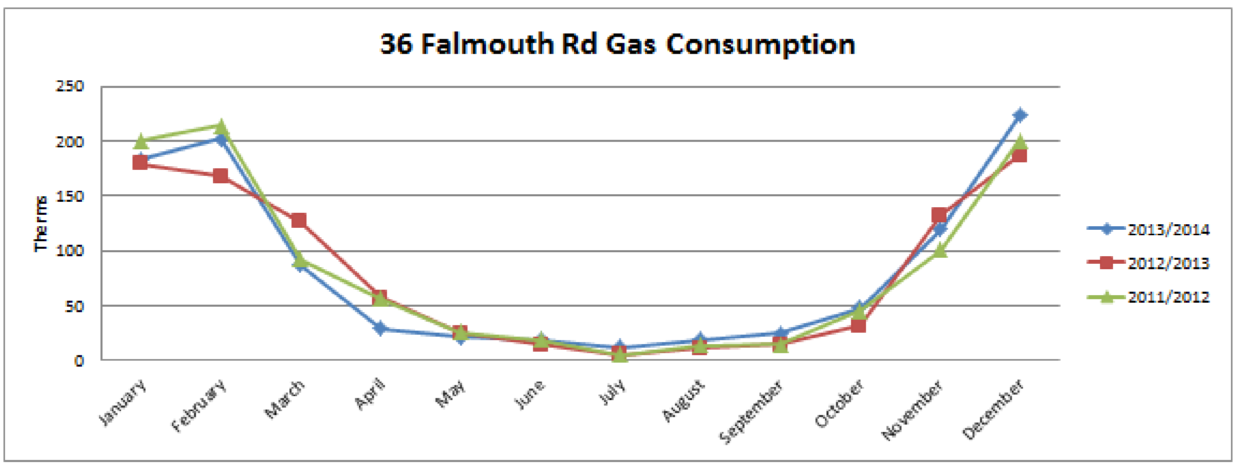
- Piping Losses
- Cycling
- Condensate Return

A general summary / breakout of energy savings is shown below. While not exact, energy savings seen at the meter are related to those derived using monitored data points.

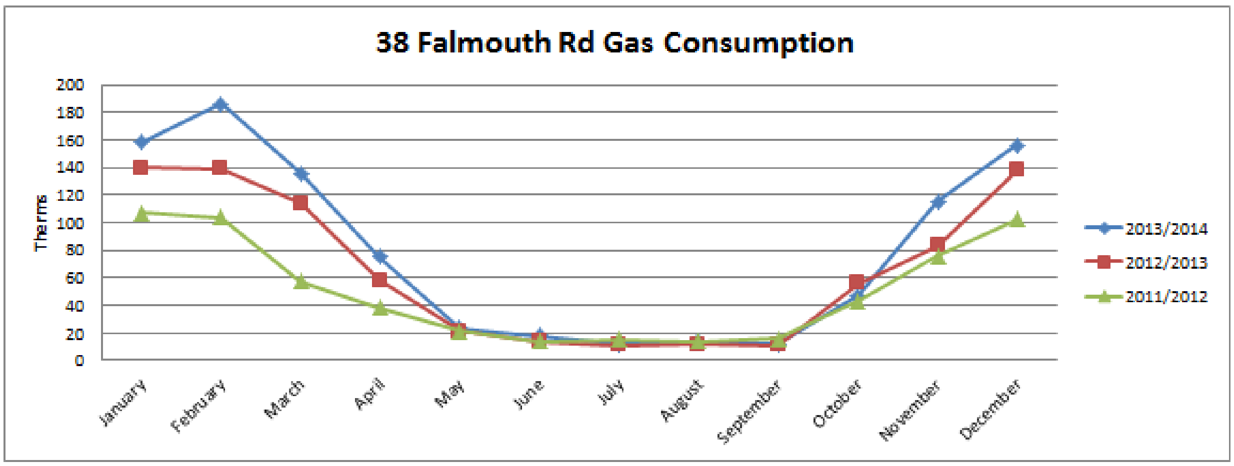
System Comparison	Derived from Fuel Metering		Quantified Using Data from Loggers				
	Predicted Consumption (Therms)	Percent Savings	Combustion Efficiency	Boiler Standby Losses	Off-cycle losses	Energy to Remove Air / Warm up pipes	Estimated Total Savings
Old Boiler - Single Pipe Steam	1,004.34	0%	0%	0%	0%	0%	0%
Old Boiler - Vacuum System	741.40	26%	2%	0%	14%	13%	29%
New Boiler - Single Pipe Steam	839.92	16%	16%	1%	-6%	3%	13%
New Boiler - Vacuum System	541.35	46%	16%	1%	20%	8%	45%
New Boiler - Balanced Vacuum System	499.74	50%	16%	1%	27%	6%	50%
Base	1,004.34	0%	0%	0%	0%	0%	0%

As the space being monitored is the second story of a residentially constructed building, any modifications to temperature set-points or occupancy conditions in the unit below could have a direct effect on the heat load of the evaluated unit. The fuel consumed by the boiler supplying heat to Unit #38 and other specific parameters were not monitored as part of this study. Historic fuel consumption for each of the units is shown below.

Account number	5084225481									
Address	36 Falmouth Rd, Newton MA									
Year	2013/2014			2012/2013			2011/2012			30 yr DD
Month	Date	Therms	DD	Date	Therms	DD	Date	Therms	DD	
January	2/1/2014	183	1,159	2/1/2013	179	1,033	2/1/2012	200	951	1,104
February	3/1/2014	202	1,007	3/1/2013	168	944	3/1/2012	214	801	951
March	4/1/2014	87	977	4/1/2013	126	841	4/1/2012	92	572	815
April	5/1/2014	29	502	5/1/2013	57	480	5/1/2012	56	366	503
May	6/1/2014	21	210	6/1/2013	25	221	6/1/2012	26	173	233
June	7/1/2014	19	28	7/1/2013	15	26	7/1/2012	19	76	48
July	8/1/2013	12	2	8/1/2012	5	0	8/1/2011	5	0	4
August	9/1/2013	19	0	9/1/2012	11	0	9/1/2011	14	0	8
September	10/1/2013	25	88	10/1/2012	15	73	10/1/2011	15	44	84
October	11/1/2013	48	266	11/1/2012	32	265	11/1/2011	45	252	344
November	12/1/2013	119	667	12/1/2012	132	676	12/1/2011	101	431	604
December	1/1/2014	223	972	1/1/2013	187	816	1/1/2012	200	770	932
Annual		987	5,878	Annual	952	5,375	Annual	987	4,436	5,630



Account number	5084225541									
Address	38 Falmouth Rd, Newton MA									
Year	2013/2014			2012/2013			2011/2012			30 yr DD
Month	Date	Therms	DD	Date	Therms	DD	Date	Therms	DD	
January	2/1/2014	158	1,159	2/1/2013	140	1,033	2/1/2012	107	951	1,104
February	3/1/2014	186	1,007	3/1/2013	139	944	3/1/2012	104	801	951
March	4/1/2014	136	977	4/1/2013	114	841	4/1/2012	57	572	815
April	5/1/2014	75	502	5/1/2013	58	480	5/1/2012	38	366	503
May	6/1/2014	23	210	6/1/2013	21	221	6/1/2012	21	173	233
June	7/1/2014	18	28	7/1/2013	14	26	7/1/2012	14	76	48
July	8/1/2013	12	2	8/1/2012	11	0	8/1/2011	15	0	4
August	9/1/2013	14	0	9/1/2012	12	0	9/1/2011	14	0	8
September	10/1/2013	12	88	10/1/2012	11	73	10/1/2011	16	44	84
October	11/1/2013	47	266	11/1/2012	56	265	11/1/2011	43	252	344
November	12/1/2013	115	667	12/1/2012	83	676	12/1/2011	76	431	604
December	1/1/2014	156	972	1/1/2013	138	816	1/1/2012	102	770	932
Annual		952	5,878	Annual	797	5,375	Annual	607	4,436	5,630



Normalized Gas Consumption - Unit #38												
Base			2013/2014			2012/2013			2011/2012			
Month	Days	Base Load	Heating	DD	Normalized	Heating	DD	Normalized	Heating	DD	Normalized	
January	31	14	144	1159	137.4	126	1033	134.9	93	951	108.2	
February	28	12	174	1007	163.9	127	944	127.5	92	801	108.7	
March	31	14	122	977	101.9	100	841	97.1	43	572	61.5	
April	30	13	62	502	61.8	45	480	46.8	25	366	33.9	
May	31	14	9	210	10.2	7	221	7.6	7	173	9.7	
June	30	15	0	28	0.0	0	26	0.0	0	76	0.0	
July	31	13	0	2	0.0	0	0	0.0	0	0	0.0	
August	31	13	0	0	0.0	0	0	0.0	0	0	0.0	
September	30	13	0	88	0.0	0	73	0.0	0	44	0.0	
October	31	14	33	266	42.9	42	265	54.8	29	252	39.9	
November	30	13	102	667	92.0	70	676	62.2	63	431	87.8	
December	31	14	142	972	136.3	124	816	141.8	88	770	106.7	
Annual	365	163	788	5878	746	641	5375	673	440	4436	556	

Normalized gas consumption associated with heating Unit #38 is depicted above. It should be noted that the site consumed approximately 11% more gas during 2013/2014 than in 2012/2013 when normalized for local weather conditions. This could be due to differences in temperature set-points at the thermostat or due to less heat being delivered indirectly from the steam system supplying Unit #36.

As part of this evaluation, the existing antiquated steam boiler was replaced with a new Peerless natural gas fired atmospheric cast iron sectional steam boiler. This four (4) section residential boiler features a spark ignition and a gross heating capacity of 147,000 BTU/hr. The original (approximately 100 years old) American Radiator Company boiler, as seen in the picture below on the left, had been retrofit with a Janitrol atmospheric natural gas conversion burner with a net input rating of 325,000 BTU/hr.

Series 63™													
Model Number	Input, MBH	Heating Capacity[3], MBH		Net Ratings[1]			Standing Pilot AFUE[3]		Spark Ignition AFUE[3]		Water Content		Approx. Shipping Weight, lb
		Water	Steam	Steam, sqft	Steam, MBH	Water, MBH	Water, %	Steam, %	Water, %	Steam, %	Water, gal	Steam, gal	
63-04	177	148	147	458	110	129	82.1	81	83.4	82.4	15.6	10.8	576

1 Net Ratings are based on DOE Heating Capacity less an allowance for normal piping and pickup as determined by the Testing and Rating Standard for Low Pressure Cast Iron Heating Boilers of the Hydronics Institute. Water ratings are based on a piping and pickup factor of 1.15. Steam ratings are based on a piping and pickup factor of 1.33. Consult PB Heat before selecting a boiler for gravity hot water installations or for installations having unusual piping and pickup requirements such as exposed piping, night set-back, etc. Ratings shown are for elevations up to 2,000 feet. For elevations above 2,000 feet, ratings should be reduced at the rate of 4% for each 1,000 feet above sea level.

2 Minimum Natural Gas Inlet Pressure exceptions: 63-04 STDG 5.3"; 63-06 STDG 5.5"; 63-06 SPRK 5.3".

3 Heating Capacity and Annual Fuel Utilization Efficiency (AFUE) ratings are based on U.S. Government tests. Before purchasing this appliance, read important information about its estimated annual energy consumption or energy efficiency rating that is available from your retailer.

a. Combustion Efficiency

Combustion Efficiency is a measure of how effectively the heat content of a fuel is transferred into usable heat. The stack temperature and flue gas oxygen (or carbon dioxide) concentrations are primary indicators of combustion efficiency.[4]

Installation of the new steam boiler is expected to have a large increase in the combustion efficiency of the overall system. The existing / original steam boiler was spot tested by RISE Engineering using a hand-held combustion analyzer displaying % oxygen, stack gas temperature and boiler efficiency. The analyzer displayed the following results while on single-pipe steam:

Combustion Efficiency Readings: SPS on 2/12/14			
Excess O2	14.5%	14.3%	14.4%
Stack Temperature (F)	450	495	504
Ambient Air Temperature (F)	41.7	43.3	[redacted]
Net Stack Temperature (F)	408.3	451.7	
Combustion Efficiency	64.0%	64.0%	63.6%

The stack temperature for all systems was measured using 10 second increment data provided by Igor. Data was provided for each monitored day. An average temperature was developed for each day during times when the boiler system was determined to be operating. Combustion air was supplied to the burner from the ambient basement air. Average daily basement temperatures are utilized as the combustion air temperature.

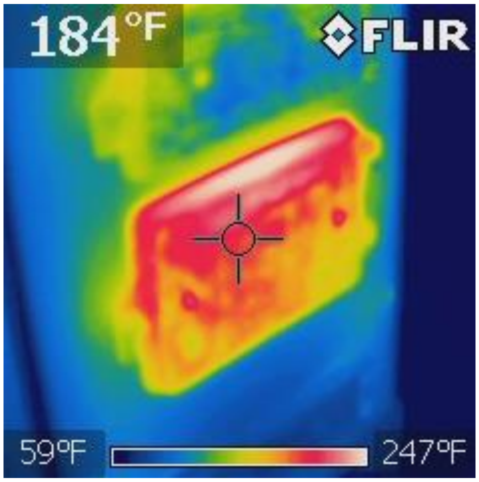
Excess %O2 in the stack was not measured on an incremental basis. The average excess %O2 for the existing boiler is approximately 14% based on spot measurements. The new boiler is predicted to be capable of firing at 10% excess O2 based on manufacturer's specifications. Excess O2 levels are kept the same between SPS and VSH when the using the same boiler as modifications were not made to the burner. Given this information and average flue gas and combustion air temperatures, the combustion efficiency for each of the heating scenarios is shown below. Available heat was calculated using the US Department of Energy's Process Heating Assessment and Survey Tool (PHAST) Version 3.0. There are slight combustion efficiency gains when switching between SPS and VSH (given the same boiler) due to a reduction in the overall net stack temperature.

Heating Scenario	Average Indoor Temperature (Deg F)	Average Stack Temperature (across all hours) - Deg. F	Average FGT when Blr On - Deg. F	Max. Stack Temperature	Average Basement Temperature	Excess O2:	Available Heat (% of HHV)	% Fuel Savings
Old Boiler Single Pipe Steam	65.96	197.83	477.10	515.93	63.24	14%	69.80%	0.0%
Old Boiler with Vac. System	65.78	167.64	451.19	505.89	62.97	14%	71.27%	2.1%
New Boiler Single Pipe Steam	66.51	200.39	326.71	361.24	60.38	10%	82.94%	15.8%
New Boiler Vac. System	66.11	144.40	316.86	360.09	59.04	10%	83.29%	16.2%
New Boiler Balanced Vac. System	66.25	129.39	320.76	362.23	59.86	10%	83.16%	16.1%

The % fuel savings all assume that the SPS with the original boiler is the "base" scenario.

[4] Advanced Manufacturing Office, Energy Efficiency and Renewable Energy, U.S. Department of Energy

b. Boiler Standby Losses



Boilers experience heat loss due to the boiler giving off heat by radiation and convection to the surroundings. This occurs because the temperate of the boiler jacket is greater than the air. The amount of jacket loss is determined largely by the surface area, surface temperature, and ambient temperature. [5]While the calculation to quantify the exact losses due to radiation and convection is complex, an acceptable approximation is considered to be 1.5% - 2% of the input rate.[6]

This percentage does not change with the load on the boiler so an oversized unit will have a greater reduction in performance efficiency.[7] With this in mind, it is apparent that the new boiler should have energy savings from a reduction in the input as well as it having a smaller surface area. It is also evident that the original boiler is currently oversized which would attribute more energy savings from reducing jacket losses to the new boiler. Additionally, the systems operating on a vacuum should also have energy savings because the temperature at which the water boils is reduced. This would reduce the surface temperature of the boiler, thus reducing jacket losses further.

As seen in the thermal image above, the original boiler's door is poorly insulated and transferring valuable energy to the ambient space. The average external temperature of the original steam boiler was measured at 113 °F versus 72 °F with the new boiler.

For the purpose of this analysis, 1.5% of the net input is assumed to be equivalent to the standby losses. No additional savings are attributed to scenarios in which the VSH is employed.

Boiler	Old	New
Input	325,000.00	177,000.00
Standby Loss	1.5%	1.5%
Standby Loss	4,875.00	2,655.00
% savings	0%	0.68%

The new boiler is estimated to save 0.68% of the base fuel consumption when compared to the original boiler.

[5] India. Bureau of Energy Efficiency, *Energy Performance of Boilers* http://beeindia.in/energy_managers_auditors/documents/guide_books/4Ch1.pdf (August 2014)
[6] Steve Dotty, *Commercial Energy Auditing Reference Handbook* (Lilburn: Fairmont Press, 2011), 347.
[7] Canada. Natural Resources Canada, *Radiation, Convection, and Other Losses* http://www.nrcan.gc.ca/energy/efficiency/industry/technical-info/tools/boilers/5429 (August 2014)

c. Off-cycle Losses

Just as the various scenarios experienced a reduction in energy during operating (firing) conditions, the system also saves energy while the burner is not firing. Energy lost up the boiler flue during off-cycle conditions was quantified for each of the five (5) tested conditions. The draft was greatly affected between the SPS and VSH due to the large reduction in average stack temperature. A summary of savings is presented below.

Stack Draft Effect	Old Boiler - Single Pipe Steam	Old Boiler - Vacuum System	New Boiler - Single Pipe Steam	New Boiler - Vacuum System	New Boiler - Balanced Vacuum System
Volumetric Air Flow Requirements for Combustion - CFM	53.6	53.6	29.2	29.2	29.2
Stack Diameter (feet)	0.6	0.6	0.6	0.6	0.6
Stack Area (square feet)	0.3	0.3	0.3	0.3	0.3
Stack Height (ft)	30.0	30.0	30.0	30.0	30.0
Gravitation Acceleration (ft/s^2)	32.2	32.2	32.2	32.2	32.2
Discharge coefficient C	0.65	0.65	0.65	0.65	0.65
Average Stack Temperature (Degree F)	197.8	167.6	200.4	144.4	129.4
Average Stack Temperature (Degree R)	657.5	627.3	660.1	604.1	589.1
Average Outside Air Temperature During Run Hours (Degree F)	66.0	65.8	66.5	66.1	66.3
Average Outside Air Temperature During Run Hours (Degree R)	525.6	525.5	526.2	525.8	525.9
Average Combustion Air Temperature (Deg F)	63.2	63.0	60.4	59.0	59.9
Q (Stack Effect Draft Flow Rate) ft^3/s	3.4	3.1	3.4	2.7	2.5
Q (Stack Effect Draft Flow Rate) cfm	205.2	184.6	206.3	164.9	150.0
Off-cycle hours / year (Hrs On - FLRH)	2130.0	2210.9	1964.5	2133.2	2156.7
cubic feet / year of air required for combustion	6,844,698	7,104,681	3,438,073	3,733,293	3,774,437
cubic feet / year of combustion air due to stack draft effect	26,220,529	24,489,081	24,319,412	21,109,678	19,408,765
Btu / yr required for combustion air	16,582,153	13,386,402	8,664,721	5,736,206	4,723,892
Btu / yr required for combustion air due to stack draft effect	63,522,576	46,141,508	61,290,419	32,435,022	24,291,018
Losses per year due to stack effect (btu/yr)	46,940,422	32,755,106	52,625,698	26,698,817	19,567,126
Savings %	0.0%	14.1%	-5.7%	20.2%	27.3%

The pictures below show the original steam boiler flue on the left and newly installed steam boiler and stack on the right.

d. Air Removal

Each heating cycle has a "warm-up" time associated with it. As the distribution system was converted from single pipe steam to the vacuum system there is a significant difference in the duration of the preliminary cycle. In all cases, the radiators operating as an SPS system took much longer to receive steam and get up to temperature.

As vented air and water vapor will technically transfer to the space within the building's shell, only stack energy lost attributed to increased run time was determined to be "energy savings." A breakout of these savings may be seen in the following six (6) tables. Each of the radiators had their preliminary heating cycle characteristic measured for each of the five (5) testing scenarios.

Upon review, it is evident that radiators connected to the SPS system take much longer to get up to temperature. The table below shows the average time the boiler needed to fire before the radiators started to get warmer than the ambient conditions. It is believed that most of the savings related to the warm up time is directly related to the elimination of the air vents.

Average Heat-up Time (Hours)					
Radiator	Old Boiler - Single Pipe Steam	Old Boiler - Vacuum System	New Boiler - Single Pipe Steam	New Boiler - Vacuum System	New Boiler - Balanced Vacuum System
Living Room	0.62	0.15	0.46	0.13	0.21
Kitchen	0.35	0.14	0.24	0.12	0.19
Bedroom #1	0.41	0.16	0.31	0.13	0.21
Bedroom #2	0.48	0.17	0.33	0.13	0.20
Office	0.50	0.18	0.38	0.15	0.23
Dining Room	0.47	0.15	0.44	0.13	0.21

The following pages break out the energy savings associated with each radiator. Predicted % fuel savings are solely based on the fuel attributed to warming up that specific radiator.

Living Room	Old Boiler – Single Pipe Steam	Old Boiler – Vacuum System	New Boiler - Single Pipe Steam	New Boiler – Vacuum System	New Boiler – Balanced Vacuum System
Date Used	2/8/2014	1/29/2014	2/25/2014	3/6/2014	3/16/2014
Start Time	3:27:30 AM	12:24:47 AM	3:41:01 AM	1:09:26 AM	4:09:15 AM
End Time	4:31:30 AM	12:45:17 AM	4:13:21 AM	1:22:56 AM	4:29:15 AM
Average start up time (hrs)	1.07	0.34	0.54	0.23	0.33
Counter Start	2	0	0	0	0
Counter End	85	28	31	21	20
Counter Delta	83	28	31	21	20
Therms	1.494	0.504	0.558	0.378	0.36
Average OA Temp	26.9	24.9	28.7	23.7	34.0
Average Indoor Temp	65.96	65.78	66.51	66.11	66.25
	39.07	40.91	37.80	42.41	32.21
Heat up Time for LR	Air Vents				
Start	3:27:30 AM	12:24:47 AM	3:41:01 AM	1:09:26 AM	4:09:15 AM
End	4:04:30 AM	12:33:37 AM	4:08:21 AM	1:17:06 AM	4:21:35 AM
Total Time	0.62	0.15	0.46	0.13	0.21
Start Temp	17.3	16.5	17.1	16.3	16.2
End Temp	26.7	25.1	24.6	23.9	25.2
Delta Temp	9.4	8.6	7.5	7.6	9.0
Estimated Startup Savings (time based)	0%	44%	15%	46%	39%
Heat to space	69.8%	71.3%	82.9%	83.3%	83.2%
% fuel savings - annual	0.0%	12.6%	2.6%	7.7%	6.5%

Kitchen	Old Boiler – Single Pipe Steam	Old Boiler – Vacuum System	New Boiler - Single Pipe Steam	New Boiler – Vacuum System	New Boiler – Balanced Vacuum System
Date Used	2/8/2014	1/29/2014	2/25/2014	3/6/2014	3/16/2014
Start Time	3:27:30 AM	12:24:47 AM	3:41:01 AM	1:09:26 AM	4:09:15 AM
End Time	4:31:30 AM	12:45:17 AM	4:13:21 AM	1:22:56 AM	4:29:15 AM
Average start up time (hrs)	1.07	0.34	0.54	0.23	0.33
Counter Start	2	0	0	0	0
Counter End	85	28	31	21	20
Counter Delta	83	28	31	21	20
Therms	1.494	0.504	0.558	0.378	0.36
Average OA Temp	26.9	24.9	28.7	23.7	34.0
Average Indoor Temp	65.96	65.78	66.51	66.11	66.25
	39.07	40.91	37.80	42.41	32.21
Heat up Time for Kitchen	Air Vents				
Start	3:27:30 AM	12:24:47 AM	3:41:01 AM	1:09:26 AM	4:09:15 AM
End	3:48:40 AM	12:33:17 AM	3:55:41 AM	1:16:36 AM	4:20:55 AM
Total Time	0.35	0.14	0.24	0.12	0.19
Start Temp	19.3	18.9	19.6	18.1	18.6
End Temp	22.0	23.0	21.3	24.0	19.1
Delta Temp	2.7	4.1	1.7	5.8	0.5
Estimated Startup Savings	0%	20%	10%	22%	15%
Heat to space	69.8%	71.3%	82.9%	83.3%	83.2%
% fuel savings - annual	0.0%	5.7%	1.7%	3.7%	2.5%

Bedroom #1	Old Boiler – Single Pipe Steam	Old Boiler – Vacuum System	New Boiler - Single Pipe Steam	New Boiler – Vacuum System	New Boiler – Balanced Vacuum System
Date Used	2/8/2014	1/29/2014	2/25/2014	3/6/2014	3/16/2014
Start Time	3:27:30 AM	12:24:47 AM	3:41:01 AM	1:09:26 AM	4:09:15 AM
End Time	4:31:30 AM	12:45:17 AM	4:13:21 AM	1:22:56 AM	4:29:15 AM
Average start up time (hrs)	1.07	0.34	0.54	0.23	0.33
Counter Start	2	0	0	0	0
Counter End	85	28	31	21	20
Counter Delta	83	28	31	21	20
Therms	1.494	0.504	0.558	0.378	0.36
Average OA Temp	26.9	24.9	28.7	23.7	34.0
Average Indoor Temp	65.96	65.78	66.51	66.11	66.25
	39.07	40.91	37.80	42.41	32.21
Heat up Time for BR1	Air Vents				
Start	3:27:30 AM	12:24:47 AM	3:41:01 AM	1:09:26 AM	4:09:15 AM
End	3:52:00 AM	12:34:07 AM	3:59:21 AM	1:17:06 AM	4:21:45 AM
Total Time	0.41	0.16	0.31	0.13	0.21
Start Temp	15.3	5.3	15.1	13.9	12.3
End Temp	20.3	11.5	24.1	22.7	18.5
Delta Temp	5.0	6.2	9.0	8.8	6.1
Estimated Startup Savings	0%	24%	10%	26%	19%
Heat to space	69.8%	71.3%	82.9%	83.3%	83.2%
% fuel savings - annual	0.0%	6.8%	1.6%	4.4%	3.2%

Bedroom #2	Old Boiler – Single Pipe Steam	Old Boiler – Vacuum System	New Boiler - Single Pipe Steam	New Boiler – Vacuum System	New Boiler – Balanced Vacuum System
Date Used	2/8/2014	1/29/2014	2/25/2014	3/6/2014	3/16/2014
Start Time	3:27:30 AM	12:24:47 AM	3:41:01 AM	1:09:26 AM	4:09:15 AM
End Time	4:31:30 AM	12:45:17 AM	4:13:21 AM	1:22:56 AM	4:29:15 AM
Average start up time (hrs)	1.07	0.34	0.54	0.23	0.33
Counter Start	2	0	0	0	0
Counter End	85	28	31	21	20
Counter Delta	83	28	31	21	20
Therms	1.494	0.504	0.558	0.378	0.36
Average OA Temp	26.9	24.9	28.7	23.7	34.0
Average Indoor Temp	65.96	65.78	66.51	66.11	66.25
	39.07	40.91	37.80	42.41	32.21
Heat up Time for BR2	Air Vents				
Start	3:27:30 AM	12:24:47 AM	3:41:01 AM	1:09:26 AM	4:09:15 AM
End	3:56:10 AM	12:34:47 AM	4:00:31 AM	1:17:06 AM	4:21:25 AM
Total Time	0.48	0.17	0.33	0.13	0.20
Start Temp	17.9	18.5	18.6	16.3	17.1
End Temp	20.7	20.4	20.4	30.5	19.1
Delta Temp	2.8	1.9	1.8	14.1	2.0
Estimated Startup Savings	0%	29%	14%	33%	26%
Heat to space	69.8%	71.3%	82.9%	83.3%	83.2%
% fuel savings - annual	0.0%	8.4%	2.4%	5.5%	4.3%

Office	Old Boiler - Single Pipe Steam	Old Boiler - Vacuum System	New Boiler - Single Pipe Steam	New Boiler - Vacuum System	New Boiler - Balanced Vacuum System
Date Used	2/8/2014	1/29/2014	2/25/2014	3/6/2014	3/16/2014
Start Time	3:27:30 AM	12:24:47 AM	3:41:01 AM	1:09:26 AM	4:09:15 AM
End Time	4:31:30 AM	12:45:17 AM	4:13:21 AM	1:22:56 AM	4:29:15 AM
Average start up time (hrs)	1.07	0.34	0.54	0.23	0.33
Counter Start	2	0	0	0	0
Counter End	85	28	31	21	20
Counter Delta	83	28	31	21	20
Therms	1.494	0.504	0.558	0.378	0.36
Average OA Temp	26.9	24.9	28.7	23.7	34.0
Average Indoor Temp	65.96	65.78	66.51	66.11	66.25
	39.07	40.91	37.80	42.41	32.21
Heat up Time for Office	Air Vents				
Start	3:27:30 AM	12:24:47 AM	3:41:01 AM	1:09:26 AM	4:09:15 AM
End	3:57:20 AM	12:35:47 AM	4:03:31 AM	1:18:16 AM	4:22:45 AM
Total Time	0.50	0.18	0.38	0.15	0.23
Start Temp	17.1	17.3	17.8	17.4	17.6
End Temp	33.2	21.0	32.2	20.0	19.7
Delta Temp	16.0	3.7	14.3	2.6	2.1
Estimated Startup Savings	0%	29%	11%	33%	26%
Heat to space	69.8%	71.3%	82.9%	83.3%	83.2%
% fuel savings - annual	0.0%	8.5%	2.0%	5.5%	4.3%

Dining Room	Old Boiler - Single Pipe Steam	Old Boiler - Vacuum System	New Boiler - Single Pipe Steam	New Boiler - Vacuum System	New Boiler - Balanced Vacuum System
Date Used	2/8/2014	1/29/2014	2/25/2014	3/6/2014	3/16/2014
Start Time	3:27:30 AM	12:24:47 AM	3:41:01 AM	1:09:26 AM	4:09:15 AM
End Time	4:31:30 AM	12:45:17 AM	4:13:21 AM	1:22:56 AM	4:29:15 AM
Average start up time (hrs)	1.07	0.34	0.54	0.23	0.33
Counter Start	2	0	0	0	0
Counter End	85	28	31	21	20
Counter Delta	83	28	31	21	20
Therms	1.494	0.504	0.558	0.378	0.36
Average OA Temp	26.9	24.9	28.7	23.7	34.0
Average Indoor Temp	65.96	65.78	66.51	66.11	66.25
	39.07	40.91	37.80	42.41	32.21
Heat up Time for Dining Room	Air Vents				
Start	3:27:30 AM	12:24:47 AM	3:41:01 AM	1:09:26 AM	4:09:15 AM
End	3:55:40 AM	12:33:57 AM	4:07:31 AM	1:17:06 AM	4:21:55 AM
Total Time	0.47	0.15	0.44	0.13	0.21
Start Temp	17.9	17.7	18.5	16.9	16.5
End Temp	58.5	20.3	27.0	33.5	22.5
Delta Temp	40.6	2.6	8.5	16.6	5.9
Estimated Startup Savings	0%	30%	3%	32%	24%
Heat to space	69.8%	71.3%	82.9%	83.3%	83.2%
% fuel savings - annual	0.0%	8.5%	0.4%	5.4%	4.1%

The air vents in single pipe steam (SPS) play a vital role in the operation of the heating system. Each radiator as well as the end of the main supply line has an air vent that performs three functions every cycle. When a cycle begins and steam begins to enter the system, the air vent must open in order to allow the air to be pushed out of the radiator by the steam. Once steam has filled the radiator, the air vent must close to prevent steam loss. Once the heating cycle ends, the air vent must then be opened to allow air back into the system. This is important to break the vacuum caused by condensing steam. If the vacuum isn't broken when the steam enters the system during the next heating cycle, water hammer can occur and may cause damage to the system. The air vents also perform the important function of closing if the radiators flood.[8]

Air vents are most likely to waste energy if they are clogged. Clogging occurs through use over time. Since the system is open to air, rust and mineral deposits build up in the system. When the system is venting, small flakes and particles can build up in the holes of the vent.[9] Over time, these deposits can clog up the air vents, reducing the venting capacity. This affects the efficiency because the time it takes for the air to be removed from the system is proportional to the time heat is emitted by the radiators. Therefore, all of the energy used by the boiler during the time attributed to the inefficiency of the venting would be considered wasted energy.

[8] Roy C.E. Ahlgren, "Low Pressure Steam Heating Systems," *Ashrae Journal* (January 1994): 54-70. ebscohost.com
[9] Dan Holohan, "Care and Feeding of Air Vents," http://www.oldhousejournal.com

VIII. Report Summary

The Vacuum Steam Heating system, as designed and implemented by Applied Engineering Consulting, appears to save a significant amount of natural gas with only a minor electric penalty. The savings range from as little as 7.7% savings up to 50.2% savings, depending on what the test scenario was. Based upon RISE Engineering's industry experience, a customer would most likely pursue the options which do not require steam boiler change out (retrofit). Using this scenario as a basis for savings a customer could expect, if upgrading from single pipe steam to the VSH system, between 20 to 28% fuel savings. The VSH system is theoretically infinitely scalable, with the only limiting factor being the size of the vacuum pump system required to hold the system at the required negative 24 inches of mercury.

Further testing, cost analysis, and code review should be performed to determine if the product is fully cost effective. In this test case, the customer did not use their existing high mass cast iron steam radiators for the vacuum system but rather low mass replacement units. While this is acceptable at the customer's residence, the capital cost to upgrade a facility with a completely new radiation system could be cost prohibitive. Beyond the potential cost issues, there was no testing performed to determine the efficiency gain by utilizing low mass radiators versus the high mass cast iron units.

There are alternatives to luxury steam radiators utilized in retrofit at a fraction of cost. Hot water panel radiators could potentially be utilized for vacuum heating after some modifications. Another valid option is cast aluminum steam radiators commonly used in Europe. Aluminum radiators' life span, warrantied to 10 years, can be exceeded significantly when operated under a vacuum.

If a customer decides to forgo replacement of their cast iron radiators their savings could be significantly different from the test data acquired here. Further, a building and plumbing code review would need to be performed to ensure that the methodologies utilized to operate the test system are code compliant.

If you have any questions with the material presented in this report please contact Jean-Paul Vandeputte at RISE Engineering by calling 800-843-3636 or by email at JPVandeputte@Thielsch.com.

Recommendations made in this report are based on engineering estimates and third party information. Costs and saving are not guaranteed. It is recommended that the customer obtain a proposal and firm price from a qualified contractor for recommended measures before making final decisions about a course of action. Any change in the measure, equipment size or efficiency may change or eliminate the estimated fuel savings.

IX. Appendices

a. Pulse Data to Therm Conversion

Applied Engineering Consulting installed a pulse recorder on the Elster gas meter. This pulse recorder would generate a pulse that was recorded into the data acquisition system. A pulse would be generated each time the magnetron in the pulse meter sensed that the gas meter had recorded 0.05 m^3 of natural gas had been consumed by the boiler. This was converted into therms to ensure that the pulse meter was recording data that would match what National Grid was billing the customer for gas consumed. The meter that National Grid was generating bills for served the entire apartment including the boiler and other gas equipment, while the secondary meter that was being monitored was an additional unit reading only consumption by the boiler. The National Grid bills can be seen below; in particular we are concerned about March 2014 (February 5th through March 7th).

View Customer Usage Premise No:- 508422548 - IGOR ZHADANOVSKY

Account Header | History | Usage | Applications |

Gas Usage Data

Bill Month and Year	Latest Meter Read Date	No Of Billing Days	Actual Therms
May 2014	May 07,2014	30	29
Apr 2014	Apr 07,2014	31	87
Mar 2014	Mar 07,2014	31	202
Feb 2014	Feb 04,2014	28	185
Oct 2013	Oct 04,2013	25	25
Sep 2013	Sep 09,2013	35	19
Aug 2013	Aug 05,2013	28	12
Jul 2013	Jul 08,2013	28	15
Jun 2013	Jun 10,2013	35	25

March's bill was for 202 therms of natural gas. Since the customer typically consumes around 25 therms of natural gas during the summer months (a base line consumption where the boiler should not be running) the heating only consumption for the March bill should be around 175 therms of natural gas. The pulse output data, which does not include 8 days, is shown below.

	Number of Clicks from daily summary sheets	Therms Consumed based on .05m3 per pulse Therms = ((Pluse count)*0.05m^3)*0.36 Therm/m^3	m^3 consumption based upon pulse data
1/29/2014	185		
1/30/2014	334	6.012	16.7
1/31/2014	0	0	0
2/1/2014	0	0	0
2/2/2014	185	3.33	9.25
2/3/2014	260	4.68	13
2/4/2014	0	0	0
2/5/2014		0	0
2/6/2014		0	0
2/7/2014	416	7.488	20.8
2/8/2014	412	7.416	20.6
2/9/2014	409	7.362	20.45
2/10/2014	412	7.416	20.6
2/11/2014	426	7.668	21.3
2/12/2014	413	7.434	20.65
2/13/2014		0	0
2/14/2014		0	0
2/15/2014	354	6.372	17.7
2/16/2014	378	6.804	18.9
2/17/2014	440	7.92	22
2/18/2014	544	9.792	27.2
2/19/2014	345	6.21	17.25
2/20/2014	211	3.798	10.55
2/21/2014		0	0
2/22/2014		0	0
2/23/2014		0	0
2/24/2014	191	3.438	9.55
2/25/2014	273	4.914	13.65
2/26/2014	284	5.112	14.2
2/27/2014	322	5.796	16.1
2/28/2014	291	5.238	14.55
3/1/2014		0	0
3/2/2014	226	4.068	11.3
3/3/2014	168	3.024	8.4
3/4/2014	277	4.986	13.85
3/5/2014	227	4.086	11.35
3/6/2014	219	3.942	10.95
3/7/2014	221	3.978	11.05
3/8/2014	124	2.232	6.2
3/9/2014	160	2.88	8
3/10/2014	158	2.844	7.9
3/11/2014	77	1.386	3.85
3/12/2014		0	0
3/13/2014	199	3.582	9.95
3/14/2014	240	4.32	12
3/15/2014	114	2.052	5.7
3/16/2014	173	3.114	8.65
3/17/2014	180	3.24	9
3/18/2014	167	3.006	8.35
3/19/2014	162	2.916	8.1
3/20/2014	87	1.566	4.35
3/21/2014	96	1.728	4.8
3/22/2014	110	1.98	5.5
3/23/2014	143	2.574	7.15
3/24/2014	175	3.15	8.75
3/25/2014	150	2.7	7.5
3/26/2014	185	3.33	9.25
3/27/2014	176	3.168	8.8
3/28/2014	76	1.368	3.8
3/29/2014	64	1.152	3.2
3/30/2014	150	2.7	7.5
3/31/2014	159	2.862	7.95
4/1/2014	229	4.122	11.45
4/2/2014	77	1.386	3.85

Less the 8 days that do not have data, the boiler consumed 134 therms of natural gas. When you utilize the average natural gas consumption per day to populate in the missing cells (Average = 5.83 Therms/Day) the total consumption by the boiler becomes 180 therms. Since 180 therms + 25 therms = 205 therms, RISE Engineering is led to believe that the pulse meter was recording data accurately, and that the correct conversion value from Pulse counts to actual consumption is $0.05m^3$ of natural gas.

b. Costing Information

The project costs are as show below. These costs were supplied by Applied Engineering Consulting.

Boiler		$3,000.00
installation		$1,850.00
	Subtotal	$4,850.00

Plumbing		
lines from basement to 2nd floor		$1,500.00
lines in basement		$800.00
	Subtotal	$2,300.00

Materials		
fittings		$800.00
tubing		$180.00
Insulation		$330.00
	Subtotal	$1,310.00

Radiators	$5,200.00
Controls	$474.00
Vacuum pump	$395.00

Total Project Cost	$14,529.00

The two major project types that could be seen for this type of installation is to either; convert an existing steam system to a VSH which would cost $9,679 (does not include cost of new boiler), or to convert an existing system to VSH and add a new boiler too $14,529. Utilizing the predicted savings from the report a simple pay back analysis was performed.

System Comparison	Predicted Consumption (Therms)	Cost of gas at $1.15/Therm	Savings ($)*	System Cost	Simple Payback (Years)
Old Boiler - Single Pipe Steam	1,004	$1,154.99	$189.08	$4,850.00	25.65
New Boiler - Single Pipe Steam	840	$965.91			
Old Boiler - Single Pipe Steam	1,004	$1,154.99	$277.84	$9,679.00	34.84
Old Boiler - Vacuum System	741	$852.61			
Old Boiler - Single Pipe Steam	1,004	$1,154.99	$507.90	$14,529.00	28.61
New Boiler - Vacuum System	541	$622.55			

*Penalty for increased electric consumption included

Based on the simple paybacks for this specific facility the projects would not pass a National Grid Benefit Cost Ratio (BCR) screening. A larger client could potentially generate the savings necessary to offset the project costs with their savings.

c. Daily outdoor average temperature

Hour of the Day	Average Temperature	Average Light Intensity (Lumens)	Fuel Consumption (Therms)	
1/29/2014	24.9	17.6	3.33	Old Boiler with Vacuum System
1/30/2014	25.7	24.3	6.01	
1/31/2014	35.4	15.4		
2/1/2014	39.8	21.9		
2/2/2014	43.0	15.4	3.33	
2/3/2014	36.7	4.8	4.68	
2/4/2014	31.5	28.9		
2/5/2014	33.3	9.3		Old Boiler with Single Pipe Steam
2/6/2014	26.9	23.4		
2/7/2014	26.0	22.7	7.49	
2/8/2014	26.9	27.7	7.42	
2/9/2014	30.4	29.0	7.36	
2/10/2014	27.3	28.2	7.42	
2/11/2014	22.4	25.3	7.67	
2/12/2014	21.8	106.6	7.43	
2/13/2014	31.8	23.0		
2/14/2014	35.7	140.9		
2/15/2014	34.0	88.9	6.37	
2/16/2014	30.4	163.0	6.80	
2/17/2014	24.9	176.3	7.92	
2/18/2014	26.8	53.1	9.79	
2/19/2014	32.6	105.5	6.21	
2/20/2014	38.9	145.8	3.80	
2/21/2014	39.2	44.0		New Boiler on Single Pipe Steam
2/22/2014	41.3	194.4		
2/23/2014	42.5	146.5		
2/24/2014	35.7	161.8	3.44	
2/25/2014	28.7	141.1	4.91	
2/26/2014	26.3	139.1	5.11	
2/27/2014	25.0	154.3	5.80	
2/28/2014	22.1	211.1	5.24	
3/1/2014	27.7	191.5		

Hour of the Day	Average Temperature	Average Light Intensity (Lumens)	Fuel Consumption (Therms)	
3/2/2014	36.9	77.9	4.068	New Boiler on Vacuum System
3/3/2014	26.1	121.5	3.024	
3/4/2014	25.0	190.8	4.986	
3/5/2014	28.5	116.1	4.086	
3/6/2014	23.7	248.6	3.942	
3/7/2014	29.4	207.8	3.978	
3/8/2014	40.3	215.3	2.232	
3/9/2014	36.6	229.0	2.88	
3/10/2014	38.5	152.2	2.844	
3/11/2014	45.0	200.5	1.386	
3/12/2014	43.2	79.9		
3/13/2014	26.4	240.2	3.582	New Boiler with Balanced Vacuum System
3/14/2014	31.0	260.5	4.32	
3/15/2014	44.7	165.9	2.052	
3/16/2014	34.0	218.4	3.114	
3/17/2014	27.0	206.5	3.24	
3/18/2014	31.3	207.4	3.006	
3/19/2014	36.6	159.3	2.916	
3/20/2014	43.4	130.9	1.566	
3/21/2014	40.3	128.2	1.728	
3/22/2014	42.0	137.5	1.98	
3/23/2014	38.1	143.4	2.574	
3/24/2014	28.0	207.4	3.15	
3/25/2014	33.3	166.2	2.7	
3/26/2014	33.0	90.7	3.33	
3/27/2014	34.9	195.9	3.168	
3/28/2014	47.2	102.9	1.368	
3/29/2014	46.6	91.9	1.152	
3/30/2014	41.7	33.5	2.7	
3/31/2014	39.3	37.6	2.862	
4/1/2014	43.9	199.2	4.122	
4/2/2014	38.4	64.9	1.386	

d. Daily indoor average temperature recorded at thermostat

Hour of the Day	Average Indoor Temperature (Deg F)	Fuel Consumption (Therms)	
1/29/2014	65.0	3.33	Old Boiler with Vacuum System
1/30/2014	65.7	6.01	
1/31/2014	65.4		
2/1/2014	66.1		
2/2/2014	66.1	3.33	
2/3/2014	66.3	4.68	
2/4/2014	65.0		
2/5/2014	66.1		Old Boiler with Single Pipe Steam
2/6/2014	66.4		
2/7/2014	66.2	7.49	
2/8/2014	66.0	7.42	
2/9/2014	65.9	7.36	
2/10/2014	66.0	7.42	
2/11/2014	66.0	7.67	
2/12/2014	65.5	7.43	
2/13/2014	66.0		
2/14/2014	66.4		
2/15/2014	66.2	6.37	
2/16/2014	66.0	6.80	
2/17/2014	No Data	7.92	
2/18/2014	No Data	9.79	
2/19/2014	No Data	6.21	
2/20/2014	No Data	3.80	
2/21/2014	No Data		New Boiler on Single Pipe Steam
2/22/2014	No Data		
2/23/2014	No Data		
2/24/2014	No Data	3.44	
2/25/2014	No Data	4.91	
2/26/2014	No Data	5.11	
2/27/2014	No Data	5.80	
2/28/2014	67.1	5.24	
3/1/2014	65.9		

Hour of the Day	Average Indoor Temperature (Deg F)	Fuel Consumption (Therms)	
3/2/2014	65.9	4.068	New Boiler on Vacuum System
3/3/2014	65.7	3.024	
3/4/2014	65.6	4.986	
3/5/2014	65.8	4.086	
3/6/2014	65.8	3.942	
3/7/2014	65.7	3.978	
3/8/2014	66.2	2.232	
3/9/2014	66.3	2.88	
3/10/2014	66.2	2.844	
3/11/2014	67.9	1.386	
3/12/2014	66.8		
3/13/2014	66.1	3.582	New Boiler with Balanced Vacuum System
3/14/2014	66.0	4.32	
3/15/2014	66.6	2.052	
3/16/2014	66.2	3.114	
3/17/2014	66.2	3.24	
3/18/2014	66.3	3.006	
3/19/2014	66.1	2.916	
3/20/2014	66.4	1.566	
3/21/2014	66.5	1.728	
3/22/2014	66.4	1.98	
3/23/2014	66.1	2.574	
3/24/2014	65.8	3.15	
3/25/2014	66.0	2.7	
3/26/2014	65.8	3.33	
3/27/2014	66.1	3.168	
3/28/2014	66.3	1.368	
3/29/2014	67.2	1.152	
3/30/2014	66.3	2.7	
3/31/2014	66.2	2.862	
4/1/2014	67.1	4.122	
4/2/2014	65.9	1.386	

e. Vacuum pump daily run time

Hour of the Day	Daily Run Time of Vacuum Pump (Hours)	Predicted Consumption of Vacuum Pump (kWh)	Fuel Consumption (Therms)	
1/29/2014	0:00:00	0.000	3.33	Old Boiler with Vacuum System
1/30/2014	0:00:00	0.000	6.01	
1/31/2014	0:00:00	0.000		
2/1/2014	0:00:00	0.000		
2/2/2014	0:00:00	0.000	3.33	
2/3/2014	0:00:00	0.000	4.68	
2/4/2014	0:00:00	0.000		
2/5/2014	0:00:00	0.000		Old Boiler with Single Pipe Steam
2/6/2014	0:00:00	0.000		
2/7/2014	0:00:00	0.000	7.49	
2/8/2014	0:00:00	0.000	7.42	
2/9/2014	0:00:00	0.000	7.36	
2/10/2014	0:00:00	0.000	7.42	
2/11/2014	0:00:00	0.000	7.67	
2/12/2014	0:00:00	0.000	7.43	
2/13/2014	0:00:00	0.000		
2/14/2014	0:00:00	0.000		
2/15/2014	0:00:00	0.000	6.37	
2/16/2014	0:00:00	0.000	6.80	
2/17/2014	0:00:00	0.000	7.92	
2/18/2014	0:00:00	0.000	9.79	
2/19/2014	0:00:00	0.000	6.21	
2/20/2014	0:00:00	0.000	3.80	
2/21/2014	0:00:00	0.000		New Boiler on Single Pipe Steam
2/22/2014	0:00:00	0.000		
2/23/2014	0:00:00	0.000		
2/24/2014	0:00:00	0.000	3.44	
2/25/2014	0:00:00	0.000	4.91	
2/26/2014	0:00:00	0.000	5.11	
2/27/2014	0:00:00	0.000	5.80	
2/28/2014	0:00:00	0.000	5.24	
3/1/2014	0:00:00	0.000		

Hour of the Day	Daily Run Time of Vacuum Pump (Hours)	Predicted Consumption of Vacuum Pump (kWh)	Fuel Consumption (Therms)	
3/2/2014	0:00:00	0.000	4.07	New Boiler on Vacuum System
3/3/2014	0:00:00	0.000	3.02	
3/4/2014	0:00:00	0.000	4.99	
3/5/2014	3:56:43	1.809	4.09	
3/6/2014	2:22:18	1.089	3.94	
3/7/2014	3:08:45	1.441	3.98	
3/8/2014	2:37:16	1.204	2.23	
3/9/2014	3:13:54	1.480	2.88	
3/10/2014	2:35:21	1.188	2.84	
3/11/2014	2:23:21	1.096	1.39	
3/12/2014	1:45:18	0.805		
3/13/2014	2:12:47	1.012	3.58	New Boiler with Balanced Vacuum System
3/14/2014	2:29:10	1.142	4.32	
3/15/2014	2:01:10	0.928	2.05	
3/16/2014	1:34:38	0.721	3.11	
3/17/2014	2:31:25	1.158	3.24	
3/18/2014	1:56:31	0.889	3.01	
3/19/2014	1:47:31	0.820	2.92	
3/20/2014	1:38:54	0.751	1.57	
3/21/2014	1:43:00	0.790	1.73	
3/22/2014	1:32:54	0.705	1.98	
3/23/2014	2:09:08	0.989	2.57	
3/24/2014	1:54:37	0.874	3.15	
3/25/2014	1:46:53	0.813	2.70	
3/26/2014	1:35:36	0.728	3.33	
3/27/2014	1:57:12	0.897	3.17	
3/28/2014	0:57:06	0.437	1.37	
3/29/2014	1:41:56	0.774	1.15	
3/30/2014	1:33:28	0.713	2.70	
3/31/2014	1:22:47	0.629	2.86	
4/1/2014	1:06:19	0.506	4.12	
4/2/2014	0:21:06	0.161	1.39	

f. TMY 3 midpoint data for heating for Boston, MA

				1	2	3	4	5	6	7	8	9	10	11	12
	Min DB	Max DB	Total	January	February	March	April	May	June	July	August	September	October	November	December
Mid-pts	(F)	(F)	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs
107.5	105	110	0	0	0	0	0	0	0	0	0	0	0	0	0
102.5	100	105	0	0	0	0	0	0	0	0	0	0	0	0	0
97.5	95	100	0	0	0	0	0	0	0	0	0	0	0	0	0
92.5	90	95	0	0	0	0	0	0	0	0	0	0	0	0	0
87.5	85	90	0	0	0	0	0	0	0	0	0	0	0	0	0
82.5	80	85	0	0	0	0	0	0	0	0	0	0	0	0	0
77.5	75	80	0	0	0	0	0	0	0	0	0	0	0	0	0
72.5	70	75	0	0	0	0	0	0	0	0	0	0	0	0	0
67.5	65	70	0	0	0	0	0	0	0	0	0	0	0	0	0
62.5	60	65	0	0	0	0	0	0	0	0	0	0	0	0	0
57.5	55	60	83	3	0	11	27	0	0	0	0	0	0	26	16
52.5	50	55	227	14	0	30	83	0	0	0	0	0	0	70	30
47.5	45	50	428	4	11	57	155	0	0	0	0	0	0	130	71
42.5	40	45	714	38	81	89	251	0	0	0	0	0	0	169	86
37.5	35	40	956	101	165	241	122	0	0	0	0	0	0	161	166
32.5	30	35	655	143	135	176	31	0	0	0	0	0	0	79	91
27.5	25	30	551	208	99	77	18	0	0	0	0	0	0	34	115
22.5	20	25	344	142	81	30	0	0	0	0	0	0	0	13	78
17.5	15	20	234	76	87	29	0	0	0	0	0	0	0	13	29
12.5	10	15	37	15	9	0	0	0	0	0	0	0	0	0	13
7.5	5	10	38	0	4	0	0	0	0	0	0	0	0	0	34
2.5	0	5	4	0	0	0	0	0	0	0	0	0	0	0	4
-2.5	-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-7.5	-10	-5	0	0	0	0	0	0	0	0	0	0	0	0	0

RISE ENGINEERING

g. Linear Regression data

Old Boiler with Vacuum System

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.381033098
R Square	0.145186222
Adjusted R Square	-0.282220667
Standard Error	1.454733238
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.718870413	0.718870413	0.339690879	0.618966902
Residual	2	4.232497587	2.116248794		
Total	3	4.951368			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	6.14698016	3.187876059	1.928236872	0.193629544	-7.569343467	19.86330379	-7.569343467	19.86330379
X Variable 1	-0.055568267	0.095342143	-0.58283006	0.618966902	-0.465792397	0.354655864	-0.465792397	0.354655864

Old Boiler with Single Pipe Steam

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.756392803
R Square	0.572130072
Adjusted R Square	0.529343079
Standard Error	0.949396042
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	12.05251956	12.05251956	13.37158876	0.004412973
Residual	10	9.01352844	0.901352844		
Total	11	21.066048			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	13.15000672	1.666246064	7.891995668	1.32611E-05	9.437379128	16.86263431	9.437379128	16.86263431
X Variable 1	-0.210575637	0.057585961	-3.65671831	0.004412973	-0.338885154	-0.08226612	-0.338885154	-0.08226612

New Boiler on Single Pipe Steam

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.047547508
R Square	0.002260766
Adjusted R Square	-0.330318979
Standard Error	1.015321892
Observations	5

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.007007567	0.007007567	0.006797665	0.939483451
Residual	3	3.092635633	1.030878544		
Total	4	3.0996432			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.668815589	2.835741892	1.646417681	0.198231627	-4.355780717	13.69341189	-4.355780717	13.69341189
X Variable 1	0.001429153	0.017334004	0.082447951	0.939483451	-0.053735385	0.056593691	-0.053735385	0.056593691

New Boiler on Vacuum System

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.78538362
R Square	0.616827431
Adjusted R Square	0.56893086
Standard Error	0.697878078
Observations	10

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	6.272177905	6.272177905	12.87832128	0.007098531
Residual	8	3.896270495	0.487033812		
Total	9	10.1684484			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	7.091727974	1.067776625	6.641583837	0.000162217	4.629430661	9.554025286	4.629430661	9.554025286
X Variable 1	-0.113607256	0.031657487	-3.5886378	0.007098531	-0.186609553	-0.04060496	-0.186609553	-0.040604959

New Boiler with Balanced Vacuum System

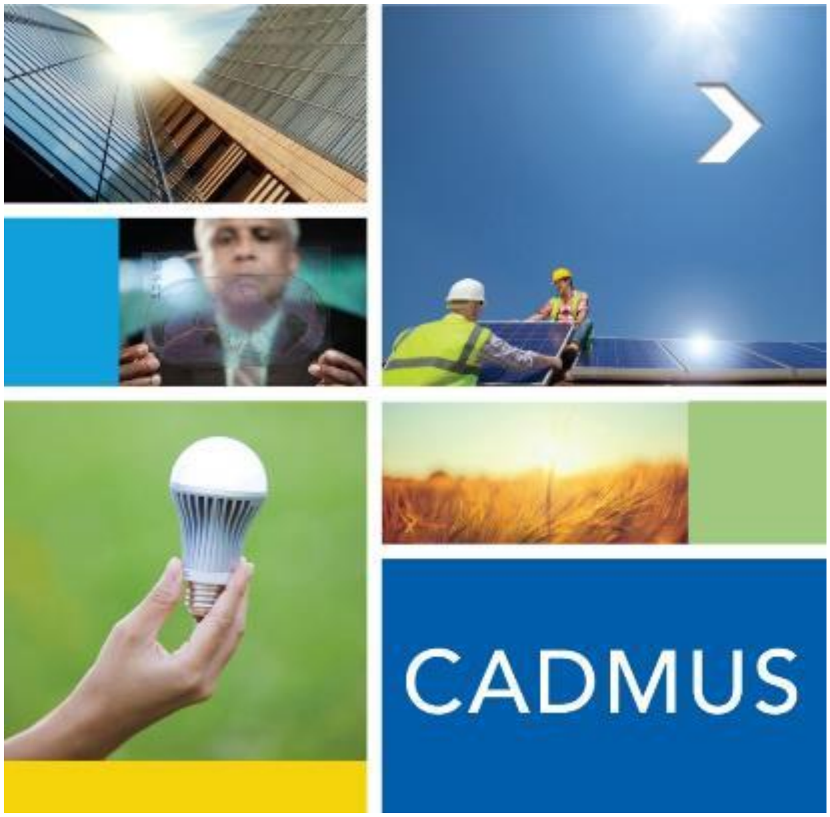
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.65253133
R Square	0.425797136
Adjusted R Square	0.395575933
Standard Error	0.693893446
Observations	21

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	6.783854964	6.783854964	14.08935082	0.001344955
Residual	19	9.148274178	0.481488115		
Total	20	15.93212914			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	6.061862013	0.916908624	6.611195329	2.51319E-06	4.142750207	7.980973819	4.142750207	7.980973819
X Variable 1	-0.091275858	0.024317025	-3.7535784	0.001344955	-0.142171976	-0.04037974	-0.142171976	-0.040379741



Wi-Fi Thermostat Assessment

April 2015

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Acknowledgements

Cadmus thanks Keith Miller and Eliza Davis of National Grid and Peter Klint of Eversource Energy (formerly Northeast Utilities). We also thank the National Grid customers who volunteered to participate in this study. These participants volunteered their homes for our testing and provided thoughtful feedback that has been an integral part of this evaluation.

We also thank the contacts for each thermostat manufacturing company, Keyes North Atlantic, Inc., and Steve Carvelli for providing their industry knowledge and expertise to support this evaluation.

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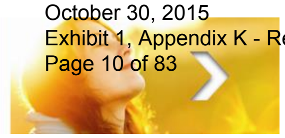
Important Considerations

The services and analysis provided in this report do not constitute or imply any endorsement by Cadmus for any product, process, manufacturer, or seller. Cadmus makes no warranty, express or implied, of merchantability or fitness for a particular purpose. Cadmus assumes no liability for any product and is not responsible for any decisions or use of any products in any way connected with this report.

The intention of this evaluation is to identify and examine potential thermostat issues that National Grid and Eversource Energy (the Companies) may consider when designing a large-scale program. When interpreting the results, we caution readers to keep in mind these important points:

- Findings are based on one thermostat installation in one home for each thermostat model;
- For the original seven thermostats, the space temperature data collection period took place over a two to three week period in February and March 2014, starting immediately after the thermostat installation. The data collection period for the three additional thermostats took place between November 2014 and March 2015;
- It is normal for the space temperature to vary up to three degrees above and below the thermostat setpoint (this is termed the temperature differential);
- A variety of factors impact how well a thermostat can regulate space temperature, including home insulation type, level of solar heat gain, and HVAC system type; and
- All ten thermostats have propriety algorithms that use feedback (which may include indoor/outdoor temperature, target setpoint, historical HVAC system run time) to adjust HVAC system run time; therefore, thermostat performance may vary over time and under different weather conditions.
- Throughout the report, the thermostat models are listed in the order the evaluation team tested them.



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Executive Summary

Utility rebate programs for programmable thermostats have been around for decades, but recent evaluations have shown low energy savings realization rates due to complex user interfaces and complicated settings options. In response, a new generation of user-friendly, Wi-Fi thermostats has entered the market to simplify programming and controlling a thermostat.[1] Many new thermostats also have energy-savings options that use algorithms to optimize the thermostat setpoints for both comfort and energy-efficiency.

National Grid and Eversource Energy (the Companies) are in the process of planning a large-scale Wi-Fi thermostat rebate program across their territories in Massachusetts and Rhode Island. The Companies solicited proposals from thermostat manufacturers interested in participating in the program and selected a short list of nine thermostat models for further research. Table 1 lists these thermostat models in the order they were tested.

Table 1. Selected Thermostat Models*

Make and Model	Abbreviation
Original Test Group	
Nest Learning Thermostat	Nest
Honeywell Wi-Fi Smart Thermostat RTH9580WF	HW
Ecobee Smart Si	ESS
Ecobee Smart	ES
EcoFactor	EF
Carrier ComfortChoice Touch	CCCT
Building 36 CT100	B36-CT
Additional Test Models	
Honeywell Lyric Thermostat	Lyric
Building 36 Intelligent Thermostat	B36-IT
Ecobee3	EC3

*Thermostat models are presented in the order they were tested. Cadmus investigated the seven thermostats in the original test group from February to April 2014, then completed tests for three additional thermostat models from November 2014 to March 2015.

In February 2014, the Companies engaged Cadmus to assess the selected thermostats in these areas:

- Ease of thermostat installation,

[1] In 2008, the EPA made it a requirement that customers "be able to change the settings on the programmable thermostat with little difficulty" for the programmable thermostat to be eligible for the ENERGY STAR® program.

- User experience and satisfaction, and
- Space temperature of participant homes.

Cadmus researched the features, functions, usability, and price of the ten selected thermostats and developed an assessment approach for each category. For each thermostat, we reviewed user manuals and other available manufacturer documentation and installed the thermostat in the home of a volunteer participant.

To assess the ease of installation, we developed an installer survey to document the installation process and findings for each thermostat. We installed and tested each of the ten thermostats in the homes of ten National Grid customers in Massachusetts. During the installation, we documented the process and any issues that occurred.

To assess the user experience and satisfaction, we distributed a customer survey at the conclusion of the 2-3 week study period.

To assess the accuracy of each thermostat in matching the space to the temperature setpoint, we installed temperature loggers next to the thermostat and compared our measured space temperature data to the programmed setpoint schedule over the duration of the study.

Summary of Findings

Table 2 summarizes the key findings for each thermostat. Rating are based on a review of product documentation and a single installation (performed by the Cadmus installer) for each thermostat model. The thermostat models are presented in the order they were tested.

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Table 2. Summary of Thermostat Ratings (n=1 for each thermostat)*

Criteria	Nest	HW	ESS	ES	EF	CCCT	B36-CT	Lyric	B36-IT	EC3
Retail Price	$249	$289.95	$179.95	$276.38	N/A	N/A	$185	$199.99	$249	$249
Wholesale Price	N/A	N/A	N/A	N/A	~$125	~$136	$70-100	N/A	$70-100	N/A
Monthly Service Fee	N/A	N/A	N/A	N/A	$5-9	N/A	$1.50	N/A	$1.50	N/A
Ease of Installation										
Ease of Installation[A]	★★★	★★	★★★	★	★★★	★★	★★	★★★	★★	★
Total Time to Install[B]	43 min	90 min	40 min	103 min	40 min	160 min	70 min	28 min	30 min	111 min
C-wire Required	No	Yes	Yes	Yes[C]	Yes	Yes[C]	No	No	No	No
Recommended Installer[D]	Homeowner	Homeowner	Homeowner	HVAC Technician	Homeowner	HVAC Technician	Homeowner	Homeowner	Homeowner	HVAC Technician
User Experience										
Customer Usability Rating	Somewhat difficult	Easy	Easy	Easy	Difficult	Easy	Easy	Easy	Easy	Easy
Space Temperature (Based on 2-week data collection in February and March 2014)										
Space Temperature Range when User is Home/Awake	Normal: Space tends to be 0–2°F warmer than setpoint	Normal: Space tends to be 0–3°F warmer than setpoint	Cool: Space tends to be 0–4°F cooler than setpoint	Cool: Space tends to be 0–4°F cooler than setpoint	Cool: Space tends to be 0–4°F cooler than setpoint	Warm: Space tends to be 2–5°F warmer than setpoint	Normal: Space tends to be 0–3°F cooler than setpoint	Normal: Space tends to be within 0–1°F of setpoint	Normal: Space tends to be 0–2°F warmer than setpoint	Warm: Space tends to be 0–4°F warmer than setpoint

* The thermostat models are listed in the order they were tested.

[A] Ratings are based on a standard installation checklist developed by Cadmus. A three-star rating is the maximum rating.

[B] Total time to install includes time to install thermostat, program setpoints, and set up Wi-Fi connection. It does not include time to install new wiring, if applicable.

[C] Needed at interface, but not at thermostat. For additional detail, see Installation Assessment section.

[D] Recommended installer applies to thermostat installation, not wiring installation. If new wire must be installed, Cadmus recommends an HVAC technician or electrician perform the installation.

Easiest to Install

The Nest and Lyric models received the best ratings overall for ease of installation. These thermostats took less than 45 minutes install, received the maximum three-star rating from the installer for ease of installation, and do not require a 24 Volt (AC) common wire (C-wire).[2]

Although the Ecobee Smart Si and EcoFactor took only 40 minutes to install and received three-star ratings for ease of installation, these thermostats require a C-wire. This requirement limits the compatibility of these thermostats for many homes in New England, where Cadmus estimates less than one quarter of customer homes have a C-wire. In a large-scale program, customers without a C-wire may need to install new wiring to install thermostats that depend on a C-wire. For homes that do not have an existing C-wire or for which adding a C-wire is expensive, HVAC power extenders exist. The Ecobee3 is the only thermostat in the test group that comes with a power extender. Although the power extender makes the Ecobee3 compatible in most Massachusetts and Rhode Island homes, the installer gave it a one-star rating for ease of installation because the installation instructions for the power extender were not clear. For more information on wire extenders for other thermostat models, see Appendix A.

The Nest, Lyric, and Building 36 Intelligent thermostats are the most compatible with MA and RI homes because they do not require power from a C-wire. Instead, these thermostats use a standard two-wire setup, which is the minimum wiring requirement for any home thermostat. The Nest and Lyric draw power from the W-wire or Y-wire if no C-wire is available. In addition, the Lyric uses a AAA Lithium battery for initial start-up and to supplement the power stealing. Both Building 36 thermostats (CT100 and Intelligent) use four AA batteries. Although the Ecobee3's included power extender kit makes it compatible with many homes in Massachusetts and Rhode Island, it requires a minimum of three wires between the thermostat and HVAC unit.

The Building 36 models and EcoFactor require the installation of a Gateway for internet/cellular connectivity. Building 36 recommends a professional install their thermostats and Gateway.

Most User-Friendly

All thermostats except the Nest and EcoFactor received an overall rating of "easy" to use by the participant. Participants gave the Nest and EcoFactor overall ratings of "somewhat difficult" and "difficult" to use, respectively. The Nest was rated as "somewhat difficult" to use because the participant found it difficult to navigate the menu to program the setpoints. The installer noted that there was no copy/paste function—setpoints for each day had to be copied manually. Participants with

[2] Cadmus estimates that less than one quarter of homes in MA and RI have a C-wire. For more details on the C-wire, see the Installation Assessment section and Appendix A.

the Ecobee Smart and Building 36 CT100 also commented that programming their thermostat was "somewhat difficult" or "difficult" to do, but still gave overall ratings of "easy."

The EcoFactor was rated as "difficult" to use because the participant found it challenging to change the schedule and manage comfort level.

Eight of the nine participants who used the mobile application rated the application as "easy" to use and three of the six participants who used the web account found it "easy" to use.[3] The participant with the Ecobee Smart Si's rated the web account as "somewhat difficult" to use, reporting there were minor display quirks and some confusing wording that made it challenging to use. The participant with the Carrier ComfortChoice Touch thermostat rated the web account as "difficult" to use, citing that he or she had some difficulty setting up the account, possibly due to having a duplicate account.

Most Accurate Space Temperatures

Among the original seven thermostat models, our comparison of setpoints and measured space temperature show that the home with the Nest thermostat most closely matched the space temperature for the home/awake setpoint (which maintained temperature within two degrees of the scheduled setpoint when the participant was home/awake).[4] In the additional testing round, this result was surpassed by the home with the Lyric thermostat, which consistently maintained temperature within one degree of the scheduled setpoint when the participant was home/awake.

In five homes, the average difference between space temperature and setpoint exceeded three degrees. The Ecobee Smart Si, Ecobee Smart, and EcoFactor thermostats tended to keep the home temperature within four degrees below the setpoint. The Carrier ComfortChoice Touch kept the home temperature between two and five degrees above of the setpoint, while the Ecobee3 kept the home temperature within four degrees above the setpoint.

All ten of the thermostats use algorithms to regulate the temperature of the home. These proprietary algorithms vary among thermostat models. The algorithms may take into account current outdoor temperature, weather forecast, equipment type, temperature difference between current indoor temperature and setpoint, and equipment protection (to limit the number of times the compressor cycles on and off). Algorithms use these data to adjust the HVAC system "cut-in" time—the time at which the HVAC system begins to pre-heat or pre-cool the home. Because these algorithms use feedback to adjust HVAC system run time, thermostat performance may vary over time and under different weather conditions. In addition to using an algorithm, the Nest and Ecobee3 use an occupancy sensor to determine when users are away or sleeping and adjusts setbacks for these periods. The Nest's occupancy sensor is located at the thermostat, whereas the Ecobee3's occupancy sensor can be

[3] The participant with the Ecobee Smart Si thermostat did not use the mobile application enough to rate it.

[4] The home/awake setpoint is the temperature setting when the user is home and awake (as opposed to home and asleep, or away).

installed in any room. Ecobee3's occupancy sensor also measures indoor temperature. The thermostat uses the indoor temperature information to adjust the heating and cooling. Users can install remote sensors in multiple rooms.

Best for Data Collection

The Ecobee Smart Si, Ecobee Smart, and Ecobee3 thermostats have the most data available. These thermostats enable the user to view and download a 15-month history of HVAC system run time and indoor temperature data from a web account. The web account also shows hourly, daily, monthly, and weather-adjusted run time (hours/degree day).The user can also view monthly reports that show total system run time, average setpoint, energy saved, and comparisons to the state average.

The EcoFactor and Carrier ComfortChoice Touch thermostats also show a full history of system run time and indoor temperature. With the Carrier ComfortChoice Touch, users can also download the last 30 days of data. The Nest shows users the last ten days of run time history and when the user demonstrated energy efficient behavior.

CADMUS

Introduction

Cadmus conducted this study to support the design of residential energy-efficiency programs in Massachusetts. In this study, we assessed the installation process, user experience, and space temperature patterns for a total of nine Wi-Fi thermostats. We completed testing for seven thermostats (the original testing group) from February to April 2014 and then completed testing for three additional thermostats (the additional testing group) in November 2014 to March 2015.

Background

National Grid and Eversource Energy (the Companies) in the process of planning a large-scale Wi-Fi thermostat rebate program across its territory in Massachusetts and Rhode Island. The Company solicited proposals from thermostat manufacturers interested in participating in the program. After reviewing the manufacturer proposals, the Companies selected a short list of ten thermostat models for further research.

In February 2014, the company engaged Cadmus to assess the selected thermostats in these areas:

- Ease of thermostat installation,
- User experience and customer satisfaction, and
- Space temperature of participant homes.

The Companies plan to use the results of this assessment for the design of its thermostat program.

Thermostats

Table 3 shows pictures of the thermostat models the Companies selected for this study.

Table 3. Thermostats Included in Study*

Thermostats		
 Nest Learning Thermostat (Nest)	 Ecobee Smart Si (ESS)	 EcoFactor (EF)
 Honeywell Wi-Fi Thermostat RTH9580WF (HW)	 Ecobee Smart (ES)	 Carrier ComfortChoice Touch (CCCT)
 Building 36 CT100 (B36-CT)	 Honeywell Lyric Thermostat** (Lyric)	 Building 36 Intelligent Thermostat** (B36-IT)
 Ecobee3** (EC3)		

* The thermostat models are listed in the order they were tested.

** Indicates thermostats in the additional testing group.

Thermostat Review

Cadmus reviewed product documentation to assess the features of each thermostat. All thermostats are Wi-Fi connected and have a web account and mobile application to remotely monitor and control the thermostat except for the Lyric thermostat, which does not have a web account.

Methods

Cadmus created a features list and score card to assess and compare the characteristics and performance of each thermostat. Features included in our checklist include: thermostat characteristics, retail value, mobile application features, and web account features. To assess each thermostat, we collected information from the thermostat user manuals, the Cadmus thermostat installer, and study participants.

Pricing

To determine each thermostat's value, we referred to the manufacturers' websites and representatives. Readers should note that retail pricing is not indicative of what a utility might pay per unit when purchased in volume and the listed wholesale values may also vary depending on volume. Additional costs to consider when purchasing in bulk include annual fees and front loading of costs.

For the Nest, Ecobee3, and both Honeywell models, information was directly available on the manufacturers' websites.

For the Ecobee Smart Si and Ecobee Smart thermostats, the Ecobee website refers potential buyers to a list of preferred contractors for professional installation. We contacted three Massachusetts contractors and received quotes for installed costs from one; these quotes are listed in the footnotes of Table 4. We estimated the retail values for the two Ecobee models from Amazon.com.

The EcoFactor and Carrier ComfortChoice Touch are not available for retail sale, but are available wholesale to contractors. We spoke with representatives to get estimated wholesale costs, but readers should note that these quotes may vary depending on volume.

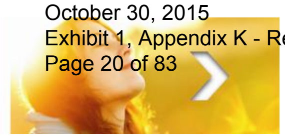
The Building 36 thermostats are available for both retail and wholesale; however, access to their cloud-based platform is only available wholesale to contractors. We listed retail and estimated wholesale values for these thermostats based on the estimated prices quoted by manufacturer representatives.

Web and Mobile Accounts

To assess the performance of web accounts and mobile applications, we obtained participants' usernames and passwords and browsed their accounts.

Results

The following tables compare each thermostat's features.



Thermostat

Table 4 shows the key characteristics of each thermostat.

Table 4. Key Thermostat Characteristics*

Criteria	Nest	HW	ESS	ES	EF	CCCT	B36-CT	Lyric	B36-IT	EC4
Color screen	X	X	X	X	-	X	-	X	-	-
Touchscreen	-	X	-	X	-	X	X	X	-	X
Programming Capabilities	7-day	7-day	7-day	7-day	5-2	7-day	7-day	7-day	7-day	7-day
Warranty (years)	2	1	3	3	1	1	1	2	1	3

* The thermostat models are listed in the order they were tested.

All of the thermostat models except for the EcoFactor and Building 36 Intelligent Thermostat have either color screens or touchscreen displays to make interacting with the thermostat user-friendly. The Honeywell, Ecobee Smart Si, EcoFactor, Carrier ComfortChoice Touch, and Building36 CT100 thermostats all have prominent buttons for adjusting the current setpoint. The Nest and Lyric have a spinning dial for adjusting the setpoint. The Ecobee Smart and Ecobee3 thermostats have a sliding button on the home touchscreen.

All thermostats, except for the EcoFactor, can program a different schedule for each day of the week. The EcoFactor has 5-2 programming capabilities, allowing for separate schedules on weekdays and weekends.

With a three-year warranty, the three Ecobee thermostat models offer the longest warranties among the thermostats tested in this evaluation. The remaining thermostats offer a one-year warranty, with the exception of Nest and Lyric, which offer two-year warranties.

Pricing

Thermostat values vary greatly depending on whether the manufacturer offers retail or wholesale values, the thermostat is self-installed or professionally installed, or if there is a monthly service fee or not (Table 5). Readers should note that retail pricing is not indicative of what a utility might pay per unit when purchased in volume and the listed wholesale values may also vary depending on volume. Additional costs to consider when purchasing in bulk include annual fees and front loading of costs.

Table 5. Thermostat Prices*[A]

Model	Value (April 2014)	Value (February 2015)	Source
Nest	$249 (retail)	$249 (retail)	Nest.com (Accessed 4/14/2014, 2/27/2015)
HW	$249 (retail)	$189.95 (retail)	Honeywell.com (Accessed 4/14/2014) Amazon.com (Accessed 2/27/15)
ESS	$270 (retail) $395 (when installed by Ecobee preferred contractor)	$179.95 (retail)	Amazon.com (Accessed 4/14/2014, 2/27/15)
ES	$454 (retail) $475 (when installed by Ecobee preferred contractor)	$276.38 (retail)	Amazon.com (Accessed 4/14/2014, 2/27/15)
EF	~$125 (wholesale) Monthly service: $5-9 (wholesale)	~$125 (wholesale) Monthly service: $5-9 (wholesale)	EcoFactor representative
CCCT	~$136 (wholesale)	~$136 (wholesale)	Carrier representative
B36-CT	$249 for first thermostat[B] (retail) $99 for each additional thermostat (retail) $70-100 (wholesale)	$185 for first thermostat[C] (retail) $90 for each additional thermostat (retail) $70-100 (wholesale) Monthly service: $1.50 (wholesale)	Building 36 representative
Lyric	n/a	$199.99 (retail)	Amazon.com (Accessed 2/13/15)
B36-IT	n/a	$249 for first thermostat[D] (retail) $99 for each additional thermostat (retail) $70-100 (wholesale) Monthly service: $1.50 (wholesale)	Building 36 representative
EC3	n/a	$249 (retail)	Ecobee.com (Accessed 3/24/15)

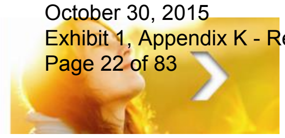
* The thermostat models are listed in the order they were tested.

[A] Retail pricing is not indicative of what a utility might pay per unit when purchased in volume. When purchased in volume, additional costs to consider include annual fees and front loading of costs.

[B] Breakdown of retail price for first Building 36 CT100 thermostat includes $99 for thermostat and $150 for Z-wave Gateway device for internet connectivity. Only one Gateway is needed for multiple Building 36 internet-connected devices.

[C] Breakdown of retail price for first Building 36 CT100 thermostat includes $90 for thermostat and $95 for Z-wave Gateway device for internet connectivity. Only one Gateway is needed for multiple Building 36 internet-connected devices.

[D] Breakdown of retail price for first Building 36 Intelligent Thermostat includes $99 for thermostat and $150 for cellular Gateway device. Only one Gateway is needed for multiple Building 36 devices.



Mobile Application

Table 6 (next page) lists the mobile application features for each thermostat.

Table 6. Thermostat Mobile App Features*

Mobile App Features	Nest	HW	ESS	ES	EF	CCCT	B36-CT	Lyric	B36-IT	EC3
Check Indoor Temperature	X	X	X	X	X	X	X	X	X	X
Check Outdoor Temperature	X	X	X	X	X	X	-	X	X	X
Adjust Setpoint	X	X	X	X	X	X	X	X	X	X
View Schedule	X	X	-	-	X	X	-	X	X	X
Program Schedule	X	X	-	-	X	X	-	X	-	X
Check Run time History	10 days	-	-	-	-	Full history	-	-	-	-
Check Indoor Temp History	-	-	-	-	-	Full history	-	-	-	-
Change Heat/Cool Mode	X	X	X	X	X	X	X	X	X	X
Change Fan Mode	X	X	X	X	X	X	-	-	-	X
Set To Away/Vacation Mode	X	-	X	X	X	X	-	X	-	X
View Weather Forecast	-	5 day	5 day	5 day	-	-	-	1 day	Current	5 day
Other Noteworthy Features: Nest: Can view when/why user demonstrated energy-efficient behavior B36-CT: Can view history of setting changes and alerts. Available home monitoring add-ons: plug load meters, light controls, lock controls. Lyric: Shortcuts for custom thermostat settings. Geofencing* tied to smart phone and app. Can define unique boundaries which trigger automatic changes in thermostat settings when smart phone enters in or out of the defined range. Auto setting option which accounts for temperature, humidity, and outdoor weather to determine most comfortable settings. Message notifications about unusual temperature swings, hardware issues, and other unexpected events. B36-IT: Can view a limited history (50 events) of setting changes and alerts. Available home monitoring add-ons: plug load meters, light controls, lock controls. EC3: Can set up reminders when HVAC, air handler filter, or UV lamp needs maintenance or to be replaced. Can create alerts when temperature and humidity is below or exceeds defined thresholds. Vacation mode where homeowner can set unique start and end date/time.										

* The thermostat models are listed in the order they were tested.

All ten thermostats feature mobile applications that enable users to check current indoor and outdoor temperatures, adjust setpoints, and change from heating to cooling mode. The Nest, Honeywell, EcoFactor, Carrier ComfortChoice Touch, Lyric, and Ecobee3 thermostats also let the user view and edit the setpoint schedule.

The Nest and Carrier ComfortChoice Touch mobile applications both provide features for checking performance history. The Nest shows users ten days of HVAC system run time history, when the user demonstrated energy efficient behavior and why. The Carrier ComfortChoice Touch gives users access to a full history of HVAC system run time and indoor temperature.

The Building 36 CT100 mobile application has the least number of features. The application only lets the user check indoor temperature, adjust the setpoint, and change from heating to cooling mode. The application does, however, have some unique add-ins for other home automation systems that can control lights and monitor appliance energy consumption, at an extra cost.

Web Account

Table 7 (next page) lists the web account features for each thermostat.

All thermostats except the Lyric come with a web account that enables the user to check current outdoor temperature and to check and adjust setpoints and schedules. Six of the nine thermostats that have a web account allow the user to view the HVAC system's run time history and/or indoor temperature history. For users who are especially interested in this kind of feedback on system performance, the Ecobee Smart Si, Ecobee Smart, Ecobee3, and Carrier ComfortChoice Touch thermostats enable users to download these data.

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Table 7.Thermostat Web Account Features*

Web Account Features	Nest	HW	ESS	ES	EF	CCCT	B36	Lyric	B36-IT	EC3
Check indoor temperature	X	X	X	X	X	X	X	N/A	X	X
Check outdoor temperature	X	X	X	X	X	X	X	N/A	X	X
Adjust setpoint	X	X	X	X	X	X	X	N/A	X	X
View schedule	X	X	X	X	X	X	X	N/A	X	X
Program schedule	X	X	X	X	X	X	X	N/A	X	X
Check run time history	10 days	-	15 months	15 months	Full history	Full history	-	N/A	-	15 months
Check indoor temp history	-	-	15 months	15 months	Full history	Full history	-	N/A	-	15 months
Download history	-	-	31 Days	31 Days	-	30 days	-	N/A	Full History	31 Days
Set up alerts	X	X	X	X	-	-	X	N/A	X	X

Other Noteworthy Features:

Nest: Can view when/why user demonstrated energy-efficient behavior

ESS: Shows hourly, daily, monthly run time AND weather-adjusted run time (hrs/degree day) View monthly reports with total system run time, average setpoint, energy saved, compare to state average.

ES: Shows hourly, daily, monthly run time AND weather-adjusted run time (hrs/degree day). View monthly reports with total system run time, average setpoint, energy saved, compare to state average

EF: Can set up estimated savings chart

CCCT: Geofencing through Energy Hub website.

B36-CT: Geofencing

Available home monitoring add-ons: plug load meters, light controls, lock controls.

B36-IT: Can view history of setting changes and alerts.

Available home monitoring add-ons: plug load meters, light controls, lock controls

Can program separate unique Heat and Cool schedules, and settings for extreme temperatures.

Can disable local thermostat controls.

Can receive alerts when target temperature has changed, when temps exceed thresholds, and when thermostat modes are changed

EC3: Can monitor and view history of heating and cooling schedule, sensor activity, temperature and humidity levels for both indoor and outdoor, and weather impacts.

Can set up reminders when HVAC, air handler filter, or UV lamp needs maintenance or to be replaced.

Can create alerts when temperature and humidity is below or exceeds defined thresholds

Quick Change feature allows user to immediately program home and away settings and override existing schedule.

Vacation mode where homeowner can set unique start and end date/time.

* The thermostat models are listed in the order they were tested.

Installation Assessment

Cadmus installed each thermostat in a participant household and completed an installer scorecard to document and assess the installation process for each thermostat.

Methods

Installer Score Card

Cadmus created the *Installer Score Card* to assess the requirements and ease of installation for each thermostat model and, at minimum, to address these elements:

- Ease of installation
- Ease of wiring
- Clarity of instructions provided
- Time frame needed for each installation including programming and Wi-Fi setup
- Skills required by the installer and if device can be installed by homeowner or requires HVAC technician and/or electrician
- Common issues or risks (if any) that may occur during installation

Installations

The Companies provided Cadmus with the names and contact information for eight participating homeowners. The ninth participant was a Cadmus employee. We reviewed the installation requirements with each participant to ensure all information was available to complete the thermostat installation and Wi-Fi setup.

A Cadmus electrician installed the seven thermostats in the original thermostat group between February 25 and March 11, 2014. The same Cadmus installer completed installations for the three additional thermostats between November 2014 and March 2015. During each installation, we connected the thermostats to the homeowners' Wi-Fi networks and rated the thermostat and installation process according to the Installer Score Card.

We replaced two of the original seven participants because their thermostat installations would have required extensive wiring that was out of the scope for this study.

Results

Table 8 presents the key thermostat installation findings from the Installer scorecard.

Table 8. Thermostat Installer Ratings*

Criteria	Nest	HW	ESS	ES	EF	CCCT	B36-CT	Lyric	B36-IT	EC3
Total Time to Install	43 min	90 min	40 min	103 min	40 min	160 min	70 min	28 min	30 min	111 min
Thermostat Installation										
Time to Install[A]	23 min	45 min	15 min	75 min	15 min	90 min	25 min	12 min	10 min	95 min
Clarity of Instructions	★★★	★★½ [B]	★★★	★★	N/A[C]	★	★★★	★★	★★★	★
Ease of Installation	★★★	★★	★★★	★	★★★	★★	★★	★★★	★★	★
Recommended Installer[D]	Homeowner	Homeowner	Homeowner	HVAC Technician	Homeowner	HVAC Technician	Homeowner	Homeowner	Homeowner	HVAC Technician[E]
Minimum Wiring[F]	2	3	3	4 (3)[G]	3	2 (3)[G]	2	2	2	3
C-wire Required	No	Yes	Yes	Yes[G]	Yes	Yes[G]	No	No	No	No
Cat5 Required	No	No	No	No	Yes[G]	No	Yes[F]	No	Yes	No
Tools Provided	Screws, Screwdriver	Screws	Screws	Screws	None	Screws	Screws, Batteries	Screws, Screwdriver, Batteries	Screws, Batteries	Screws, Power Extender, Remote Sensor
Programming of Thermostat Setpoints and Schedule										
Time to Program	14 min	30 min	10 min	8 min	15 min	10 min	15 min	1 min[G]	10 min	1 min[H]
Clarity of Instructions	N/A[C]	★★★	★★	★★★	N/A†	★★★	★	★★★	★★★	★★★
Ease of Programming	★★★	★★★	★★	★★★	★★★	★	★★	★★	★★★	★★
Wi-Fi Set Up										
Time to Set Up	6 min	15 min	15 min	20 min	10 min	60 min	30 min	15 min	10 min	15 min
Clarity of Instructions	N/A[C]	★★★	★★★	★★	N/A[C]	N/A[C]	★★★	★★★	★★★	★
Ease of Set Up	★★★	★★★	★★★	★★	★★★	★	★★	★★★	★★	★★
Required Equipment	None	Computer	None	Computer	Port at router	Computer	Computer, port at router	Customer's tablet or smartphone	Screwdriver, tablet, port at router	Smartphone, Registration code
Wi-Fi Login Required	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes

* The thermostat models are listed in the order they were tested.

[A] Time to install does not include time it took to install a C-wire, if applicable.

[B] Detailed instructions were clear, but there was some key information on wiring was missing from Quick Start Guide.

[C] Not included.

[D] Recommended installer applied to thermostat installation, not wiring installation. If new wire must be installed, Cadmus recommends an electrician.

[E] Cadmus recommends an HVAC technician only if the Power Extender Kit needs to be installed.

[F] Minimum wiring requirement for connecting thermostat to heating system only.

[G] Wires needed from HVAC unit to interface, but not to thermostat.

[H] The Lyric thermostat took only 1 minute to program because it uses a default schedule and then adjusts the schedule using geofencing and user prompts.

[I] The Ecobee3 thermostat took only 1 minute to program because the thermostat allowed the user to apply a single setpoint schedule across all days of the week.

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Thermostat Installation

The Nest and Lyric models received the best ratings overall for ease of installation. These thermostats took less than 45 minutes install, received the maximum three-star rating from the installer for ease of installation, and do not require a 24 Volt (AC) common wire (C-wire).[5]

The Nest, Lyric, Building 36 CT100 and Building 36 Intelligent thermostats are the most compatible with Massachusetts and Rhode Island homes because the thermostats do not require a C-wire for power. Instead, these thermostats use a standard two-wire setup, which is the minimum wiring requirement for any home thermostat. Although the Nest and Lyric can use a C-wire for power, it is not required. If no C-wire is present in a Nest installation, the Nest draws power from the W-wire or Y-wire through a method commonly called "power stealing." In this setup, the thermostat uses the circuits that turn on and off the HVAC system to charge an internal battery. The thermostat can charge its battery regardless of the HVAC system status (on or off), but the available power is limited when the HVAC system is running. If there is an extended home power outage and the battery level gets low, the Nest will turn off the Wi-Fi to conserve power.[6,7,8] The Lyric uses a similar "power stealing" method they term "Phantom Power" to store power and uses a AAA Lithium battery for initial start-up and to supplement Phantom Power. Both Building 36 thermostats (CT100 and Intelligent) use four AA batteries.

Cadmus estimates that less than one quarter of homes in New England have an existing C-wire. In a 2013 Cadmus pilot program evaluation for Liberty Utilities (LU) of New Hampshire, only seven of 29 pilot program participants (24%) had a C-wire.[9] During recruitment for the LU study, 45 customers provided information about their HVAC system type and thermostat wiring in a survey. Of the 45 survey respondents, eight (18%) had a C-wire. Of the respondents with heating and air conditioning, 25% had a C-wire. Of the respondents with heating only, 14% had a C-wire.

For homes that do not have an existing C-wire or for which adding a C-wire is expensive, HVAC wire extenders exist. The Ecobee3 is the only thermostat in the test group that comes with a power extender. Although the power extender makes the Ecobee3 compatible in most Massachusetts and Rhode Island homes, the installer gave it a one-star rating for ease of installation because the installation instructions for the power extender were not clear. In addition, although the Ecobee3's included power extender kit makes it compatible with many homes in Massachusetts and Rhode Island, it requires a minimum of

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[5] Cadmus estimates that less than one quarter of homes in MA and RI have a C-wire. For more details on the C-wire, see the Installation Assessment section and Appendix A.

[6] http://support.nest.com/article/A-low-battery-level-will-cause-Nest-to-disconnect-from-the-Internet (Accessed 5/14/14)

[7] http://www.businessinsider.com/nest-thermostat-problem-2014-1 (Accessed 5/14/14)

[8] http://www.ecobee.com/blog/the-problem-with-power-stealing/ (Accessed 5/14/14)

[9] The Cadmus Group, Inc. Wi-Fi Programmable Thermostat Pilot Program Evaluation. 2013.

three wires between the thermostat and HVAC unit. For more information on wire extenders for other thermostat models, see Appendix A.

Although the Ecobee Smart Si and EcoFactor took only 40 minutes to install and received three-star ratings for ease of installation, these thermostats require a C-wire.

The Building 36 models and EcoFactor require the installation of a Gateway for internet/cellular connectivity. Building 36 recommends a professional install their thermostats and Gateway.

The Ecobee Smart, Ecobee3, and Carrier ComfortChoice Touch were the most challenging to install. Both took over an hour to install, not including the installation of new wiring.

In total, six of the ten participants needed new thermostat wiring installed in their home to make it compatible with the new thermostat. Table 9 (next page) lists the reasons each participant's home required the installation of new wiring.

Table 9. Reasons for Installing New Wiring*

Thermostat	Time to Install New Wire	Reason for Installing New Wires
Ecobee Smart Si	1 hour 45 minutes[A]	Thermostat required C-wire. In addition, new transformer was installed because voltage from existing transforming was not high enough (19 V rather than 24 Volt (AC)).
Ecobee Smart	1 hour 15 minutes	New wiring had to be installed to run to from HVAC unit to interface.
EcoFactor	1 hour	Thermostat required a C-wire.
Carrier ComfortChoice Touch	20 minutes	New wiring had to be installed to run to from HVAC unit to interface. In addition, because of age of zone control box, had to run wire from zone control box to an isolation relay and HVAC unit in order to get power for C-wire.
Building 36 CT100	5 minutes	This thermostat only requires two wires. However, the existing wires were too short to connect to thermostat terminals so the wires were extended.[B]
Ecobee3	1 hour	Thermostat required a C-wire so had to use included Power Extender Kit. This took longer than expected because the instructions were confusing.

* The thermostat models are listed in the order they were tested.

[A] Took 45 minutes to figure out how to get a C-wire wire from the boiler.

[B] Building 36 is developing an updated thermostat model. Improvements include centrally located terminal placements to reduce the length of wire needed to make terminal connections and the addition of an optional back plate to cover any footprint from an old thermostat. The new model is scheduled to be released in July 2014.

All ten thermostats are not compatible with electric baseboard or electric wall heating because they are 110 or 120 Volt (AC) systems, which are considered high voltage (also called line voltage) for residential thermostat applications. The smart thermostat can be used with high voltage systems only if an electrician installs a relay. Smart thermostats are compatible with electric baseboard heating as part of heat pump systems because the relay is built into the heat pump. Nest recommends potential users check their thermostat wiring for wire nuts or wire thicker than 18 gauge to see if they have a high voltage system. Figure 1 shows high voltage thermostat wiring with wire nuts.

Figure 1. Line Voltage Residential Thermostat Wiring

Source: diyadvice.com

Nest estimates the thermostat is compatible with 95% of low voltage systems. Of low voltage systems, the Nest is not compatible with direct vent furnaces known as millivolt systems. Figure 2 and Figure 3 show examples of wall-mounted and floor direct vent furnaces.

Figure 2. Wall-mounted Direct Vent Furnace

Figure 3. Floor Direct Vent Furnace

Programming of Thermostat Setpoints and Schedule

All thermostats except the Honeywell Wi-Fi Smart Thermostat (RTH9580WF) took 15 minutes or less to program. Although the Honeywell Wi-Fi Smart Thermostat took longer to program, the installer gave it three stars for the clarity of instructions, ease of programming, and unique user survey format. The survey asks the user questions about daily behavior to set up the program, making it more intuitive than some of the other thermostats.

The Carrier ComfortChoice Touch was one of the quickest thermostats to program, but the installer gave it only a rating of one star because its web interface was not user-friendly.

At one minute, the Lyric and Ecobee3 were the fastest thermostats to program. For the Lyric, this is because the thermostat uses a default schedule, then adjusts the schedule based on geofencing and user prompts. One downside to setting up the Lyric is that the installer had to use the customer's tablet or smartphone—they could not use their own tablet or smartphone. The participant with the Ecobee3 reported the programming only took one minute because the thermostat allowed him/her to apply their settings for one day across all days of the week.

Wi-Fi Set Up

All ten thermostats except for the Carrier ComfortChoice Touch took 30 minutes or less to set up the Wi-Fi connection. All but the Carrier ComfortChoice Touch, Ecobee Smart, Ecobee3 and Building 36 models received three-star ratings for ease of setup. The Carrier ComfortChoice Touch received a low rating because an installation code and MAC address were required from the thermostat to complete setup and the instructions did not explain this clearly. The Ecobee Smart received a low rating because some of the icons and terminology in the setup process were vague. The Ecobee3 received a low rating because it required a registration code and the instructions did not clearly explain where to find it.

The EcoFactor and Building 36 models had unique internet connection setups because neither required a username or password. Both of these thermostats communicate wirelessly to an interface that plugs directly into the homeowner's router.

Building 36 offers two models of Gateways for wireless communication. One Gateway communicates with the thermostat using Z-wave, while the other uses cellular data. For a secure connection, Building 36 recommends the user keep the Z-wave Gateway within 50 ft of the thermostat and the cellular Gateway within 100 ft of the thermostat. To extend the range between the Gateway and thermostat, users can install repeaters. Each repeater will add another 50 fit (Z-wave) or 100 ft (celluar) to the range. If a C-wire is present, this will also act as a repeater and extend the range.

Key Findings by Thermostat

Table 10 lists the thermostat installer's observations from the installation process. To model a typical homeowner installation experience, the installer did not receive training on the installation protocols for

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each specific device. In a utility program, a program installer would typically undergo training on how to install each thermostat.

Table 10. Key Findings by Thermostat – Installation and Wi-Fi Setup*

Thermostat	Installer Findings
Nest Learning Thermostat (Nest)	• The packaging included a back plate in case old thermostat was larger than Nest. • Programming setpoints was very easy but required a new setting for each day—did not have a copy/paste function. • The thermostat included a built-in level to support installation
Honeywell Wi-Fi Smart Thermostat RTH9580WF (HW)	• The quick setup guide does not note that C-wire and B-wire are the same; noted only in detailed instructions. The typical homeowner may not know these are the same. • There was not much space behind thermostat for wires; therefore, installer must push excess wire into wall before installing mounting plate.
Ecobee Smart Si (ESS)	• The instructions do not mention that thermostat requires C-wire was needed; the installer must check each wiring diagram. • Installer tried to program settings from computer but this was not possible (instructions did not make this clear). The website was a bit confusing—need to "Add a Thermostat." • If no C-wire and do not want to install new one, Ecobee sells Power Extender Kit.
Ecobee Smart (ES)	• The wiring diagram was difficult to interpret with old furnace. • This was more than just a thermostat installation, since interface needed to be installed. • At least three wires are needed from furnace to interface and four wires from interface to thermostat if system is heating only. This participant's setup required nine wires from furnace to interface because of the location of their C-wire terminal and because they had heating and cooling. • It was not obvious that ⃠ icon meant "skip." • The screen timeout was too fast. • The website cursor was difficult to see—color too similar to background. • For "home type," there was no option for "single family." Chose "detached." • The website asks to rate contractor, but does not give option if contractor is not on list. • The thermostat screen had three lines across bottom that did not go away after resetting. • User cannot create program while thermostat is on hold. • The scrolling is finicky. • The factory setting on thermostat was for heat pump, but instructions do not mention this. It was difficult to find the setting to change the system type.
EcoFactor (EF)	• There were no instructions were included with the thermostat.
Carrier ComfortChoice Touch (CCCT)	• Because there was no C-terminal at the heating system, we had to install an isolation relay. • The factory setting was for heating *and* cooling and instructions did not mention heat-only system. It took some time to understand heat-only setup. • We needed two wires to thermostat, access to zone control box, and 24 Volt (AC) isolation relay. The zone control box connects to basement unit and isolation relay. • User needs install code and MAC address from thermostat in order to set up web account.

Thermostat	Installer Findings
Building 36 CT100 (B36-CT)	• There is minimal space for wires behind thermostat. • The terminals on top of thermostat rather than in center. Current wiring was not long enough to reach so wires had to be extended. • There are hardly any instructions on how to program setpoints. Could not program from thermostat—had to use PC. • Building 36 recommends professional installation of thermostats • Building 36 recommends the thermostat be within 50 ft of the Gateway in order to maintain a wireless connection. If the thermostat is more than 50 ft away from the Gateway, they recommend using a repeater.
Honeywell Lyric (Lyric)	• Installer needed to use customer's tablet or smartphone to program. • There are no paper instructions. We had to download app to program setpoints. • Using the app allowed user to customize instructions for wiring setup. • There is a rubber gasket for wires to enter thermostat, which stops wall draft. • Thermostat has a built-in level.
Building 36 Intelligent (B36-IT)	• User has to program on tablet or PC. It was a little difficult on the tablet. • Thermostat has a built-in level. • Building 36 recommends professional installation of thermostats. • Building 36 recommends the thermostat be within 100 ft of the Gateway in order to maintain a wireless connection. If the thermostat is more than 100 ft away from the Gateway, they recommend using a repeater. If the thermostat uses a C-wire, then it acts as a repeater (if you have multiple zones/thermostats throughout the house).
Ecobee3	• The instructions for using the power extender kit were very confusing • When using the Power Extender Kit, a minimum of three wires is needed between the thermostat and HVAC unit.

* The thermostat models are listed in the order they were tested.

Key Installation Problems

Two of the original seven participants had to drop out of the study because their thermostat installations would have required an electrician rather than HVAC technician. The reasons Cadmus recommends an electrician are described below.

Ecobee Smart Si

This thermostat requires a C-wire, but the original participant's thermostat only had two wires. Installing new wire would involve running wire through another tenant's basement space and through a finished ceiling. Cadmus recommends an electrician perform this wiring installation.

EcoFactor

The original participant had an air handler in attic for cooling and a forced hot water boiler in the basement. The thermostat required the installation of a C-wire, but accessing a C-wire terminal from either the cooling or heating unit would have required an electrician. The thermostat was located on the first floor. Running the C-wire from the boiler in the basement to the first floor would require drilling into a wall and risking drilling into a floor. Running the C-wire from the attic to the first floor would require going through finished space. Cadmus recommends an electrician perform this wiring installation.

User Assessment

Cadmus developed and conducted a survey to assess participants' experiences and satisfaction with their installed thermostat.

Methods

Cadmus developed a web-based survey to address the following aspects of the user experience:

- How participants programmed their setpoints
- How frequently participants overrode their setpoints
- What the participant liked and disliked about the thermostat
- How the participant used the web account and mobile application
- If the participant believes they will save energy without compromising quality
- If the participant would purchase the thermostat
- If the participant had problems with the thermostat

Two-and-a-half weeks after each thermostat installation, Cadmus distributed the survey to study participants. A copy of the survey is available in Appendix B.

Results

All ten participants completed the web-based customer survey. To see responses on how participants programmed their setpoints, see the results of the Space Temperature Analysis section. Key survey responses that address the remaining items are shown in Table 11. Additional participant feedback is included in Table 12 through Table 18.

Table 11. Participant Survey Reponses (n=1 for each thermostat)*

Nest	HW	ESS	ES	EF	CCCT	B36-CT	Lyric	B36-IT	EC3
How frequently did you override your thermostat setting from home?									
Rarely	Several times per day	Rarely	Several times per week	Several times per day	Never	Several times per week	Rarely	Once per day	Rarely
Did you use your mobile application to adjust thermostat settings remotely?									
Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes
Did you use the web account to adjust thermostat settings remotely?									
No	No	No	No	No	No	No	N/A (No web app)	Yes	No
How did you use the mobile application?									
Check indoor and outdoor temp, adjust setpoint, change schedule, view history	Check indoor, temp, adjust setpoint, program schedule, change schedule	N/A	Check indoor and outdoor temp, adjust setpoint, change schedule	Check indoor and outdoor temp, adjust setpoint, program schedule, change schedule	Check indoor and outdoor temp, adjust setpoint, view history	Check indoor temp, adjust setpoint, program schedule	Check indoor and outdoor temp, adjust setpoint, other: Geofencing	Check indoor temp, view history	Check indoor and outdoor temp, adjust setpoint
How did you use the web account?									
Program schedule	N/A	Check indoor and outdoor temp	N/A	Check indoor temp, program schedule, change schedule	Check indoor temp	N/A	N/A	Check indoor temp, adjust setpoint, program schedule, change schedule	View history
How did you access web account?									
iPad	N/A	Computer	N/A	Computer	iPad	N/A	N/A	iPad	iPad
Rate the overall level of difficulty of using the thermostat.									

Nest	HW	ESS	ES	EF	CCCT	B36-CT	Lyric	B36-IT	EC3
Somewhat easy	Easy	Easy	Easy	Difficult	Easy	Easy	Easy	Easy	Easy
Rate the overall level of difficulty of using the mobile application.									
Easy	Easy	N/A	Easy	Easy	Easy	Easy	Easy	Somewhat difficult	Easy
Rate the overall level of difficulty of using the web account.									
Easy	N/A	Somewhat difficult	N/A	Easy	Difficult	N/A	N/A	Somewhat difficult	Easy
How satisfied were you with your old thermostat?									
Somewhat satisfied	Satisfied	Satisfied	Somewhat satisfied	Satisfied	Somewhat satisfied	Somewhat satisfied	Unsatisfied	Satisfied	Satisfied
How satisfied are you with your new thermostat?									
Satisfied	Very satisfied	Very satisfied	Very satisfied	Unsatisfied	Very satisfied	Very satisfied	Very satisfied	Very satisfied	Very satisfied
How likely were you to buy a Wi-Fi thermostat before participating in the study?									
Maybe	Maybe	Likely	Not likely	Not likely	Likely	Maybe	Likely	Maybe	Likely
Now that you have used the new thermostat, would you recommend it?									
Likely	Definitely recommend	Definitely recommend	Definitely recommend	Not likely	Definitely recommend	Likely	Definitely recommend	Likely	Definitely recommend
Before the study, how much would you be willing to pay for a Wi-Fi thermostat?									
$50	$100	$100	$50	$50	$250	$100	$50	$50	$100
Now that you have used the new thermostat, how much would you be willing to pay?									
$100	$150	$100	$100	$0	$250	$100	$50	$50	$100
If you were not / allowed to keep your new thermostat, what would you do?									
Purchase a cheaper thermostat	Reinstall old thermostat	Reinstall old thermostat	Purchase a cheaper thermostat	Reinstall old thermostat	Purchase same thermostat	Purchase, depending on value of rebate	Reinstall old thermostat	Reinstall my old thermostat	Purchase same thermostat
Has the comfort of your home changed with the new thermostat?									
No	More comfortable	No	More comfortable	Less comfortable	More comfortable	No	More comfortable	More comfortable	No

* The thermostat models are listed in the order they were tested.

Participant Feedback

Participant responses to key open-ended survey questions are shown in the following tables. The thermostat models are listed in the order they were tested.

Table 12. What do you like best about the thermostat? Please describe.

Thermostat	Comments
Nest	Easy to use, good mobile app, learning feature, ability to set away mode from phone, cool design.
HW	I like the fact that it is Wi-Fi, which allows for mobile access. Having a vacation mode is another huge plus.
ESS	The screen was easy to read.
ES	The usability and easy setup. I also like the smart phone app.
EF	The simplicity and easiness of adjusting the temp online as well as being able to set an "away" temp was very useful and efficient.
CCCT	It set back when I left my house automatically.
B36	Ability to monitor and set remotely.
Lyric	Love the geofencing, since I have so many folks in and out of my house - me, husband, and nanny with kids. Also love programming with app instead of on wall.
B36-IT	Programmable, iPhone app.
EC3	Easy to use. I love the online capability.

Table 13. Is there anything you dislike about the thermostat? Please describe.

Thermostat	Comments
Nest	Price
HW	N/A
ESS	When I go away for a weekend, I need to go into several layers of the T-stat software to make changes. My old one had just a temp hold button. Not all vacations are for a long period of time.
ES	The screen is slightly lower quality with a grainy display.
EF	The thermostat did not work correctly as I previously stated. In addition to that, I also did not like that the actual device was not user-friendly. I was unable to adjust the settings using the device. I had to make all adjustments online, which is ok for me because I am constantly on my smart phone, but if someone is not typically online it would be very frustrating and inconvenient.
CCCT	N/A
B36	N/A
Lyric	One time internet went down in my house, so the thermostat disconnected and actually shut off the heat!!! That was very bad.
B36-IT	N/A
EC3	The registration process needs to be better described in directions.

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Table 14. What features will you most likely continue to use and why?

Thermostat	Comments
Nest	Mobile app, see and control the temperature with the phone.
HW	Mobile app feature and vacation mode.
ESS	Usage and possible remote temp change when coming home from vacation.
ES	Mobile app, schedule and weather display.
EF	Due to complications, we replaced the new thermostat with old device. However, if I were to continue using one, I would definitely continue to use the mobile app to monitor, set and change the temperatures. I really liked that feature.
CCCT	The geofencing feature setback.
B36	Indoor temp.
Lyric	Geofencing and remote control app. I also liked that this thermostat seems to learn. Originally it went from 68 to 63 when I left home. After a few times when I manually set it at 58 when no one was home, it now automatically goes to 58 when no one is home.
B36-IT	Schedule -- easy to set through web interface.
EC3	All features.

Table 15. Which features … are most likely to help / reduce your energy consumption?

Thermostat	Comments
Nest	"Leaf" icon notifications on energy-efficient behavior, mobile app.
HW	The mobile app feature that will allow me to adjust the T-stat schedule if I am not home.
ESS	N/A (Participant did not use mobile app enough to provide feedback).
ES	Easy programming (result in using schedule more), ability to delay thermostat deadband (reducing short cycling).
EF	Being able to set "away" temp.
CCCT	Geofencing, remote access.
B36	Turning down temps in zones when unoccupied.
Lyric	Geofencing, ability to control easily from my phone and or automate.
B36-IT	Schedule -- but would save more I think in a cooling application than for the heating.
EC3	The ability to monitor remotely.

Table 16. Were there any features that might cause an increase in your energy / consumption?

Thermostat	Comments
Nest	No response.
HW	No response.
ESS	No response.
ES	No response.
EF	Yes, dropping the temp lower than scheduled causing me to increase the temp manually.
CCCT	No response.
B36	No response.
Lyric	No response.
B36-IT	No response.
EC3	No.

Table 17. Why do you think you will save energy with your new thermostat? If yes, how?

Thermostat	Comments
Nest	Yes, controlling the temperature when you are not home, and the away setting.
HW	Yes, because I will have the ability to adjust the temp when I know I won't be home at one of the setpoints.
ESS	Yes, newer devices should have more accurate temp settings and remote access.
ES	Yes, reduced system run time, easier to stick to schedule so less indulgence in temperature.
EF	I don't know.
CCCT	Yes, it will setback immediately when I am more than 4 miles from home.
B36	Yes, turning down zones remotely when people are not in the house.
Lyric	I don’t know.
B36-IT	I don’t know.
EC3	Yes, likely because I will be more engaged in monitoring temperature because I'll look at it more frequently; make changes.

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Table 18. Are there any features your old thermostat had that you wish your new thermostat had?

Thermostat	Comments
Nest	No response.
HW	No response.
ESS	Easily accessible HOLD button. Also, scheduling took a little figuring out.
ES	No response.
EF	Mobile app to manually change temp and the ability to set an "away" temp
CCCT	No response.
B36	No response.
Lyric	No response.
B36-IT	No response.
EC3	No.

Problems with Thermostat

One participant reported problems with the thermostat. The participant with the EcoFactor thermostat made the following comment on the thermostat's ability to regulate the home temperature.

> *"Since the new thermostat was installed, the house was significantly colder throughout the day and night. The thermostat would read 68 – 70 ℉, but the data loggers and a personal thermometer would read 66 – 68 ℉. The differential was always two degrees colder. At night it would get worse. The temp was set at 67 ℉, but the new thermostat would at times read as low as 65 ℉.I was constantly manually changing the temp online to adjust for the coldness. I believe there had to have been a problem with the thermostat, but it was very frustrating."*

To try to resolve the issues, the participant increased the temperature setpoint but was concerned about how this would impact the energy bills.

The participant also reported that the thermostat was not very user-friendly, noting that he or she was unable to adjust the temperature settings using the device and had to make all adjustments with the mobile application and/or web account instead. The participant added personally liking using the mobile application to control the thermostat, but that this may not be convenient for all users.

In the end, the participant reinstalled the old thermostat and returned the EcoFactor.

Cadmus followed-up with EcoFactor about the disparity between the setpoint and the indoor air temperature. EcoFactor reported that the gateway and thermostat were not connected, so the thermostat was not operating on EcoFactor software, which is cloud-based, but rather the Computime thermostat default settings. They reported the thermostat must have been operating on the default schedule shown in Table 19 (next page).

Table 19. Computime Thermostat Default Settings

Schedule Period	Time	Start Heating At	Start Cooling At
Morning	6:00 am – 8:00 am	73	76
Day	8:00 am – 6:00 pm	71	78
Evening	6:00 pm – 10:00 pm	72	75
Night	10:00 pm – 6:00 am	72	76

Space Temperature Analysis

Cadmus collected thermostat setpoint and household temperature data to assess how closely the space temperature matched the thermostat setpoints. This comparison may demonstrate the performance of each thermostat in maintaining the thermostat setpoint temperature. However, when interpreting findings, readers should consider these important points:

- Findings are based on one thermostat installation in one home for each thermostat model;
- The space temperature data collection period took place immediately after the thermostat installation. This included a two to three week period in February and March 2014 for the original thermostat group and between November 2014 and January 2015 for the additional thermostat group;
- It is normal for the space temperature to vary up to three degrees above and below the thermostat setpoint (this is termed the temperature differential);
- There are a variety of factors that impact how well a thermostat can regulate space temperature, including home insulation type, level of solar heat gain, and HVAC system type; and
- All nine thermostats have propriety algorithms that use feedback (which may include indoor/outdoor temperature, target setpoint, historical HVAC system run time) to adjust HVAC system run time; therefore, thermostat performance may vary over time and under different weather conditions.

Methods

Cadmus used temperature data loggers to record space temperature for a minimum of two weeks after the thermostat installation. We analyzed the record of thermostat setpoints and schedules during the data collection period and assessed how well the measured household temperature matched the thermostat setpoint.

Data Collection

During the site visit, Cadmus installed a temperature data logger next to each thermostat. These high-accuracy data loggers recorded the space conditions at one-minute intervals throughout the data collection period (minimum of two weeks for each thermostat). Table 20 describes our data collection points for each participant household.

Table 20. Thermostat Assessment Data Collection Points

Parameter	Units	Equipment	Frequency	Duration
Temperature at thermostat	Deg. F/RH%	Onset U10	1-minute	2-3 weeks

Data Analysis

To assess how well the household temperature matched the thermostat setpoints, Cadmus compared the average hourly actual temperature (measured from the Onset U10 temperature loggers) to the setpoints the participant programmed during the installation for a 24-hour profile. One participant reported that she changed her setpoints during the data collection period. We contacted this participant to collect the new setpoint settings. We also quantified the average temperature difference between the actual temperature and setpoint.

Results

For each thermostat, we present a figure that demonstrates how closely the space temperature matched the thermostat setpoint. The figures compare the profiles of average hourly measured temperature to the thermostat setpoint for that hour. Each figure also shows the average temperature differences for each thermostat.

In each figure:

- Orange lines show scheduled setpoint temperatures;
- Blue lines shows average measured temperature; and
- The bar graphs show the average temperature difference between the setpoint and actual temperature.
    - Red bars indicate that the average measured space temperature was warmer than the setpoint temperature.
    - Blue bar graphs indicate that the average measured space temperature was cooler than the setpoint temperature.

Five participants programmed one setpoint schedule for all seven days of the week. The other participants scheduled either weekday/weekend (5-2) schedules or weekday/Saturday/Sunday (5-1-1) schedules. We assessed each setpoint schedule separately.

The thermostat models are presented in the order they were tested.

Nest

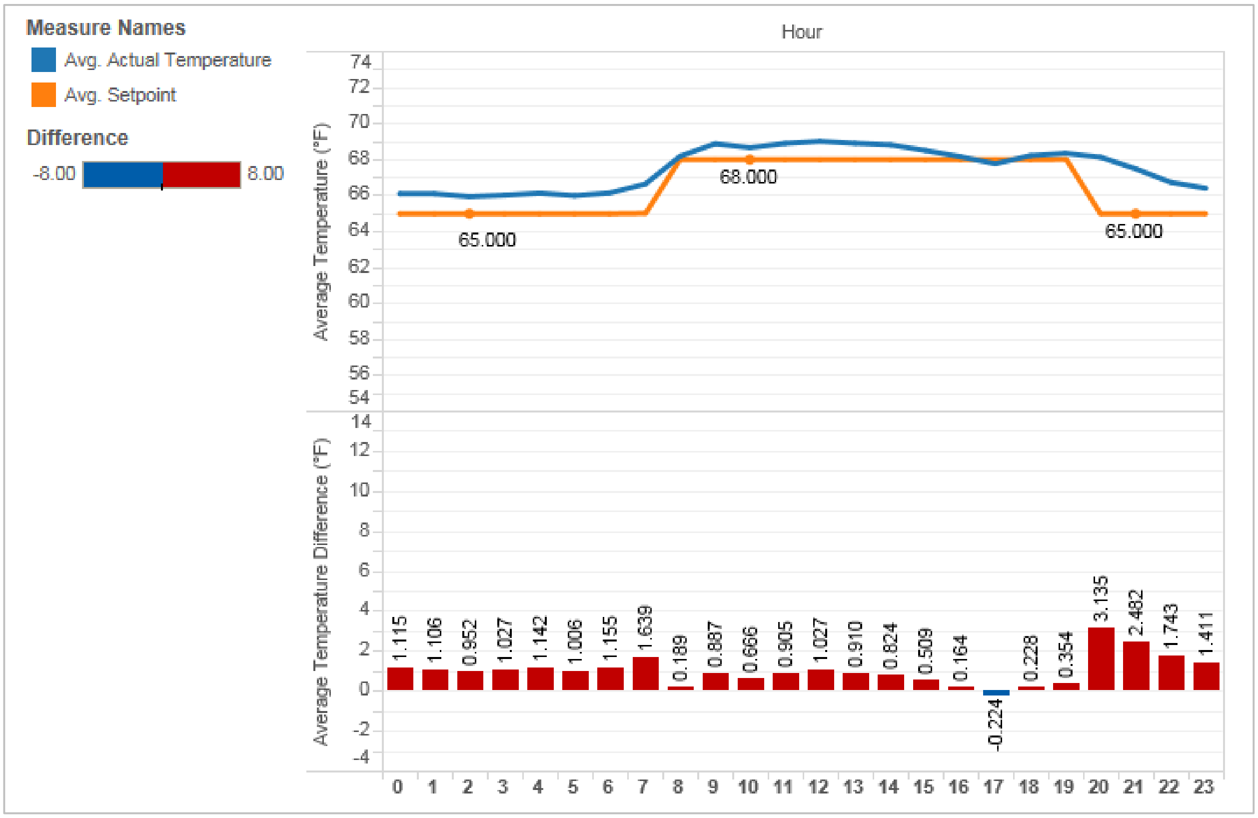
The Nest uses an algorithm to learn the user's preferred temperature and schedule and estimate the HVAC unit run time required to meet a particular setpoint and an occupancy sensor to learn when users are away or asleep. The Nest uses this data to learn when to start pre-heating or pre-cooling the home and to adjust setback periods.[10]

Although the Nest thermostat can program different schedules for each day of the week, the participant programmed the same setpoints for all seven days of the week. Figure 4 compares the thermostat

[10] Nest Labs. Nest Learning Thermostat Efficiency Stimulation: Update Using Data from First Three Months. April 2012.

setpoints (in orange) to the average measured space temperature (in blue), by hour. The bar graph shows the average difference between the setpoint and actual temperature, by hour.

Figure 4. Average Hourly Temperature – Nest – All Days



In the home with the Nest thermostat, the space temperature closely matched the scheduled setpoints of 65°F when home/asleep (20:00 to 8:00) and 68°when home/awake (8:00 to 20:00). During the home/awake period, the Nest kept the home within two degrees of the scheduled setpoint. During the home/asleep period, the average measured temperature was no more than four degrees warmer than the setpoint. The temperature difference is larger during the setback period because it takes time for the home to cool down to meet the 65°F setpoint.

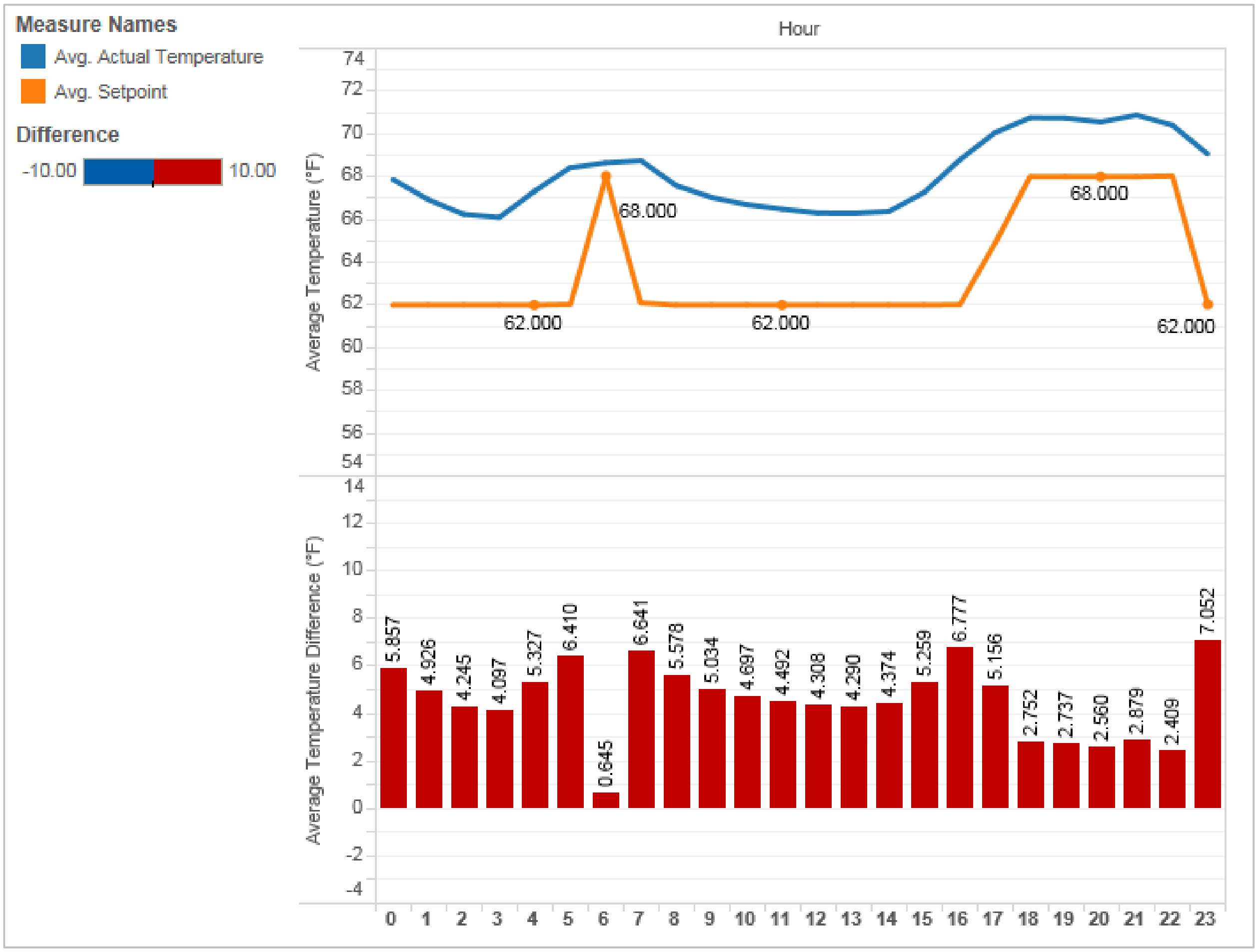
Honeywell Wi-Fi Smart Thermostat

This participant has Smart Response Technology enabled on their thermostat. Smart Response Technology uses an algorithm to learn heating and cooling cycle times and adjust the HVAC unit run time required to meet a particular setpoint. Over time, Smart Response Technology should improve how accurately the thermostat meets the setpoints.[11]

[11] http://yourhome.honeywell.com/home/Products/Thermostats/7-Day-Programmable/Wi-Fi+Smart+Thermostat.htm (Accessed 4/14/14)

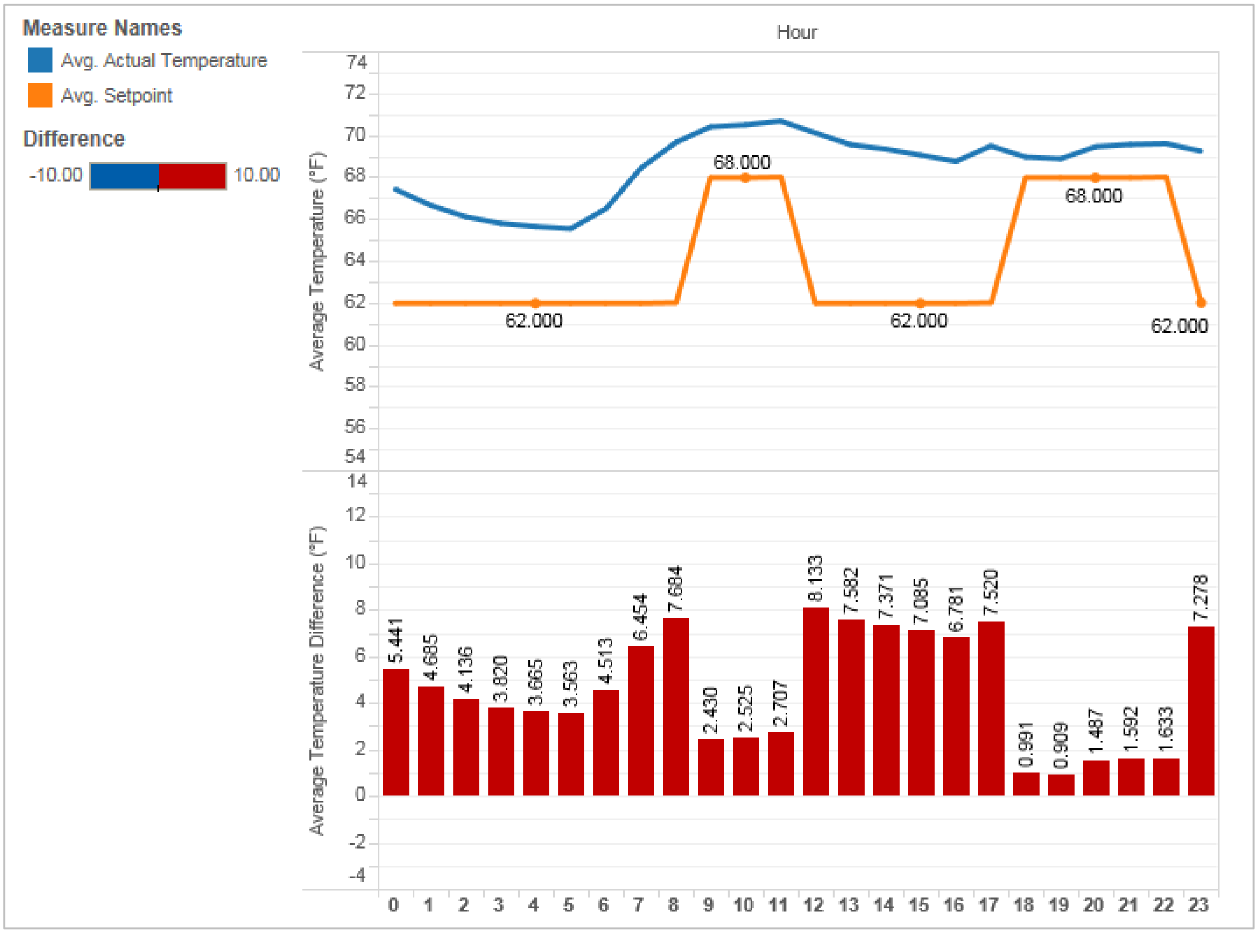
The participant who received the Honeywell thermostat programmed three setpoint schedules: one for weekdays, one for Saturdays, and one for Sundays. Figure 5, Figure 6, and Figure 7 show the space temperature analysis for each of these setpoint schedules.

Figure 5. Average Hourly Temperature – Honeywell – Weekdays



For weekdays, the participant programmed a setpoint of 62°F when away or home/asleep and 68°F when home/awake in the morning and evening. The Honeywell thermostat consistently kept the home temperature above both these setpoints. When home/awake, the average space temperature was 0–3° warmer than the setpoint. When away, the average space temperature was 4–7° warmer than the setpoint. This relatively large difference is because it takes hours for the space temperature to drop 8°F to reach the setback of 62° F. The space temperature drops approximately 2.5 degrees from 7:00 to 14:00, before the house begins to warm up again to meet the 68°F setpoint at 17:30.

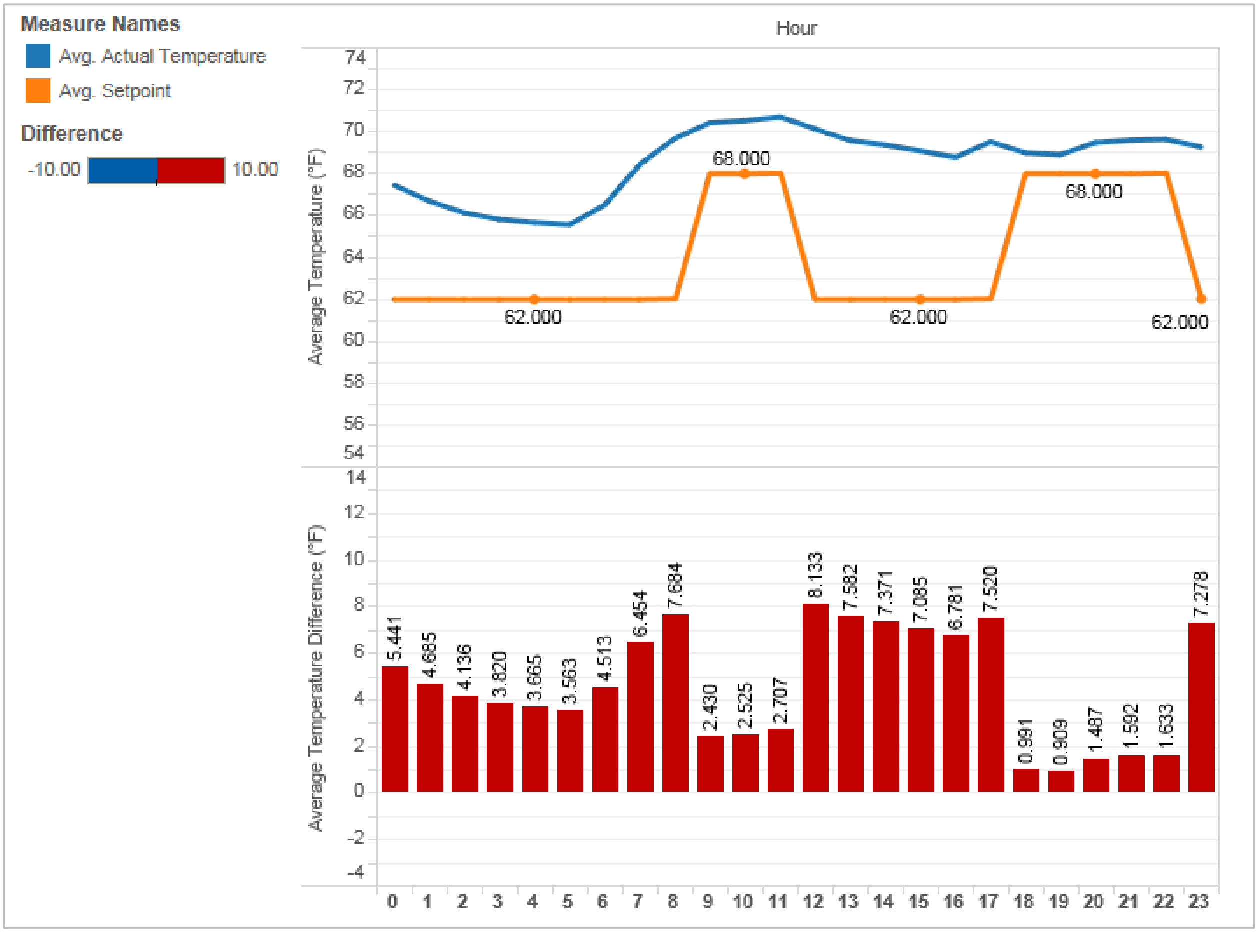
Figure 6. Average Hourly Temperature – Honeywell – Saturdays



For Saturdays, the participant programmed the same temperature setpoints as for weekdays but extended the morning's home/awake setpoint from one hour (6:00–7:00 on weekdays) to three hours (9:00–12:00 on Saturdays). The participant also shortened the evening home/awake setpoint from 5.5 hours (17:30–23:00 on weekdays) to 2.5 hours (20:30–23:00 on Saturdays).

Similar to weekdays, the thermostat consistently kept the space temperature within three degrees above the home/awake setpoint with larger temperature differences during the setback periods.

Figure 7. Average Hourly Temperature – Honeywell – Sundays



The Sunday setpoint schedule was similar to Saturday, except the afternoon away setpoint was shortened from 10.5 hours (12:00–20:30 on Saturdays) to six hours (12:00–18:00 on Sundays). Like on weekdays and Saturdays, the thermostat consistently kept the average space temperature within 3° F warmer than the setpoint with larger temperature differences during the setback periods.

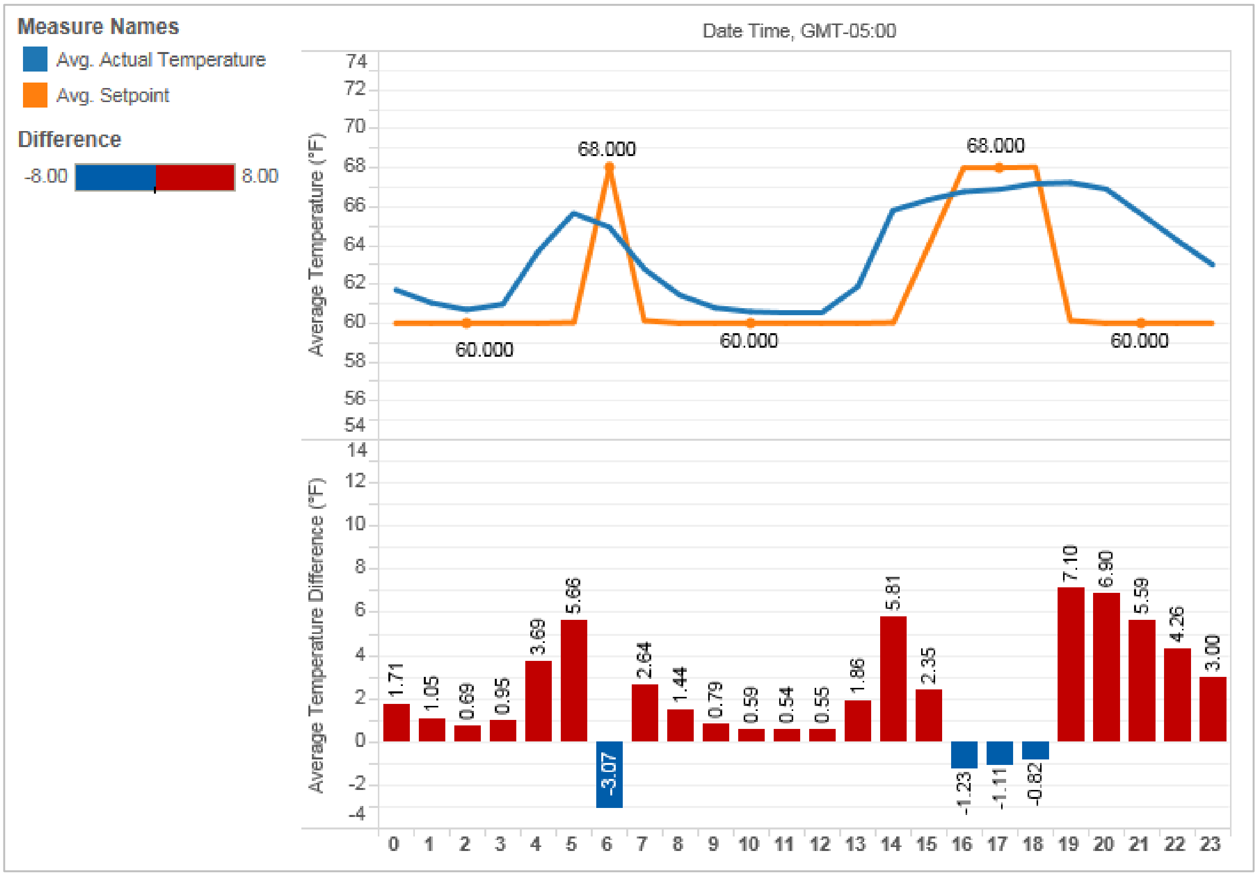
Ecobee Smart Si

The Ecobee Smart Si thermostat uses an algorithm and weather observations to adjust HVAC system run time.[12]

The participant with the Ecobee Smart Si thermostat programmed three setpoint schedules—one for weekdays, one for Saturdays, and one for Sundays. Figure 8, Figure 9, and Figure 10 show the space temperature analysis for these three schedules.

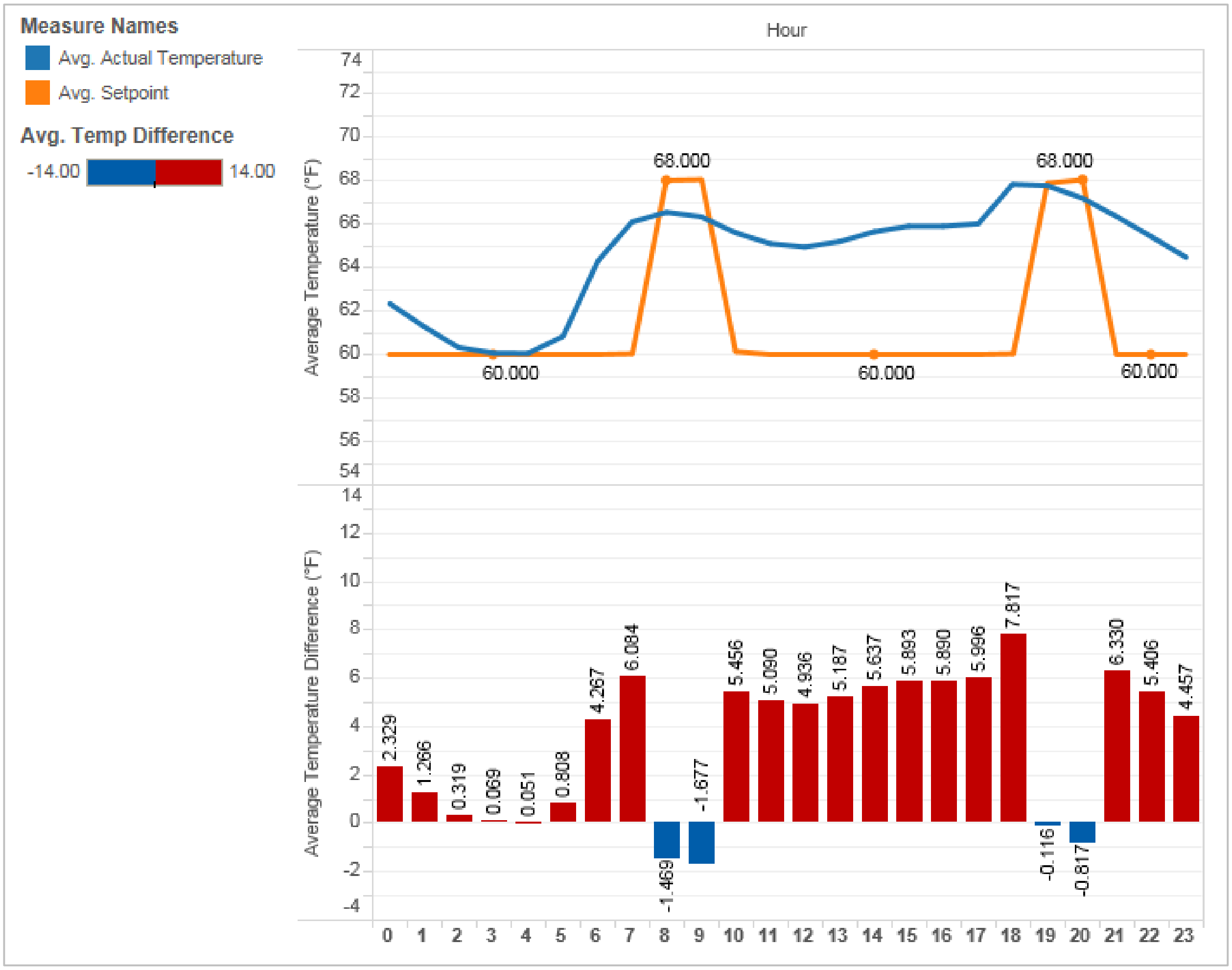
[12] http://www.ecobee.com/solutions/home/smart-si/ (Accessed 4/14/14)

Figure 8. Average Hourly Temperature – Ecobee Smart Si – Weekdays



On weekdays, the participant set the Ecobee Smart Si thermostat to 68°F when home/awake and 60°F when away or home/asleep. During the home/awake period, the average space temperature remained 1–3°F cooler than the 68°F setpoint. When in the away setback period, the average space temperature dropped until it was approximately 0.5 degrees above the setback temperature of 60°F before warming up again to meet the 68°F home/awake setpoint.

Figure 9. Average Hourly Temperature – Ecobee Smart Si – Saturdays



On Saturdays, the participant used the same setpoints, but shifted the home/awake setpoints from 6:00–7:00 and 15:30–19:00 to 8:00–10:00 and 19:00–21:00, respectively. For the home/awake setpoint periods, the average space temperature remained within two degrees cooler than the setpoint. During the home/asleep period, the average space temperature dropped to the setback temperature of 60°F, but during the day, the average space temperature did not typically drop to less than five degrees above the setback.

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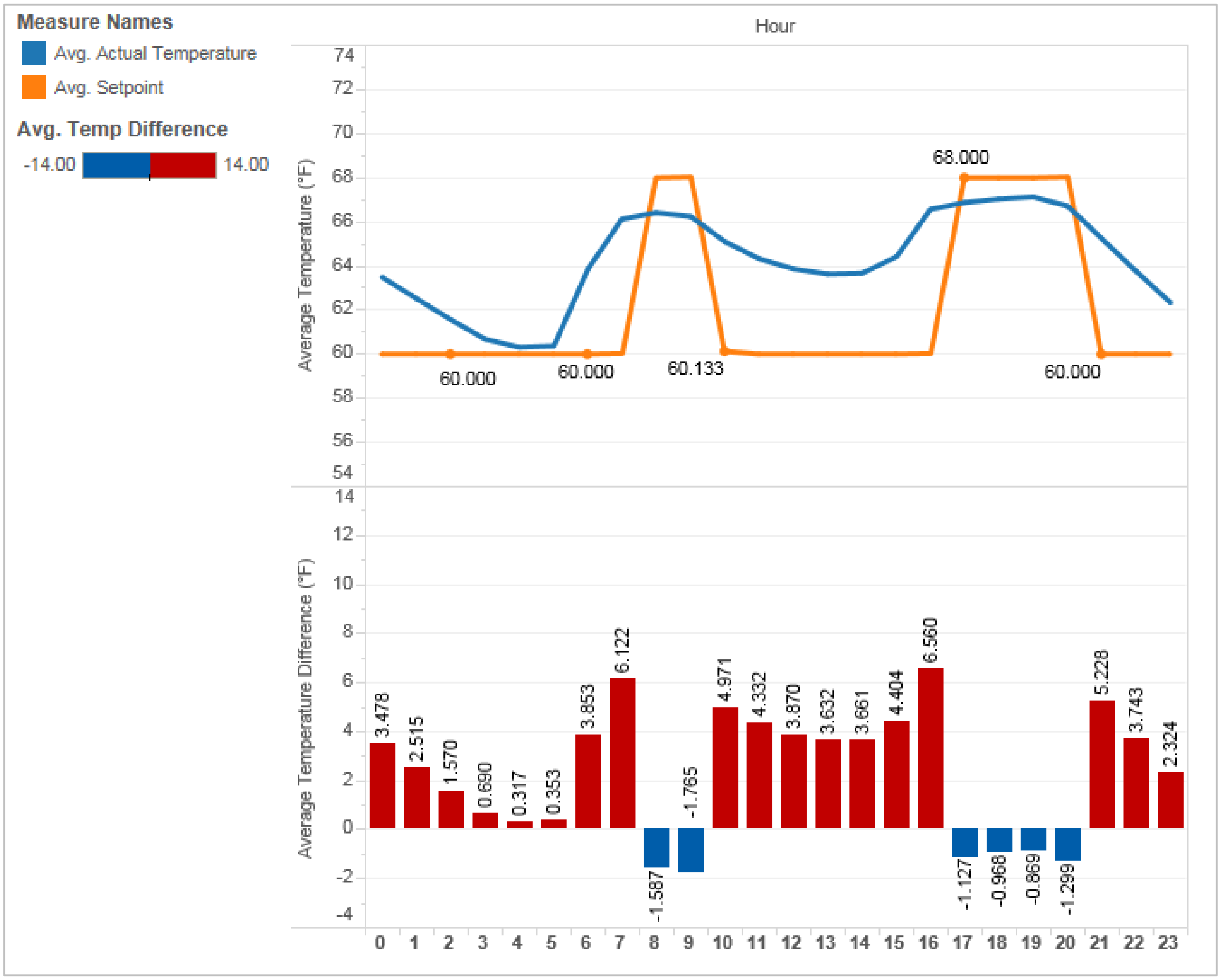
Figure 10. Average Hourly Temperature – Ecobee Smart Si – Sundays



On Sundays, the participant programmed similar setbacks as on Saturdays, but changed the away setback period from 10:00–19:00 to 10:00–17:00. During the home/awake period, the average space temperature was consistently 1–2 degrees cooler than the setpoint. During the home/asleep period, the average space temperature dropped to the setback temperature, but when away, it remained no less than four degrees above the setback temperature.

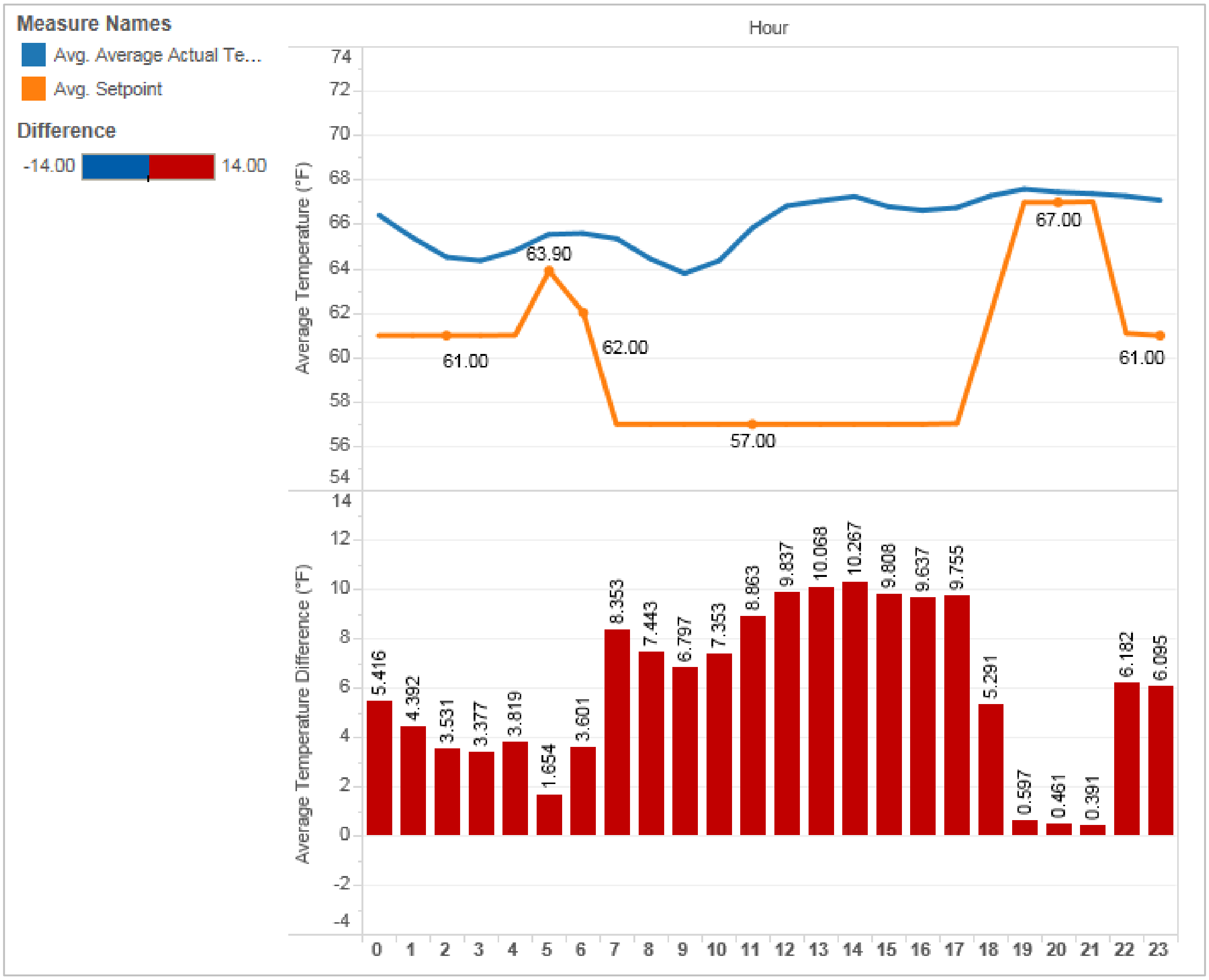
Ecobee Smart

The Ecobee Smart thermostat uses an algorithm and weather observations to adjust the HVAC unit run time to meet a particular setpoint.[13]

[13] http://www.ecobee.com/solutions/home/smart-si/ (Accessed 4/14/14)

The participant who received the Ecobee Smart thermostat programmed two schedules of setpoints—one for weekdays and one for weekends. Figure 11 and Figure 12 show the space temperature analyses for the Ecobee Smart thermostat.

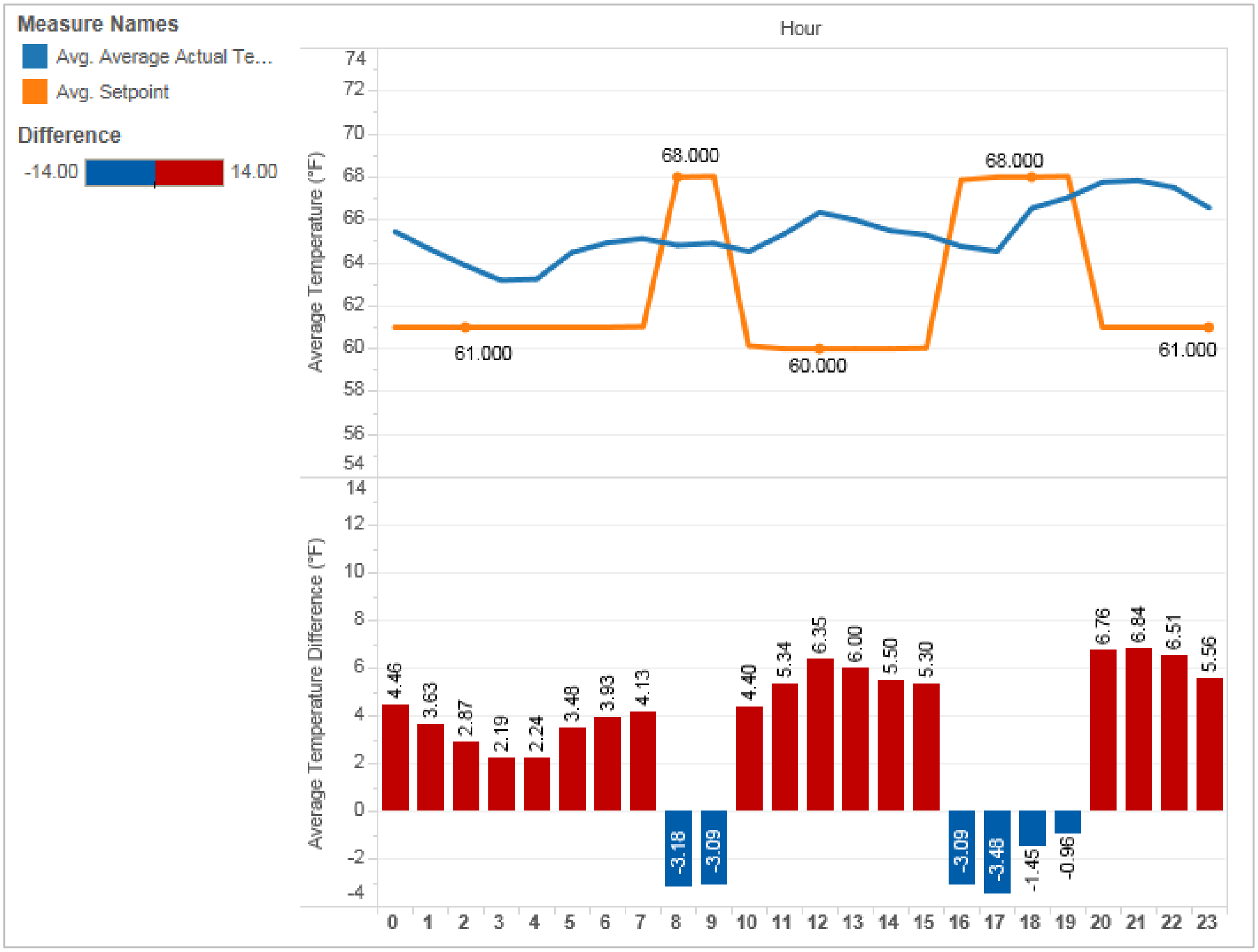
Figure 11. Average Hourly Temperature – Ecobee Smart – Weekdays



On weekdays, this participant scheduled a setpoint of 61°F when home/asleep and 57°F when away. During the home/awake period, the participant scheduled a setpoint of 67°F (5:30–6:30 and 18:30–22:00). Figure 11 shows the average hourly setpoint at 5:00 and 6:00 as 63.9°F and 62°F because the 67°F setpoint period overlaps the 5:00 and 6:00 hour.

The average space temperature when home/awake was consistently within two degrees warmer than the setpoint. When home/asleep, the average space temperature dropped to approximately three degrees above the setpoint before starting to increase in the 4:00 hour to meet the 6:30 setpoint of 67°F. When away, the average space temperature dropped to meet the 57°F setpoint, but remained about seven degrees warmer than this setpoint. By 14:00, the average space temperature increased to more than ten degrees warmer than the setpoint, which is over four hours earlier than needed to meet the 18:30 setpoint of 67°F.

Figure 12. Average Hourly Temperature – Ecobee Smart – Weekends



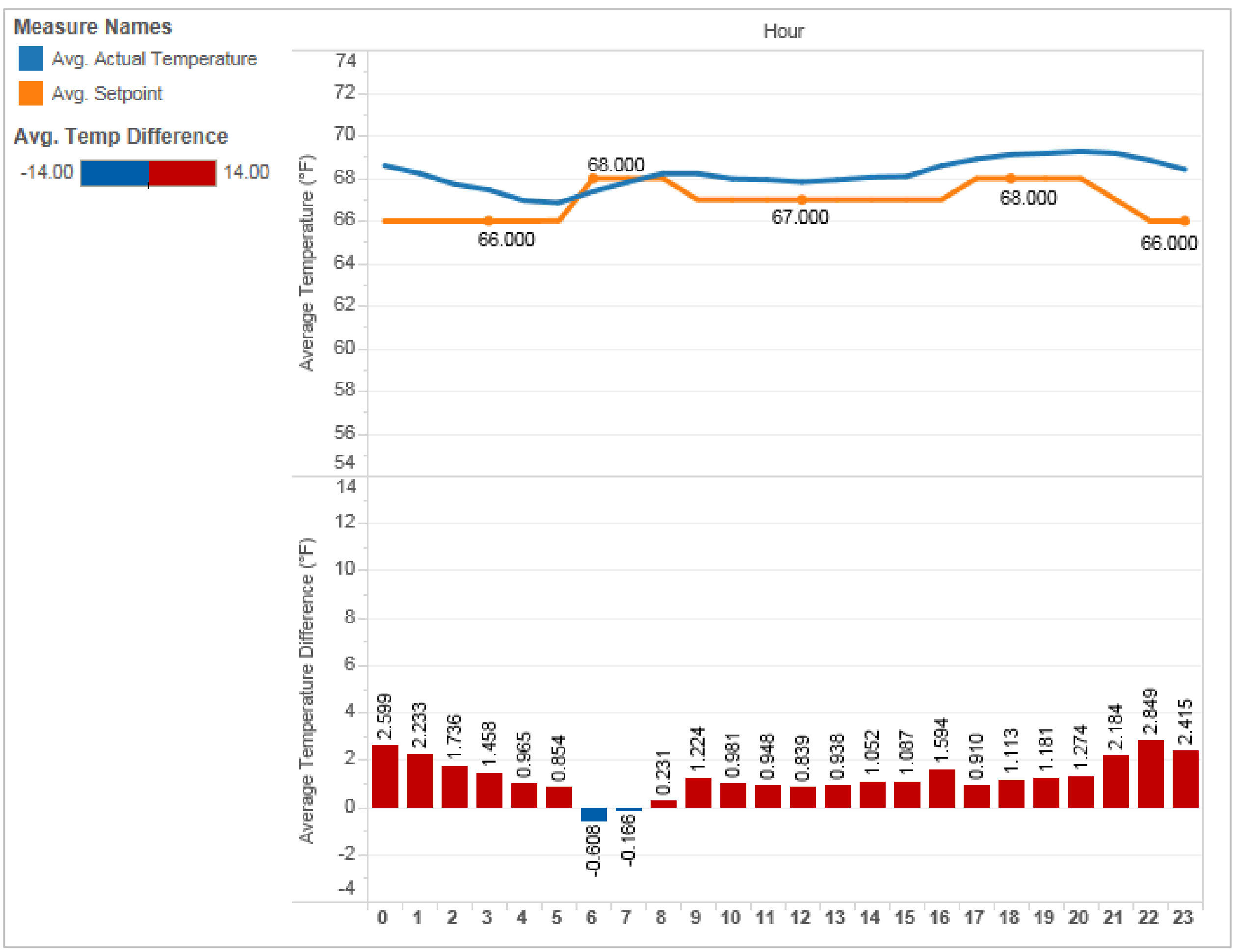
On weekends, the participant schedule changed their home/awake setpoint from 67°F to 68°F and shifted the time period from 6:60–8:30 and 18:30–22:00 to 8:00–10:00 and 16:00–22:00. They also changed their away setpoint to 60°F. Their home/asleep setpoint remained at 61°F. On weekends, the average space temperature was no more than four degrees cooler than the setpoint. During the away period, the average space temperature did not drop to the setpoint, but increased for several hours until it was no more than seven degrees warmer than the setpoint. During the home/asleep period, the average space temperature dropped until it was approximately two degrees above the 61°F setpoint, before increasing to meet the 68°F setpoint.

EcoFactor

The EcoFactor uses information including indoor/outdoor temperature, programmed setpoints, and HVAC system run time in an algorithm to determine how best to heat or cool a home while maintaining comfort.

The participant with the EcoFactor thermostat programmed a setpoint schedule for weekdays and weekends. One week into the study, the participant changed the schedule of setpoints for both weekdays and weekends. Figure 13 and Figure 15 show the space temperature analyses for the first week of the study (Phase 1). Figure 14 and Figure 16 show the space temperature analyses for the remainder of the study period (Phase 2).

Figure 13. Average Hourly Temperature – EcoFactor – Weekdays – Phase 1



During the first week of the study, the participant scheduled the home/awake setpoint for 68°F, away setpoint for 67°F, and home/asleep setpoint for 66°F. During the morning home/awake setpoint period

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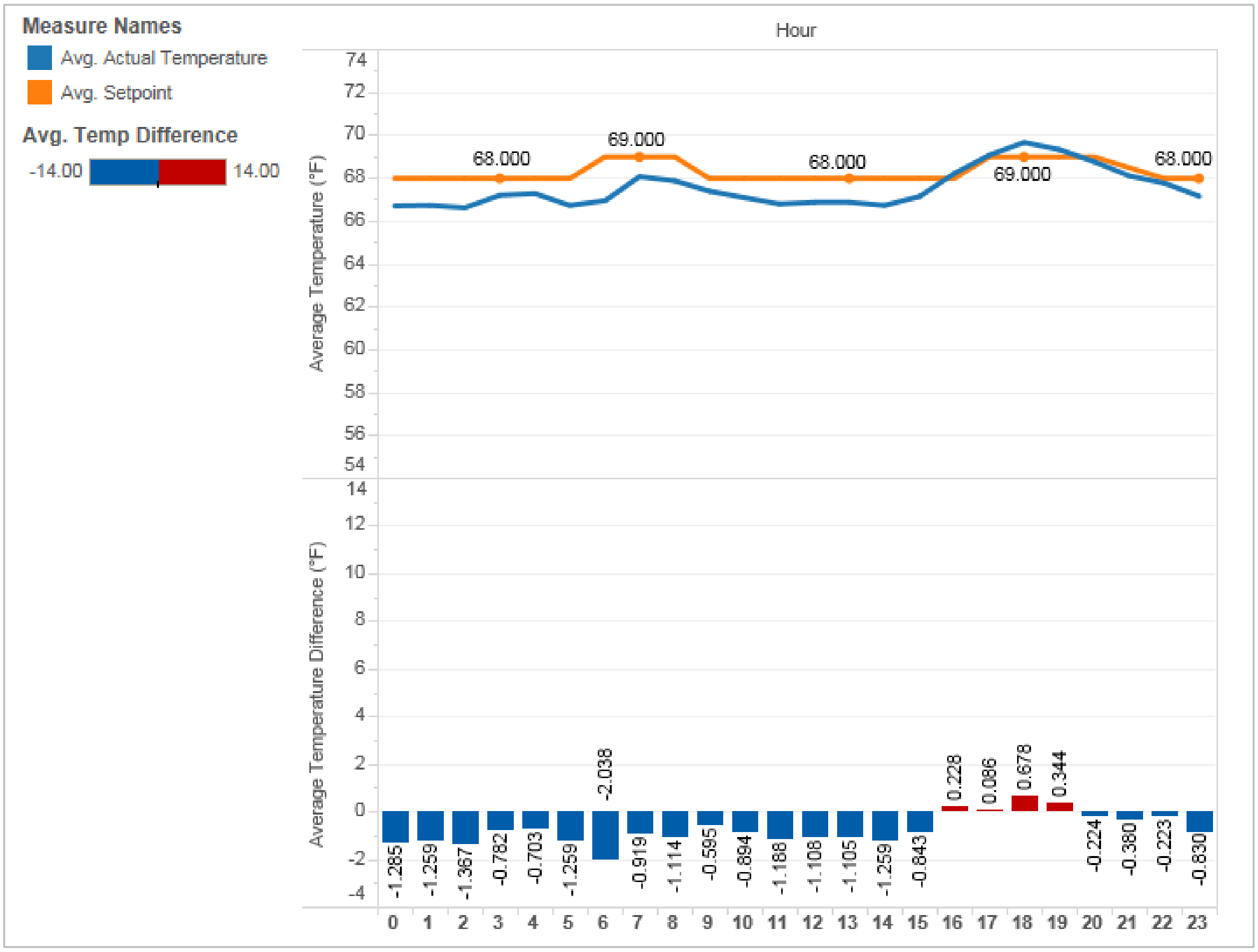
(6:00–7:00), the average space temperature remained within one degree below the setpoint. During all other hours of the day, the average space temperature remained within two degrees above the setpoint, except when the home was cooling down during the setback period (home/asleep period).

Figure 14. Average Hourly Temperature – EcoFactor – Weekdays – Phase 2



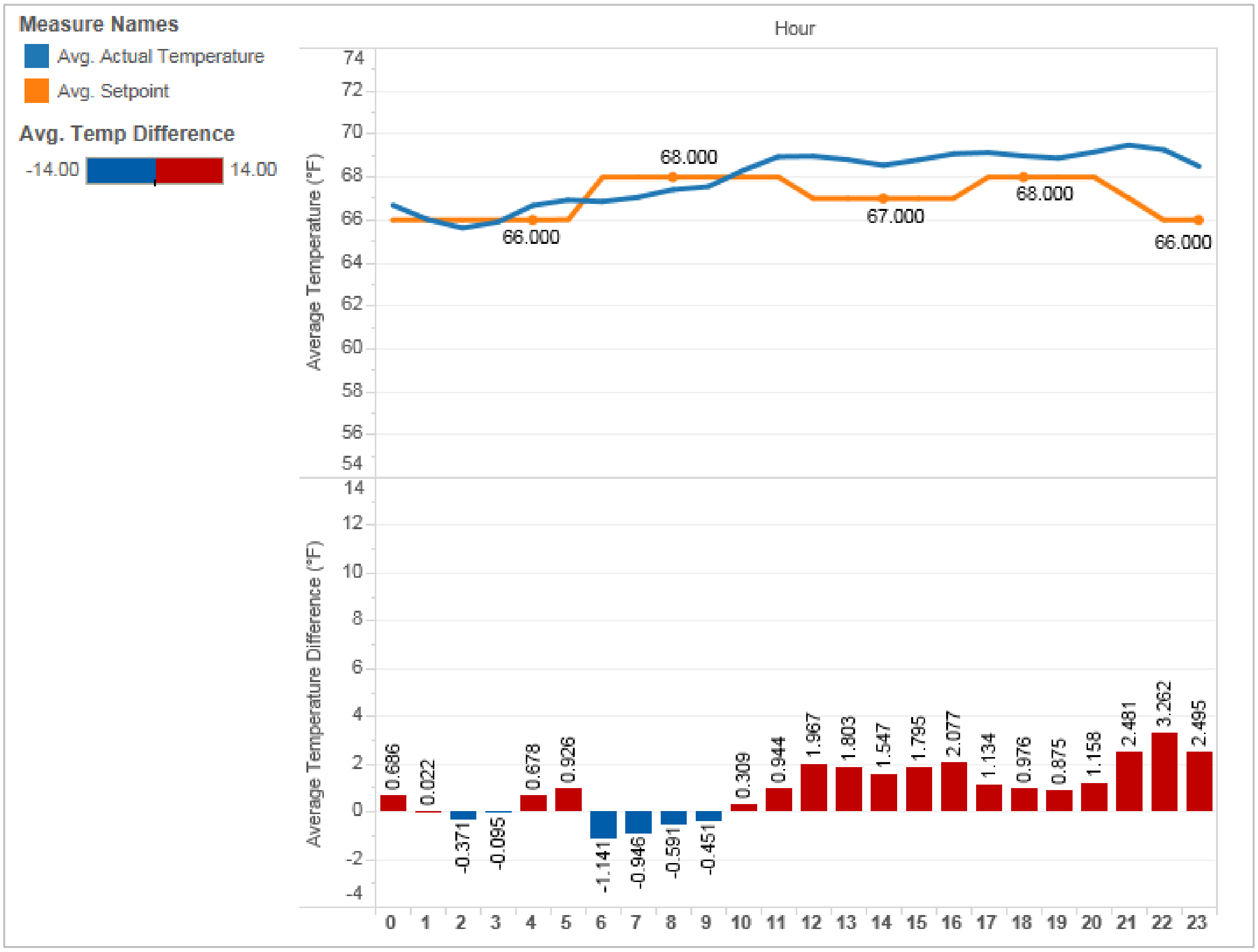
One week into the study, the participant with the EcoFactor thermostat changed the schedule of weekday setpoints in an effort to increase the thermal comfort of the home. The participant kept the same periods for home/awake, away, and home/asleep periods, but increased the setpoint temperatures. Table 21 shows the setpoint changes the participant made to the weekday schedule.

Table 21. Mid-study Weekday Setpoint Changes for EcoFactor

Time Frame	Old Setpoint(°F)	New Setpoint(°F)
6:00 AM – 9:00 AM	68	69
9:00 AM – 5:00 PM	67	68
5:00 PM – 9:30 PM	68	79
9:30 PM – 6:00 AM	66	68

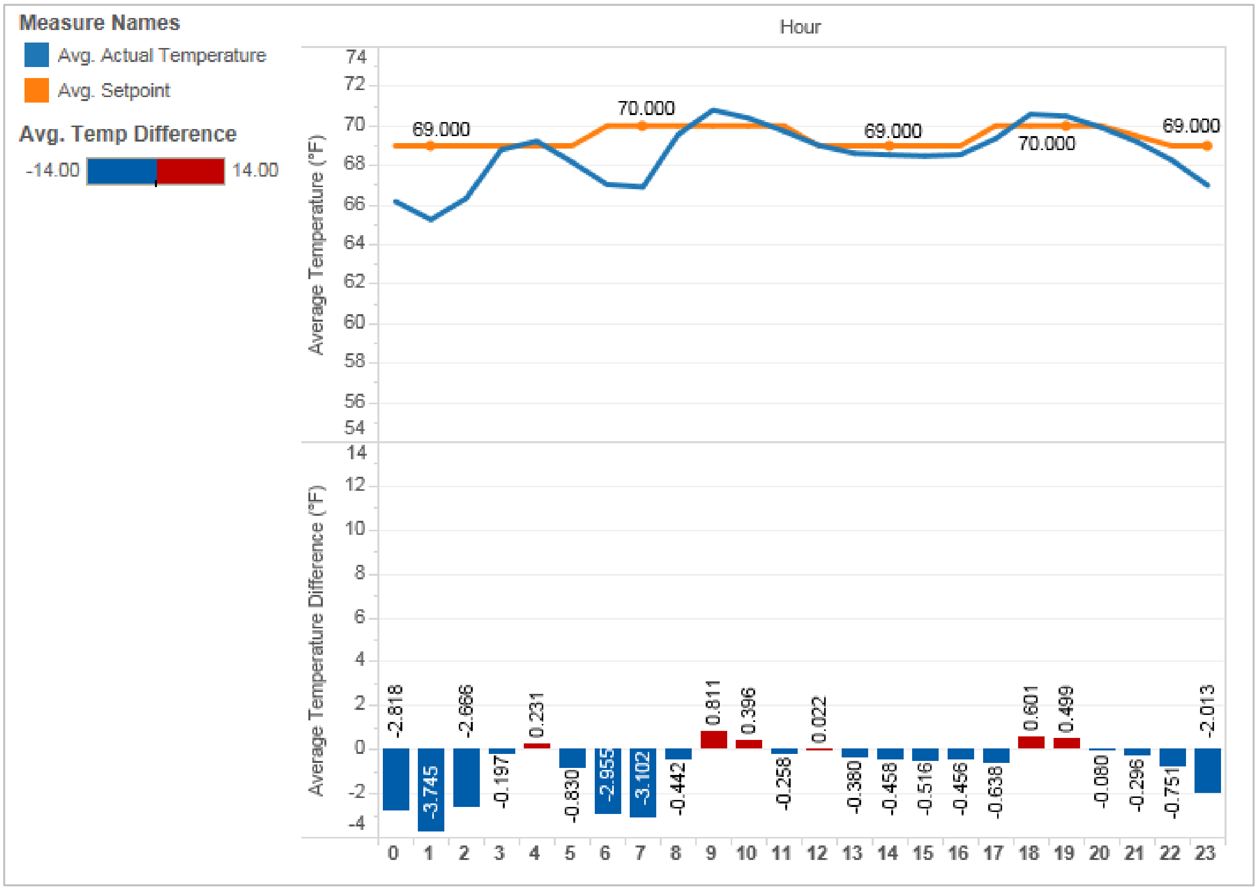
After the participant made the setpoint changes, the average space temperature tended to be within two degrees below the setpoint, whereas in phase 1, the average space temperature tended to be within two degrees above the setpoint.

Figure 15. Average Hourly Temperature – EcoFactor – Weekends – Phase 1



During the first week of the study, the weekend schedule the participant programmed for the EcoFactor thermostat was similar to the weekday schedule, but with an extended the morning home/awake setpoint period (6:00–12:00 rather than 6:00–9:00). During the morning home/awake period, the average space temperature remained approximately one degree cooler than the setpoint. During the evening home/awake period, the average space temperature remained approximately one degree warmer than the setpoint.

Figure 16. Average Hourly Temperature – EcoFactor – Weekends – Phase 2



One week into the study, the participant with the EcoFactor thermostat changed the schedule of weekend setpoints in an effort to increase the thermal comfort of the home. The participant kept the same periods for home/awake, away, and home/asleep periods, but increased the setpoint temperatures. Table 22 shows the setpoint changes the participant made to the weekday schedule.

Table 22. Mid-study Weekend Setpoint Changes for EcoFactor

Time Frame	Old Setpoint(°F)	New Setpoint(°F)
6:00 AM – 12:00 PM	68	70
12:00 PM – 5:00 PM	67	69
5:00 PM – 9:30 PM	68	70
9:30 PM – 6:00 AM	66	69

After the participant made the setpoint changes, the average space temperature tended to be within four degrees below the setpoint during the morning home/awake period, whereas in phase 1, the average space temperature tended to be within two degrees below the setpoint during this period.

During the home/asleep setback period, the difference between the space temperature and setpoint temperature increased to four degrees below the setpoint of 69°F.

Carrier ComfortChoice Touch

The Carrier ComfortChoice Touch thermostat uses an algorithm to adjust the HVAC run time. This algorithm takes into account the equipment type, temperature difference between indoor temperature and target setpoint, and equipment protection (to limit the number of times the compressor is cycled per hour and the time between cycling). It also has Smart Recovery, where the thermostat will gradually ramp up temperature to meet a target setpoint.[14]

The participant with the Carrier ComfortChoice Touch thermostat programmed a single setpoint schedule for all seven days of the week. Figure 17 shows the space temperature analysis for this thermostat.

[14] Carrier representative (4/29/14)

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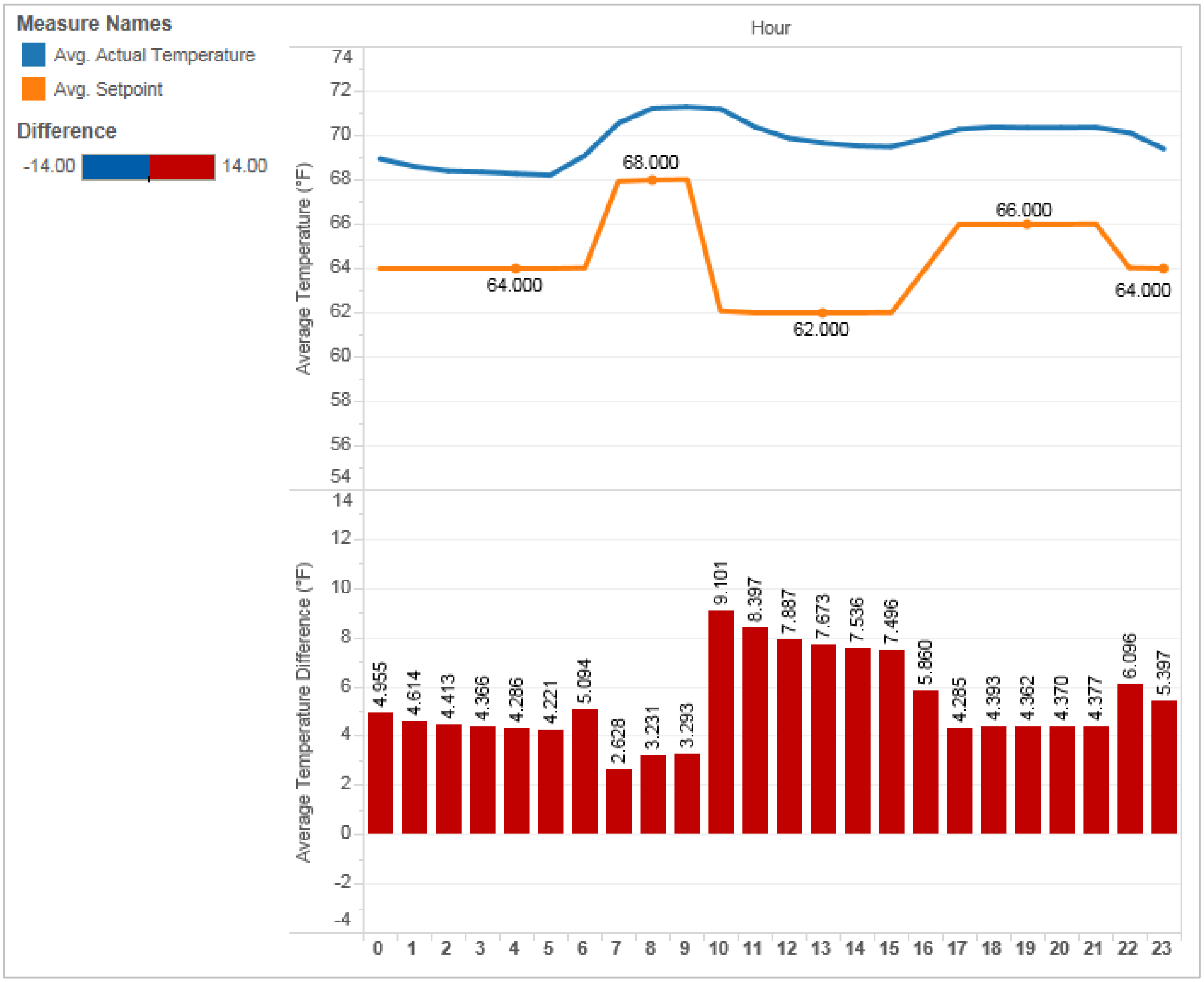
Figure 17. Average Hourly Temperature – Carrier ComfortChoice Touch – All Days



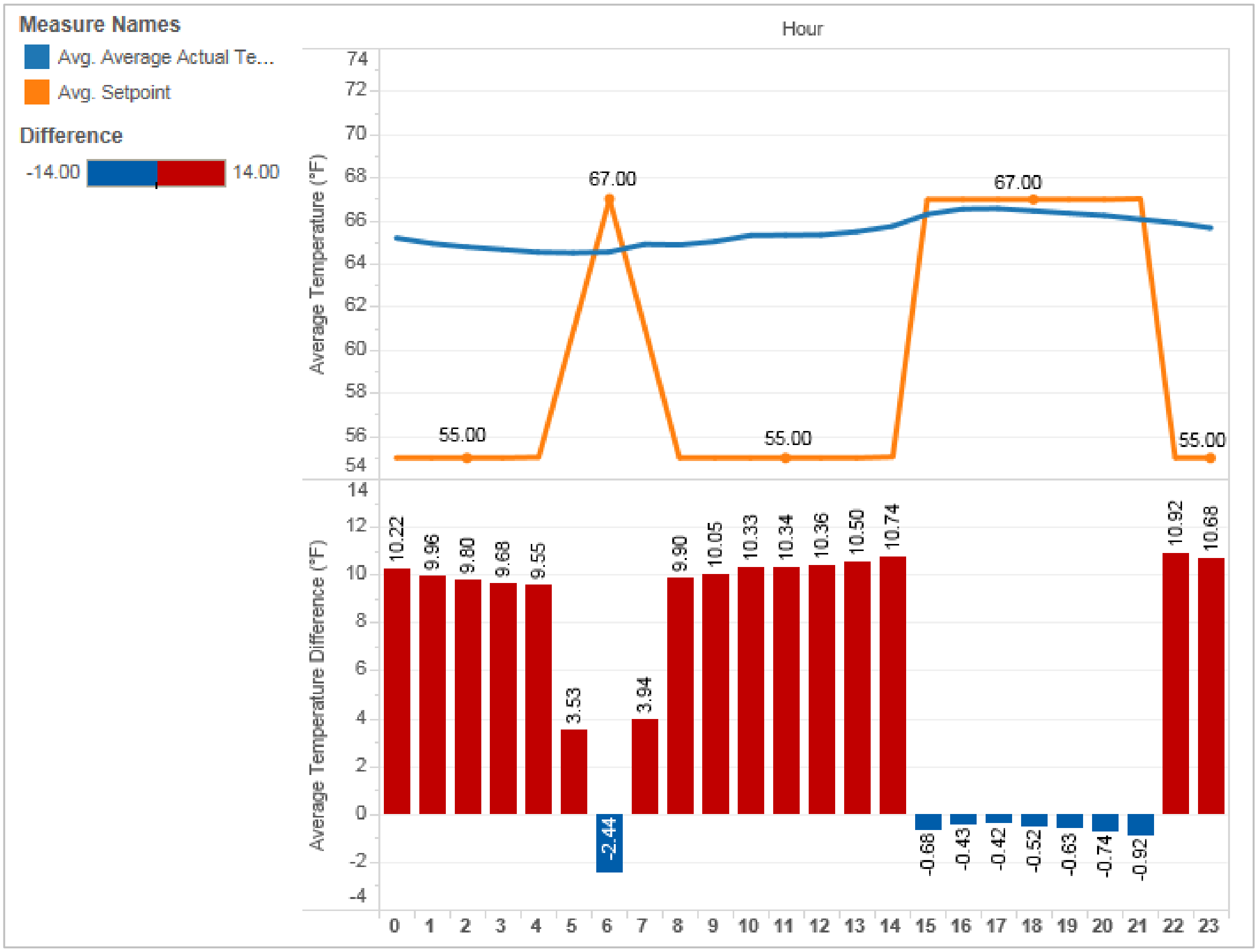
The participant programmed the Carrier ComfortChoice Touch setpoint to 68°F when home/awake in the mornings, 66°F when home/awake in the evening, 62°F when away during the day, and 64°F when asleep at night. When home/awake, the average space temperature was consistently 2–5 degrees above the setpoint. When away during the day, because it took time for the space temperature to drop, the average space temperature remained 5–9 degrees above the setpoint. Similarly, when the thermostat went into the sleep setback period, the average space temperature remained 4–6 degrees above the setback temperature.

Building 36 CT100

The Building 36 CT100 thermostat uses an algorithm to adjust HVAC run time based on factors including indoor/outdoor temperatures and weather data.[15]

The participant with the Building 36 CT100 thermostat programmed one schedule of setpoints for weekdays and one for weekends. Figure 18 and Figure 19 show the space temperature analysis for these two schedules.

Figure 18. Average Hourly Temperature – Building 36 CT100 – Weekdays



On weekdays, the participant scheduled a setpoint of 67°F when home/awake in the mornings and evenings, and 55°F when away or home/asleep. When home/awake in the evenings, the average space temperature was consistently less than one degree cooler than the setpoint. During the short morning home/awake period, the average space temperature was more than two degrees cooler than the setpoint. The difference between space temperature and setpoint is greater during this home/awake period because it is a shorter period, so the HVAC system has less time to reach and maintain a setpoint.

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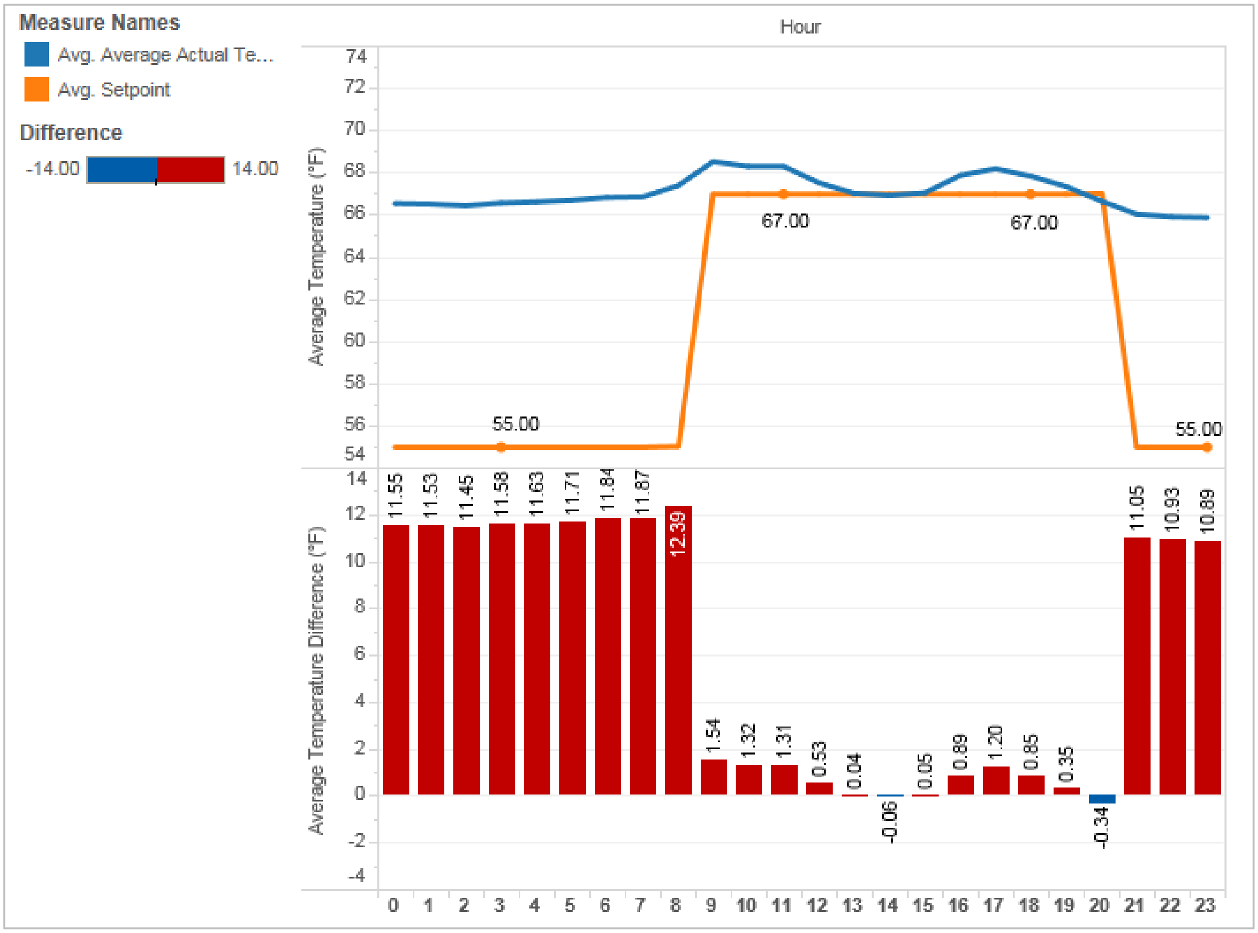
15 Building 36 representative (4/29/14)

When away and home/asleep, the average space temperature increased up to 11 degrees warmer than the setpoint. This is in part due to the fact the there is a 12 degree setback and it takes time for the home to cool down. Between the morning and evening home/awake periods when the user is away, the average space temperature does not drop enough to meet the 55°F setpoint.

Figure 19. Average Hourly Temperature – Building 36 CT100 – Weekends



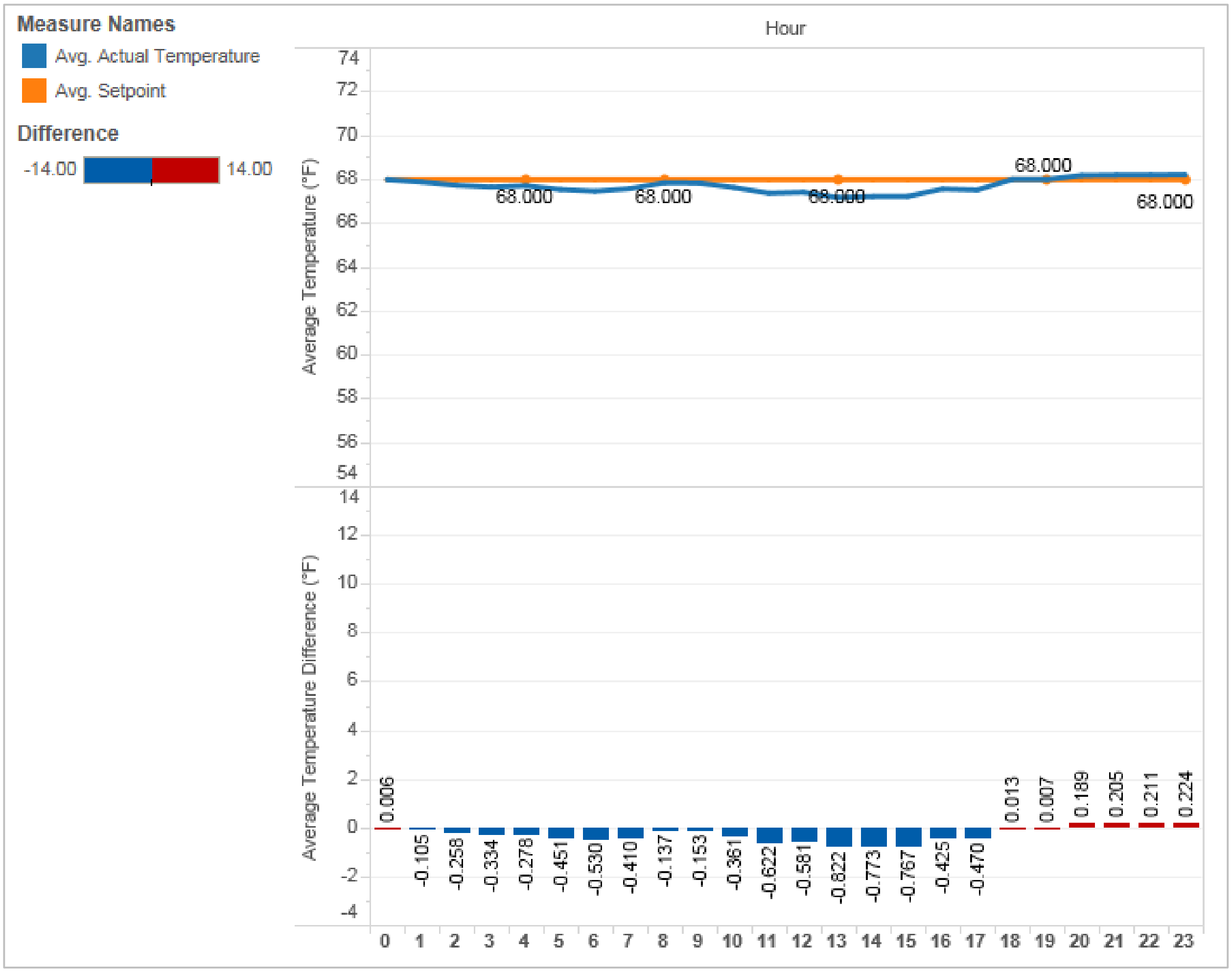
On weekends, the participant scheduled the same setpoints but changed the home/awake period to 9:00—21:00 and the home/asleep period to 21:00—9:00. During the home/awake period, the average space temperature remained no more than two degrees of the setpoint. During the home/asleep period, the average space temperature remained approximately 12 degrees warmer than the setback temperature of 55°F.

Honeywell Lyric

The Honeywell Lyric thermostat uses an algorithm to adjust settings based on factors including indoor/outdoor temperatures and weather data. The Lyric also has geofencing capabilities where the user can define unique boundaries which trigger automatic changes in thermostat settings when smart phone enters in or out of the defined range.

The participant with the Lyric thermostat set a single setpoint of 68 degrees. Figure 20 shows the space temperature analysis based on the user settings.

Figure 20. Average Hourly Temperature – Lyric – All Days



The participant scheduled a setpoint of 68 °F. The average space temperature was consistently within one degrees of the setpoint for all hours of the day.

Building 36 Intelligent Thermostat

The Building 36 Intelligent Thermostat uses an algorithm to adjust HVAC run time based on factors including indoor/outdoor temperatures and weather data.

The participant with the Building 36 Intelligent Thermostat programmed a single setpoint schedule for all seven days of the week. Figure 21 shows the space temperature analysis for this thermostat.

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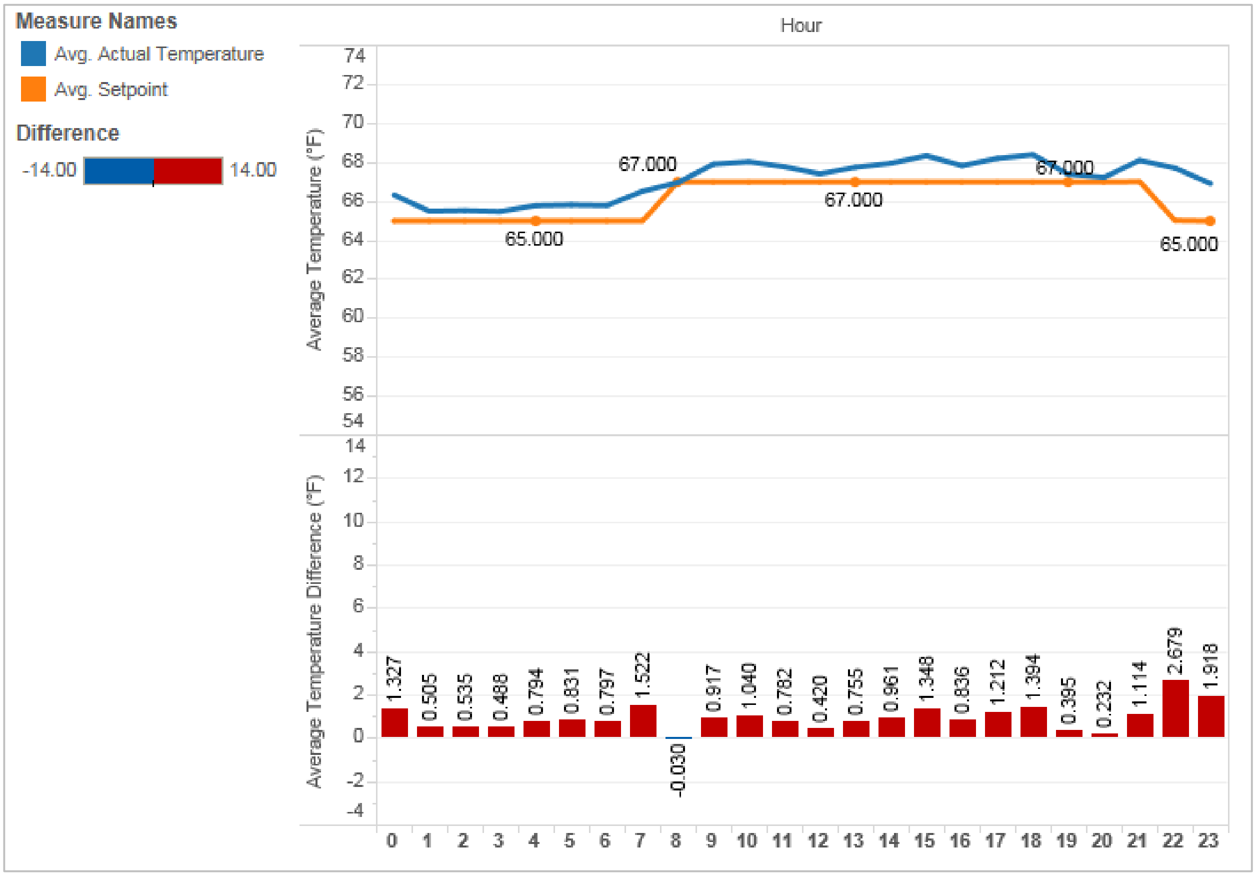
Figure 21. Average Hourly Temperature – Building 36 Intelligent Thermostat – All Days



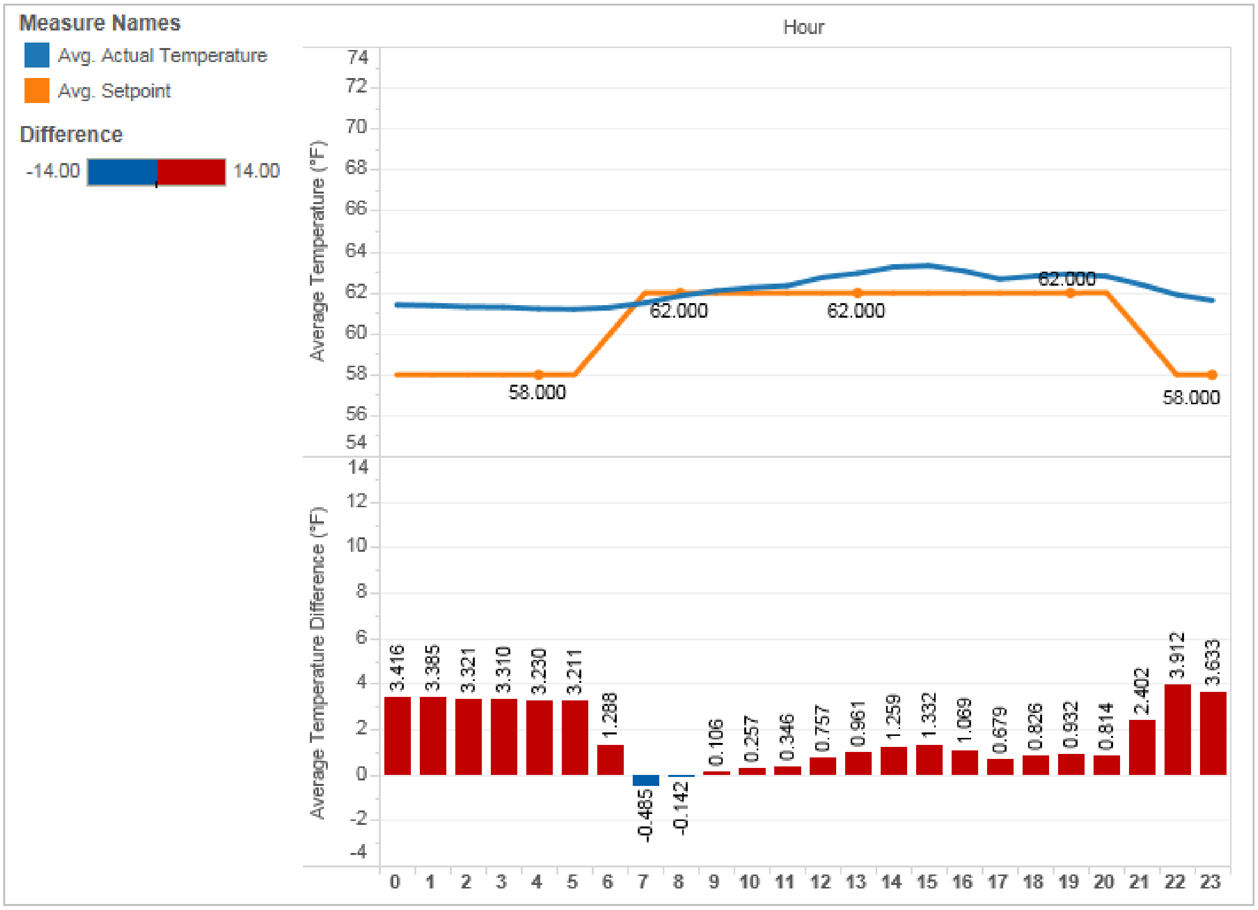
The participant programmed the Building 36 Intelligent Thermostat with a setpoint of 67 °F when home/awake during the day and 65 °F when asleep at night. During all hours of the day, the average space temperature was consistently within 2 degrees above the setpoint, except for 8:00 AM when the setpoint changed from 65 to 67 degrees.

Ecobee3

The Ecobee3 uses a remote occupancy and temperature sensor to adjust the heating and cooling based on the conditions in whatever space the user chooses to install it. It also uses an algorithm to adjust HVAC run time based on factors including indoor/outdoor temperatures and weather data and has geofencing capabilities.

The participant with the Ecobee3 programmed a single setpoint schedule for all seven days of the week. Figure 21 shows the space temperature analysis for this thermostat.

Figure 22. Average Hourly Temperature – Ecobee3 Thermostat – All Days



The participant programmed the Ecobee3 with a setpoint of 62 °F when home/awake during the day and 58 °F when asleep at night. During the daytime period, the average space temperature was consistently within 2 degrees above the setpoint. However, when the participant used a setback of four degrees at night, the average space temperature was up to four degrees warmer than the setpoint. This might be attributable to the quality of the home's insulation. If the home is well-insulated, it might not lose enough heat over the setback period to drop from 62 °F to 58 °F.

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Conclusions and Recommendations

Cadmus gathered data to assess the ease of installation, user experience and satisfaction, and ability to maintain the setpoint temperature of nine thermostats selected by the Companies for this study. Despite the small sample size for this study, these data provide valuable information for the Companies. In addition, through our involvement with the study participants, we identified and examined potential issues for these thermostats as part of a large-scale utility program. The following sections describe the thermostats that performed the best and worst in the study.

Easiest to Install

The Nest and Lyric models received the best ratings overall for ease of installation. These thermostats took less than 45 minutes install, received the maximum three-star rating from the installer for ease of installation, and do not require a 24 Volt (AC) common wire (C-wire).[16]

Although the Ecobee Smart Si and EcoFactor took only 40 minutes to install and received three-star ratings for ease of installation, these thermostats require a C-wire. This requirement limits the compatibility of these thermostats for many homes in New England, where Cadmus estimates less than one quarter of customer homes have a C-wire. In a large-scale program, customers without a C-wire may need to install new wiring to install thermostats that depend on a C-wire. For homes that do not have an existing C-wire or for which adding a C-wire is expensive, HVAC power extenders exist. The Ecobee3 is the only thermostat in the test group that comes with a power extender. Although the power extender makes the Ecobee3 compatible in most Massachusetts and Rhode Island homes, the installer gave it a one-star rating for ease of installation because the installation instructions for the power extender were not clear. For more information on wire extenders for other thermostat models, see Appendix A.

The Nest, Lyric, and Building 36 Intelligent thermostats are the most compatible with MA and RI homes because they do not require power from a C-wire. Instead, these thermostats use a standard two-wire setup, which is the minimum wiring requirement for any home thermostat. The Nest and Lyric draw power from the W-wire or Y-wire if no C-wire is available. In addition, the Lyric uses a AAA Lithium battery for initial start-up and to supplement the power stealing. Both Building 36 thermostats (CT100 and Intelligent) use four AA batteries. Although the Ecobee3's included power extender kit makes it compatible with many homes in Massachusetts and Rhode Island, it requires a minimum of three wires between the thermostat and HVAC unit.

The Building 36 models and EcoFactor require the installation of a Gateway for internet/cellular connectivity. Building 36 recommends a professional install their thermostats and Gateway.

[16] Cadmus estimates that less than one quarter of homes in MA and RI have a C-wire. For more details on the C-wire, see the Installation Assessment section and Appendix A.

Most User-Friendly

All thermostats except the Nest and EcoFactor received an overall rating of "easy" to use by the participant. Participants gave the Nest and EcoFactor overall ratings of "somewhat difficult" and "difficult" to use, respectively. The Nest was rated as "somewhat difficult" to use because the participant found it difficult to navigate the menu to program the setpoints. The installer noted that there was no copy/paste function—setpoints for each day had to be copied manually. Participants with the Ecobee Smart and Building 36 CT100 also commented that programming their thermostat was "somewhat difficult" or "difficult" to do, but still gave overall ratings of "easy."

The EcoFactor was rated as "difficult" to use because the participant found it challenging to change the schedule and manage comfort level.

Eight of the nine participants who used the mobile application rated the application as "easy" to use and three of the six participants who used the web account found it "easy" to use.[17] The participant with the Ecobee Smart Si's rated the web account as "somewhat difficult" to use, reporting there were minor display quirks and some confusing wording that made it challenging to use. The participant with the Carrier ComfortChoice Touch thermostat rated the web account as "difficult" to use, citing that he or she had some difficulty setting up the account, possibly due to having a duplicate account.

Most Accurate Space Temperatures

Among the original seven thermostat models, our comparison of setpoints and measured space temperature show that the home with the Nest thermostat most closely matched the space temperature for the home/awake setpoint (which maintained temperature within two degrees of the scheduled setpoint when the participant was home/awake).[18] In the additional testing round, this result was surpassed by the home with the Lyric thermostat, which consistently maintained temperature within one degree of the scheduled setpoint when the participant was home/awake.

In five homes, the average difference between space temperature and setpoint exceeded three degrees. The Ecobee Smart Si, Ecobee Smart, and EcoFactor thermostats tended to keep the home temperature within four degrees below the setpoint. The Carrier ComfortChoice Touch kept the home temperature between two and five degrees above of the setpoint, while the Ecobee3 kept the home temperature within four degrees above the setpoint.

All ten of the thermostats use algorithms to regulate the temperature of the home. These proprietary algorithms vary among thermostat models. The algorithms may take into account current outdoor temperature, weather forecast, equipment type, temperature difference between current indoor temperature and setpoint, and equipment protection (to limit the number of times the compressor cycles on and off). Algorithms use these data to adjust the HVAC system "cut-in" time—the time at

[17] The participant with the Ecobee Smart Si thermostat did not use the mobile application enough to rate it.

[18] The home/awake setpoint is the temperature setting when the user is home and awake (as opposed to home and asleep, or away).

which the HVAC system begins to pre-heat or pre-cool the home. Because these algorithms use feedback to adjust HVAC system run time, thermostat performance may vary over time and under different weather conditions. In addition to using an algorithm, the Nest and Ecobee3 use an occupancy sensor to determine when users are away or sleeping and adjusts setbacks for these periods. The Nest's occupancy sensor is located at the thermostat, whereas the Ecobee3's occupancy sensor can be installed in any room. Ecobee3's occupancy sensor also measures indoor temperature. The thermostat uses the indoor temperature information to adjust the heating and cooling. Users can install remote sensors in multiple rooms.

Best for Data Collection

The Ecobee Smart Si, Ecobee Smart, and Ecobee3 thermostats have the most data available. These thermostats enable the user to view and download a 15-month history of HVAC system run time and indoor temperature data from a web account. The web account also shows hourly, daily, monthly, and weather-adjusted run time (hours/degree day).The user can also view monthly reports that show total system run time, average setpoint, energy saved, and comparisons to the state average.

The EcoFactor and Carrier ComfortChoice Touch thermostats also show a full history of system run time and indoor temperature. With the Carrier ComfortChoice Touch, users can also download the last 30 days of data. The Nest shows users the last ten days of run time history and when the user demonstrated energy efficient behavior.

Appendix A. The C-Wire Problem

This study confirmed that a major obstacle to installing Wi-Fi thermostats in many existing New England households is the absence of a 24 Volt (AC) common wire, or "C-wire." Five of the nine thermostats in this study require a C-wire,[19] but Cadmus estimates that less than one quarter of homes in Massachusetts and Rhode Island have a C-wire.. The most common heating systems operate with a simple two-wire thermostat. When there is a call for heat, the thermostat will connect the two wires together until the demand is satisfied.

What is the C-wire?

A C-wire is a 24 Volt (AC) common wire that brings power to a thermostat by connecting it to a 24 Volt power source at the transformer of an HVAC system. Most Wi-Fi connected thermostats require a C-wire to power the Wi-Fi connectivity. Five of the seven thermostats in this evaluation require a C-wire. The Nest does not because it can use the W-wire (heating) or Y-wire (cooling) to power itself by a method called "power stealing." In this setup, the thermostat uses the circuits that turn on and off the HVAC system to charge an internal battery. The thermostat can charge its battery regardless of the HVAC system status (on or off), but the available power is limited when the HVAC system is running. If there is an extended home power outage and the battery level gets low, the Nest will turn off the Wi-Fi to conserve power.[20,21]

Figure 23 shows a standard two-wire thermostat that does not require a C-wire. It requires only the standard R-wire (power) and W-wire (heating). When there is a call for heat, the R-wire and W-wire connect and the heating system turns on.

[19] The four thermostat models that do not require a C-wire are Nest, Lyric, Building36-CT, Building36-IT

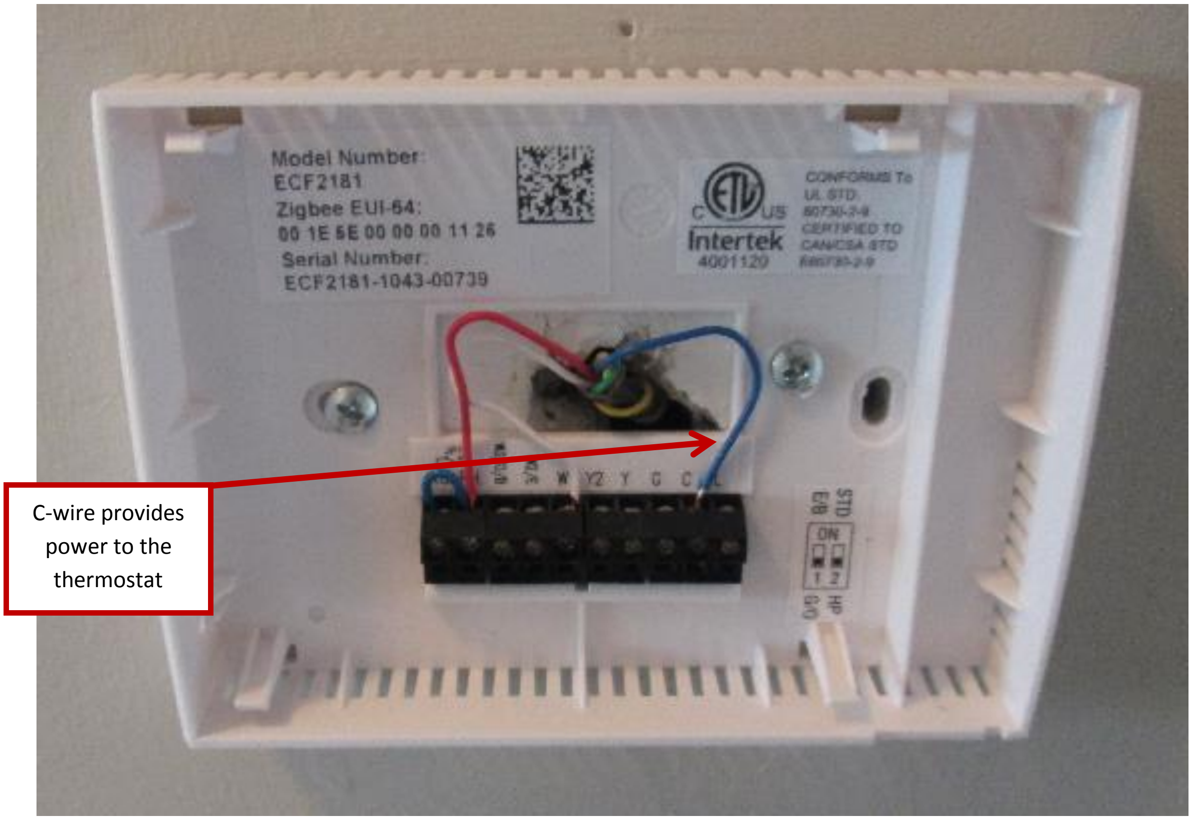
[20] http://support.nest.com/article/A-low-battery-level-will-cause-Nest-to-disconnect-from-the-Internet (Accessed 5/14/14)

[21] http://www.ecobee.com/blog/the-problem-with-power-stealing/ (Accessed 5/14/14)

Figure 23. Standard Thermostat without C-wire

Figure 24 shows the EcoFactor thermostat, which requires a C-wire in addition to the R-wire and W-wire.

Figure 24. EcoFactor Thermostat with C-wire



How much of a problem is this?

Cadmus estimates that less than a quarter of households in Massachusetts and Rhode Island have a C-wire and that average installation costs could be $200-$300. In a 2013 Cadmus study of Wi-Fi thermostats in New Hampshire for Liberty Utilities (LU), seven of 29 participants (24%) had a C-wire in their homes.[22] During recruitment for the LU study, 45 customers responded to a survey about their HVAC system type and thermostat wiring. Of the 45 respondents, eight (18%) had a C-wire. Of the respondents with both heating and air conditioning, 25% had a C-wire. Of the respondents with heating only, 14% had a C-wire. For those participants who had a contractor install their thermostat wiring and thermostat, the average cost was $229.55 (n=11). The minimum cost was $80 and the maximum cost was $320. Costs varied depending on the distance the wire had to be run from the heating system to the thermostat.

Can we just add a C-wire to homes?

The cost and complexity of adding a C-wire to an existing home varies. For some homes, the installation is straightforward due to the proximity of the thermostat to the HVAC unit and an HVAC technician may be able to complete the installation. However, for the majority of homes, the C-wire should be added by

[22]The Cadmus Group, Inc. Wi-Fi Programmable Thermostat Pilot Program Evaluation. 2013.

a licensed electrician. The C-wire installation requires replacing the existing cable between the thermostat and HVAC unit. If the thermostat is not directly above or below an unfinished space, an electrician may need to drill many holes in finished surfaces to conceal the cable.

In this study, we only performed C-wire installations that an HVAC technician could perform. If a C-wire installation involves wiring through a finished space, Cadmus recommends an electrician perform the installation. For one 2-family site visit, the existing thermostat cable ran through a finished ceiling in the locked space of the other occupant. Coordination with the property owner, as well as many holes in the finished ceiling would have been necessary for this installation, which was aborted. Another installation that was aborted was a large single-family home where the thermostat was located between two finished levels. This installation would have required holes in a wall and ceiling of finished space.

Are there other options?

For homes that do not have an existing C-wire or for which adding a C-wire is expensive, HVAC wire extenders exist.

For homes with four wires at the existing thermostat—there is R (power), W (heating), G (fan), Y (cooling), but no C-wire (24 Volt AC)—Ecobee offers a Power Extender Kit for Ecobee Smart Si thermostat users. The kit is not compatible with the Ecobee Smart thermostat.

In addition, the Fast-Stat Common Maker (Figure 25) is a universally compatible device that provides a C-wire connection for thermostats using two or more wires. The Fast-Stat Common Maker uses a "sender" installed in the wall space behind the thermostat and a "receiver" installed at the HVAC unit to create a 24 Volt AC connection. The sender and receiver can be up to 2,500 feet apart.

Figure 25. Fast-Stat Common Maker – Sender

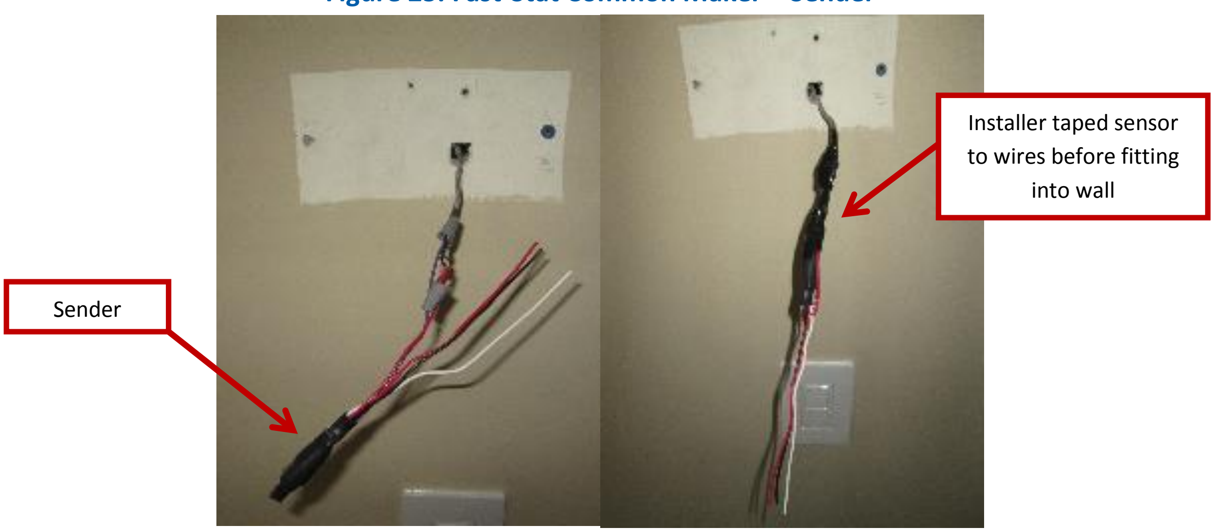


Figure 26. Fast-Stat Common Maker – Receiver

A Cadmus electrician installed the Fast-Stat Common Maker in a customer home with an Ecobee Smart Si thermostat. The Fast-Stat installation took 20 minutes—five minutes to install the sender and 15 minutes to install the receiver. The electrician found the installation to be straightforward, but it does require professional installation by an electrician or HVAC technician.

Cadmus contacted the Massachusetts Electrical Code Interpretation Committee to determine if the Fast-Stat is permitted for use in residential homes. We received written confirmation from the Chairman of the Electrical Code Interpretation Committee that products like Fast-Stat are permitted for use in residential homes as long as "the splice is accessible." If the splice is behind the thermostat in the wall (installer does not need to impact the wall plaster to get to it), then it is considered accessible. The written confirmation from the Massachusetts Electrical Code Interpretation Committee is attached in Appendix C.

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How do the Wi-Fi thermostat powering options compare?

In this assessment, we encountered four methods of connecting power to the thermostat. Listed below are some of the advantages and disadvantage of each method.

Table 23. Comparison of Thermostat Power Methods

Wi-Fi Power Method	Description	Advantages	Disadvantages
Batteries + Gateway	Batteries power thermostat. Thermostat communicates over Z-Wave Network with Gateway. Gateway is connected to internet via Ethernet and powered by wall outlet. *(EF, B36-CT, B36-IT)*	• Only 2-wire system required • No professional installation required	• Batteries need to be replaced • Gateway requires access to wall outlet and Ethernet • Monthly service fee to use Gateway (estimated cost: $1.50-$8.99 per month)
C-wire	C-wire powers thermostat with 24 Volt (AC) power. This provides enough power for the thermostat to communicate over home Wi-Fi. *(HW, CCCT, ESS, ES)*	• Provides lifetime power	• Depending on home, new wiring may need to be installed • Estimated cost to install: $200-300
Power Stealing / Phantom Power	Thermostat uses the circuits that turn on and off the HVAC system to charge an internal battery. This provides enough power for the thermostat to communicate over home Wi-Fi. *(Nest, Lyric)*	• Only 2-wire system required • No professional installation required • Provides lifetime power	• Available power limited when HVAC system is running. If extended home power outage and the battery level gets low, the Nest will turn off the Wi-Fi to conserve power. Lyric requires AAA battery to supplement and for start-up.
Fast-Stat Common Maker	"Sender" installed in wall behind thermostat. "Receiver" installed at HVAC unit.	• Only 2-wire system required • Provides lifetime power	• Professional installation required • Additional expense ($29.95)*

*Fast-stat.net. Accessed 2/18/15.

Appendix B. Participant Survey

This document describes the participant survey for this Thermostat Assessment. Cadmus distributed this survey to all study participants using web-survey software Qualtrics®.

Research Questions for Participant Survey

Table 24 describes the research questions for this survey and indicates the related survey questions.

Table 24. Research Questions

Researchable Question	Survey Question
What thermostat setpoints and schedules did you use?	Installer score card
How frequently did you change or override the setpoint in home? How frequently did you change or override the setpoint remotely?	Q15 Remote control log
What did the participant like about the thermostat? What did you dislike about the thermostat?	Q26 Q27
Did customer use web site? How did they access it? Was it easy to use?	Remote control log, Q32 Q34 Q44-49
Did customer use mobile app? Was it easy to use?	Remote control log, Q32 Q44-49
What features were most appreciated?	Q36
What features are most likely to be used? What features are most likely to reduce or increase energy consumption?	Q32-36, Q44-49 Q56-60
Would the participant purchase the same thermostat model? If so, what price would they pay?	Q23-25 Q22
Does customer believe they will save energy without compromising quality with the device?	Q59, 60 (savings) Q36-37, Q38-Q43 (quality compared to old t-stat)
Has the customer had any problems with the thermostat since it was installed? What problem? How did you resolve it?	Q28-31

Outline of Participant Survey

This section outlines the progression of survey questions.

Survey Start

Thank you for participating in the Smart Thermostat study. Please complete this 15-minute survey about your experience and satisfaction with your new thermostat. Your responses provide valuable information for future energy-efficiency programs.

-----------------------------------NEW PAGE-----------------------------------

Baseline Thermostat

The questions in this section are designed to provide us with a baseline for how you used your *OLD* thermostat.

1) How did you use your old thermostat?
   - ☐ I programmed my thermostat.
   - ☐ I manually controlled my thermostat.
   - ☐ I used a single setpoint.
   - ☐ I never touched it.
   - ☐ Other
   - ☐ I don't know
2) [IF 1=OTHER] Please describe how you used your old thermostat.
3) How did you determine your temperature settings with your old thermostat? CHECK ALL THAT APPLY.
   - ☐ Based on comfort
   - ☐ Based on being energy efficient
   - ☐ Based on saving money
   - ☐ Based on habit
   - ☐ Other
   - ☐ N/A: I rarely changed the temperature on my thermostat.
4) [IF 3=OTHER] You indicated you determined your thermostat settings for a different reason. Please describe.
5) How comfortable was your home during winter with your old thermostat?
   - ☐ My home was usually comfortable.
   - ☐ My home was usually comfortable, with the exception of some rooms.
   - ☐ My home was usually comfortable, except on especially cold days.
   - ☐ My home was frequently uncomfortable.
6) How satisfied were you with your old thermostat?
   - ☐ Very satisfied: I would recommend my old thermostat.
   - ☐ Satisfied: It met my needs.
   - ☐ Somewhat satisfied: It met my needs, but I would change some things.
   - ☐ Unsatisfied: I wanted to replace my old thermostat.

7) Before participating in this study, how likely is it that you would have bought a smart thermostat on your own?
   - ☐ I was already planning to purchase a smart thermostat
   - ☐ Likely
   - ☐ Maybe
   - ☐ Not likely
   - ☐ I had never heard of a smart thermostat before.
8) Before participating in this study, what is the most you would have been willing to pay for a smart thermostat?
   - ☐ $0
   - ☐ $50
   - ☐ $100
   - ☐ $150
   - ☐ $200
   - ☐ $250
   - ☐ More than $250

---**NEW PAGE**---

New Thermostat

The questions in this section are designed to help understand how you used your *NEW* thermostat.

9) Our records indicate you received a [THERMOSTAT NAME] thermostat for this study. Please verify if this true.
   - ☐ Yes, this is the thermostat I received.
   - ☐ No, I received a different thermostat.
10) [IF 9=NO] What thermostat did you receive?
11) How have you used your new thermostat?
   - ☐ I programmed my thermostat.
   - ☐ I manually adjusted the thermostat temperature setting.
   - ☐ I used a single setpoint.
   - ☐ I have not touched it since it was installed.
   - ☐ Other
   - ☐ I don't know
12) [IF 11=OTHER] Please describe how you have used your new thermostat.
13) Do you control your new thermostat similarly to your old thermostat?
   - ☐ Yes
   - ☐ No
   - ☐ I don't know
14) [IF 13=NO] How is the way you control your new thermostat different?
15) How frequently you override your thermostat settings FROM HOME?
   - ☐ Several times per day

- ☐ Once per day
- ☐ Several times per week
- ☐ Rarely
- ☐ Never
- ☐ I don't know

16) Which of the following influence how you control your new thermostat? CHECK ALL THAT APPLY.
    - ☐ Based on comfort
    - ☐ Based on being energy efficient
    - ☐ Based on saving money
    - ☐ Based on habit
    - ☐ Other
    - ☐ N/A: I rarely change the temperature on my thermostat
17) [IF 16=OTHER] You indicated you determined your thermostat settings for a different reason. Please describe.
18) Has the comfort of your home changed since you installed your new thermostat?
    - ☐ Yes
    - ☐ No
    - ☐ I don't know
19) [IF 18=Yes] Please describe the change.
20) How satisfied are you with your new thermostat?
    - ☐ Very satisfied: I would recommend this thermostat
    - ☐ Satisfied: It meets my needs
    - ☐ Somewhat satisfied: It meets my needs, but I would change some things
    - ☐ Unsatisfied: I want to return the thermostat
21) Would you recommend your new thermostat to others?
    - ☐ I would definitely recommend this thermostat
    - ☐ Likely
    - ☐ Maybe
    - ☐ Not likely
    - ☐ I would definitely NOT recommend this thermostat
22) Now that you used your new thermostat, what is the most you would be willing to pay for it?
    - ☐ $0
    - ☐ $50
    - ☐ $100
    - ☐ $150
    - ☐ $200
    - ☐ $250
    - ☐ More than $250
23) The market cost of the [TSTAT MODEL] is [PRICE].If you were not allowed to keep your new thermostat, what would you do?
    - ☐ I would reinstall my old thermostat.

☐ I would purchase and install the same model of my new thermostat.
☐ I would purchase and install a different type of thermostat.
☐ Other.

Thermostat	List Price
Carrier	$249
HW RTH5980WF	$249
Ecobee Smart	$454
Nest	$249
Building 36	$249
Ecobee Smart Si	$270
EcoFactor	$150

24) [IF 23=OTHER] Please describe.
25) [IF 23=purchase different thermostat] What thermostat would you purchase?
26) What do you like best about the thermostat? Please describe.
27) Is there anything you dislike about the thermostat? Please describe.
28) Have you have any problems with your new thermostat?
   ☐ Yes
   ☐ No
29) [IF 28 = YES] What was the problem?
30) [IF 28=YES] Were you able to resolve it?
   ☐ Yes
   ☐ No
31) [IF 30 = YES] How did you resolve it?

Thermostat Features

32) Please indicate the features you have used with your thermostat, mobile app and web account. Check all that apply.

Feature	Thermostat	Mobile App	Online Web Account	N/A
Checked indoor temperature				
Checked outdoor temperature				
Adjusted setpoint				
Programmed schedule				
Changed schedule				
Checked system run time or temp history				
Other				

33) [IF Q32 = MOBILE APP and ONLINE WEB ACCOUNT = 0] If you did not use your web account or mobile app, please describe why.
34) [IF Q32 = MOBILE APP and ONLINE WEB ACCOUNT ≠ 0] How did you access the web account?
    - ☐ Computer
    - ☐ iPad
35) [IF Q32 = OTHER ≠ N/A] Please describe what other feature you used.

36) What features will you most likely continue to use and why?
37) Are there any features you dislike? Please describe.

Thermostat Comparison

The following questions will ask you to compare your NEW thermostat to your OLD thermostat.

38) Are there any features of your old thermostat that you wish your new thermostat had?
    - ☐ Yes
    - ☐ No
    - ☐ I don't know
39) [IF 38=YES] Please describe which features and why.
40) [IF Q32 = CHECKED SYSTEM RUN TIME OR TEMP HISTORY ≠ N/A] Has checking your system run time or temp history affected how you use your thermostat?
    - ☐ Yes
    - ☐ No
    - ☐ I don't know
41) [IF 40=YES] Please describe how.
42) Compared to your old thermostat, has your new thermostat been easier or more difficult to use?
    - ☐ New thermostat is easier to use
    - ☐ New thermostat is more difficult to use
    - ☐ They are the same
    - ☐ I don't know
43) [IF 42 = easier or more difficult]Please describe how.

Usability

The following questions explore your experience using your NEW thermostat.

44) Please rate the level of difficulty for each of the following installation/setup actions:

	Easy: It was mostly straightforward	Somewhat Difficult: It took some time to figure out	Difficult: I needed assistance	I don't know	N/A
Program schedule					

	Easy: It was mostly straightforward	Somewhat Difficult: It took some time to figure out	Difficult: I needed assistance	I don't know	N/A
Set up mobile application					
Set up web account					

45) Please use this space to include any comments or suggestions regarding your experience with the actions listed above.
46) Please rate the level of difficulty for each of the following actions:

	Easy: It was mostly straightforward	Somewhat Difficult: It took some time to figure out	Difficult: I needed assistance	I don't know	N/A
Navigate the thermostat menu					
View current thermostat settings					
View current indoor temperature					
View current temperature setting					
View system run time or temp history					
Change temperature setting					
Change schedule					
Manage comfort level					

47) Please use this space to include any comments or suggestions regarding your experience with the actions listed above.
48) Please rate the overall level of difficulty of using the following products/services:

	Easy: It was mostly straightforward	Somewhat Difficult: It took some time to figure out	Difficult: I needed assistance	I don't know	N/A
Thermostat					
Mobile application					
Web account					

49) Please use this space to include any comments or suggestions regarding your experience and satisfaction with the products/services listed above.

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Customer Support

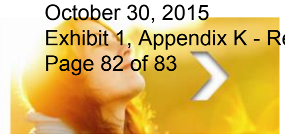
50) Have you contacted your thermostat manufacturer for customer support since the thermostat was installed?
    - ☐ Yes
    - ☐ No
    - ☐ I don't know
51) [IF 50=YES] Was it difficult to get connected to customer support?
    - ☐ Yes
    - ☐ No
52) [If 51=YES] Did you receive support from the manufacturer?
    - ☐ Yes
    - ☐ No
53) [If 52 = YES] What did you receive support for?
54) [If 52 = YES] Please rate the helpfulness of the support you received?
    - ☐ Very helpful
    - ☐ Somewhat helpful
    - ☐ Not too helpful
    - ☐ Not at all helpful
55) [If 54 = not too or not at all helpful] Please explain this rating.

Impact on Energy Usage

56) Which features of your new thermostat are most likely to help reduce your energy consumption?
57) Were there any features that might cause an increase in your energy consumption?
    - ☐ Yes
    - ☐ No
    - ☐ I don't know
58) [IF 57 = YES] List which features and describe why.
59) Do you think you will save energy with your new thermostat?
    - ☐ Yes
    - ☐ No
    - ☐ I don't know
60) [IF 59 = YES] Please describe why.

61) Please provide any additional comments you have about your new thermostat:

____
____
____
____



End of Survey

Thank you for completing this survey. Your feedback is important for this study as well as future programs and we appreciate your time.

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Appendix C. Electrical Code Interpretation

L. **PA-Specific Programming**

Introduction

In addition to the statewide plan, which is the core of the Compact's approved 2013-2015 Three-Year Plan, the Compact provides specific program enhancements in several plan areas. These program enhancements result from the Governing Board's policy direction to continue existing programs that are both successful and responsive to the Compact's unique customer population. The Compact has tailored the statewide program offerings, where necessary to better meet its customers' unique profiles and needs. The Compact's Governing Board has determined that these enhancements are necessary to continue to best serve the needs and meet the demands of the Compact's unique customer base.

In the following sections, the Compact explains by program the enhancements it proposes for the 2016-2018 Three-Year Plan term. In addition, the Compact provides a description of its enhancements to its 2016-2018 Energy Education offering, associated with the Residential Education offering. See the Statewide Plan for the full program descriptions associated with each program (See Section III of the Statewide Plan, annexed as Exhibit Compact-1 to the Compact's Petition).

Residential and Low-Income Program Descriptions

Residential Whole House

Program Goals	The Compact expects lifetime energy savings of 284,181 MWh.
Program Budget	$50,849,827
Compact Enhancements	<u>Home Energy Services Initiative</u> The Compact has identified cost-effective enhancements during the 2013-2015 term that assist customers with identified barriers such as split incentives and difficulty with co-payments. To address these issues, the Compact has offered 100% incentives, up to the program cap of $4,000, for qualified weatherization incentives (in a fuel blind manner) for year-round renters that are responsible for payment of the electric bill, those customers whose income is within 61-80% of state median income, and those that are operated by municipalities or other government entities. The Compact raised the cap for weatherization to $4,000 for all customers after it identified that average recommendations often surpassed the previous cap of $2,000. The change has allowed customers to make improvements within one year rather than over several years.

	Multi-Family Retrofit Initiative In addition to serving customers whose facilities are heated with electricity, the Compact is proposing to also serve customers with oil- and/or propane-heated facilities in order to provide enhanced benefits for increased participation at Multi-Family sites based upon the pending RCS updates by the Massachusetts Department of Energy Resources. Residential Behavior Feedback The Compact is offering its customers a unique initiative which is designed to promote energy savings through the use of automation tools that will give homeowners the ability to remotely control their homes' energy usage as well as potentially offer demand response incentives.

Residential Products

Program Goals	The Compact expects lifetime energy savings of 332,165 MWh.
Program Budget	$12,691,029
Compact Enhancements	Residential Lighting To continue educating customers in how to make smart, efficient lighting choices, the Compact will work with towns on the Cape and Vineyard in 2016 to offer a free LED bulb to town residents who attend the annual Town Meeting. In addition to the give-away, the Compact will provide residents with educational materials on how to make the best lighting purchase for their needs.

Commercial & Industrial ("C&I") Program Descriptions

C&I New Construction and Major Renovation

Program Goals	The Compact expects lifetime energy savings of 135,687 MWh.
Program Budget	$4,006,049
Compact Enhancements	The Compact continues to offer its municipal customers specialized incentives that cover 100% of incremental custom measure costs as part of this program. In 2016, the Compact proposes to enhance its new construction and major renovation program to include cost-effective thermal measures designed to save oil, propane and other unregulated fuels.

C&I Retrofit Program for Existing Buildings

Program Goals	The Compact expects lifetime energy savings of 793,980 MWh.
Program Budget	$40,053,121
Compact Enhancements	The Compact continues to offer its municipal customers specialized incentives that cover 100% of custom and direct install cost-effective measure costs as part of this program. The Compact also plans to continue two special incentive options first adopted in 2013 to assist small business customers further in overcoming barriers to participation: a 95% incentive option for qualifying small business tenants; and for other small businesses, the zero interest financing option. For 2016, the Compact is rolling out several additional enhancements to its C&I Retrofit Program, each designed to further reduce barriers to participation for key customer segments. First, the Compact proposes to enhance its commercial and industrial retrofit program to include all cost-effective thermal measures designed to save oil, propane and other unregulated fuels. Second, the Compact is launching a new effort for its small C&I customers. The new initiative will be modeled after the HES program and will include a BEA (Business Energy Audit) and a core offering of deemed savings measures, many of which can be installed in the first visit, some at 100% incentive coverage. For its small business direct install customers, the Compact continues to offer higher incentives for standard Direct Install measures (up to 100% rather than up to 70% as offered in the Statewide Plan). Third, the Compact plans to begin phasing in segment-focused delivery options. Fourth, the Compact will also offer 100% incentive for all cost-effective measures for up to 100 (first come, first serve) non-profit corporations on Cape Cod and Martha's Vineyard per year as follows: (a) Non-profit organizations must be a 501(c)(3); (b) Operating more than 5 years with an unrestricted annual operating revenue of less than $15M for non-profit serving low income customers and less than $2M for all other non-profit organizations.

Special Marketing and Education Activities

Energy Education

Program Goals	Recognizing that education is key to affecting change in our society, the Compact has made a strong commitment to education outreach and continues to be a nationally recognized leader in the design and implementation of energy education programs. The Compact strives to address the continuing need for greater consumer awareness and encourage the development of deeper and broader community knowledge and commitment of energy efficiency technology and practices. Using a model for science-based learning, the Compact's energy education program aligned with the Massachusetts State Frameworks for Science and Technology allowing teachers to introduce lessons discussing energy efficiency and conservation as well as emerging renewable energy technologies.
Program Budget	$375,000
Compact Enhancements	• Coordination between other PAs and education agencies on teacher training, In-service, workshops and graduate level courses for teachers • Co-ordination for "Kids Teaching Kids" program at the high school and middle school level • Support and coordination for school and community based Energy Clubs • In-class hands-on presentations on 1. Science of Energy and Energy Transformations 2. Energy Sources (renewable and non-renewable) 3. Electricity 4. Energy Efficiency and Conservation 5. Hydrogen Fuel Cells and Biofuels 6. Climate Change • Statewide Awards program in conjunction with other PAs, the Division of Energy Resources and the NEED Youth Awards Program • Support for school-based "Energy" summer camps • Support for school districts STEM improvements through energy education

	New Program Enhancements: • Classroom based energy efficiency education program designed to continue to the home in educational outreach to the school families. • This program will capture savings through measures taken by the students in their own homes through kits supplied to them by the Compact.

Cape Light Compact Demand Response Demonstration Offering

As described below, the Cape Light Compact ("Compact") is proposing a Demand Response Demonstration Offering ("DR Demonstration Offering") as part of its 2016-2018 Three-Year Energy Efficiency Plan.[1] Demand response ("DR"), however, is inextricably linked to grid modernization ("Grid Mod") and rate design. Currently, the Department of Public Utilities ("Department") has docketed each of the electric utilities' proposed Grid Mod plans for Department review and approval. The Compact's ability to implement a fully developed DR Demonstration Offering as part of its 2016-2018 Energy Efficiency Plan is dependent upon the outcomes of the Grid Mod dockets and the related implementation of Time Varying Rates ("TVR") in the Commonwealth.[2]

A. The Compact's Proposed Interim Demand Response Demonstration Offering

1. Offering Overview

The Compact proposes to roll out its DR Demonstration Offering to customers of Cape Cod and Martha's Vineyard in the second quarter of 2016. The goals of this DR Demonstration Offering are to reduce customer demand through curtailment events and to encourage load-shifting through technology and behavioral change.

- Building on the success of the behavioral initiatives pioneered early in the field, the Compact will begin to establish the platform for the "connected home" (and possibly "connected business") and will install The Energy Detective ("TED") devices on up to 200 residential and small commercial electric meters through the Compact's Home Energy Assessment ("HES") and Business Energy Assessment ("BEA") initiatives.
    - TED will allow electric customers to access their electric usage on a real time basis through a Cape Light Compact customized application on their mobile device or computer.
- Through a mobile application, the Compact plans to enable the "connected home," allowing customers to view real time energy use in their homes and businesses and to permit better management of their energy consumption and costs.
- The Compact intends to hold approximately 7-10 events each year over the 2016-2018 timeframe. During these events, customers will be asked to curtail electric usage for a specified number of hours during the event. Customers who successfully participate in the event will be provided an incentive payment.

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[1] The Act Relative to Green Communities (2008) as amended by An Act Relative to Competitively Priced Electricity in the Commonwealth (2012) ("GCA") expressly directs the three-year plans for electric offering administrators "shall provide for the acquisition of all available energy efficiency and demand reduction resources." G.L. c. 25, § 21(b)(1).

[2] The Compact provided comments to the Department in D.P.U. 14-04 (Investigation into Time Varying Rates) and intends to participate in D.P.U. 15-122 (NSTAR Electric Company, d.b.a. Eversource Grid Mod Plan).

- If the customer is participating in the Compact's power supply program, the customer could be eligible for additional savings through a critical peak pricing option.
- Initially, participation in the Compact's DR Demonstration Offering will be targeted towards those customers with central air conditioning and electric heat. Participants will be offered Wi-Fi thermostats free of charge. The Compact will install Wi-Fi thermostats through its direct install core initiatives. Wi-Fi thermostats are available to all other customers with potential co-pays (as applicable).
- The Compact intends to incorporate connected appliances such as dishwashers, washing machines, refrigerators, freezers and smart window ACs. Potential rebates for smart appliances have not been determined at this time.
- The "connected home" is expected to grow in value by providing enhanced DR and energy efficiency benefits as other plug load uses, such as pool pumps/heaters, heat pump water heaters, electric vehicle charging stations become available.

2. *Customer Education, Outreach and Engagement*

The Compact will build on its existing community outreach efforts to offer the "connected home" DR Demonstration Offering. The Compact will promote the DR Demonstration Offering through its website, e-newsletter, and community civic/energy committee meetings.

3. *Budget Goals*

The attached Table 1 provides an estimate of the proposed budget for the DR Demonstration Offering as proposed.

B. The Next Generation of the Compact's DR Demonstration Offering

1. *The Importance of Full Implementation of DR*

The unique demographics of the Cape and Vineyard, the effects of generation retirement on SEMA capacity costs, the level of energy efficiency program participation, and growth of distributed energy resources present the case for a highly motivated market for DR. The Compact's DR Demonstration Offering will enable the Compact to further explore this market during the 2016-2018 Three-Year term.

Of particular importance is the ability of DR offerings to reduce demand during ISO-NE's annual system peak hour. Doing so allows participants, assuming ISO-NE settlement-quality data is available, to reduce their installed capacity tags. Given that FCM results show SEMA capacity prices for new resources reaching the administratively-set maximum for 2018-2019, reduced demand could help mitigate the multiple-cent price increase Cape and Vineyard ratepayers will face as a result of increasing capacity prices. Because capacity prices will begin increasing dramatically in 2017, a faster rollout is a priority. Reducing peak usage in the SEMA zone is the most effective method to prevent Cape and Vineyard electric customers from this impending rate increase.

2. Impediments to the Compact's Full Implementation of Demand Response

The Compact's unique status as the only municipal aggregator Program Administrator complicates its implementation of its ideal DR offering during the 2016-2018 Three-Year term. Ideally, the Compact would propose the installation of advanced metering instead of a TED but cannot do so until implementation of the local distribution company's Grid Mod plan. Advanced metering would provide seamless access to real-time energy usage, allowing customers to better understand and manage their consumption, would allow for two-way communications, and would provide the granular and accurate load data which would be required for the implementation of TVR as a method to reduce peak usage.

a. Implementation of TVR

The Compact is supportive of an opt-out TVR offering because experience has shown that while average participant response may be lower for opt-out offerings; higher participation outweighs this effect, resulting in more cost-effective DR offerings.[3] The Compact acknowledges that the Grid Mod plans filed by the distribution companies are inconsistent regarding implementation of TVR offerings. The Compact believes that there must be consistency between the offerings of distribution companies regarding the type of TVR (opt-out or opt-in) and customer TVR eligibility (basic service and competitive supply) so a full array of DR offerings may be available to the maximum number of customers and the full potential benefits of DR realized.

b. Energy Storage

The Compact maintains that a fully integrated DR offering should incorporate energy storage. The availability of TVR is necessary to capture full DR benefits from energy storage. Energy storage, both small and large scale, continues to decrease in price, making it an increasingly viable option for customers interested in DR options. Energy storage is presently being marketed by solar installation companies as a complement to photovoltaic ("PV") installations. Additionally, energy storage is a non-wires alternative ("NWA"), in certain circumstances, that presents a more cost-effective solution than traditional infrastructure upgrades as a means of meeting demand in congested areas. See National Grid DR Pilot Updates, by Tim Roughan, Washington, DC, May 28, 2015 (noting NWAs provide for the integration of customer-facing resources such as energy efficiency and distributed energy resources along with utility/grid-facing resources that together, in specific geographic areas, defer a planned transmission or distribution infrastructure investment). The Compact plans to advocate for policies that will

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[3] Page vi, Department of Energy, "Interim Report on Customer Acceptance, Retention, and Response to Time-Based Rates from the Consumer Behavior Studies," June, 2015: http://energy.gov/sites/prod/files/2015/06/f24/ARRA-CBS_interim_offering_impact_report_June2015.pdf.

encourage the effective deployment of storage to defer infrastructure investments and allow storage owners to monetize these benefits.

c. Customer Data and AMI Electric Meters

As noted above, the installation of AMI electric meters is necessary to realize the full benefits of a DR offering. Moreover, participation in ISO New England's Demand Response Program is a priority as it will maximize the benefits of DR for electric ratepayers. ISO New England requires 5-minute interval data for participation in its DR program. This level of customer data is presently not available from the majority of existing electric meters on Cape Cod and Martha's Vineyard.[4] As such, in order to fully implement a DR offering to effectively reduce the peak on Cape Cod and Martha's Vineyard, upgrades to existing customer electric meters to AMI meters will be required. The Compact maintains that the cost for meter upgrades should be borne by the local distribution company on its regulated portion of the electric bill and not through the energy efficiency surcharge. The Compact strongly supports analysis that evaluates whether the cost of deploying AMI meters in the SEMA zone accompanied by full deployment of DR is less expensive for SEMA electric customers than the anticipated customer bill increases due to SEMA capacity prices, as noted above.

[4] While TED can provide real-time usage data for customers, it may not satisfy the data requirements for participating in ISO-NE energy and capacity markets. The Compact will work with ISO-NE to establish whether or not data from the installed TEDs can be used in these markets.

2016 Cape Light Compact Demand Response Budget

Sector	Program Planning and Administration	Marketing and Advertising	Participant Incentive	Sales, Technical Assistance & Training	Evaluation and Market Research	Total Program Costs
A - Residential	$ -	$ 4,500	$ 5,850	$ 156,957	$ -	$ 167,307
B - Low-Income	$ -	$ -	$ -	$ -	$ -	$ -
C - Commercial & Industrial	$ -	$ 500	$ 650	$ 17,440	$ -	$ 18,590
Grand Total	**$ -**	**$ 5,000**	**$ 6,500**	**$ 174,397**	**$ -**	**$ 185,897**

2017 Cape Light Compact Demand Response Budget

Sector	Program Planning and Administration	Marketing and Advertising	Participant Incentive	Sales, Technical Assistance & Training	Evaluation and Market Research	Total Program Costs
A - Residential	$ -	$ 4,500	$ 11,700	$ 224,817	$ -	$ 241,017
B - Low-Income	$ -	$ -	$ -	$ -	$ -	$ -
C - Commercial & Industrial	$ -	$ 500	$ 1,300	$ 24,980	$ -	$ 26,780
Grand Total	**$ -**	**$ 5,000**	**$ 13,000**	**$ 249,797**	**$ -**	**$ 267,797**

2018 Cape Light Compact Demand Response Budget

Sector	Program Planning and Administration	Marketing and Advertising	Participant Incentive	Sales, Technical Assistance & Training	Evaluation and Market Research	Total Program Costs
A - Residential	$ -	$ 4,500	$ 17,550	$ 292,677	$ -	$ 314,727
B - Low-Income	$ -	$ -	$ -	$ -	$ -	$ -
C - Commercial & Industrial	$ -	$ 500	$ 1,950	$ 32,520	$ -	$ 34,970
Grand Total	**$ -**	**$ 5,000**	**$ 19,500**	**$ 325,197**	**$ -**	**$ 349,697**

2016-2018 Cape Light Compact Demand Response Budget

Sector	Program Planning and Administration	Marketing and Advertising	Participant Incentive	Sales, Technical Assistance & Training	Evaluation and Market Research	Total Program Costs
A - Residential	$ -	$ 13,500	$ 35,100	$ 674,452	$ -	$ 723,052
B - Low-Income	$ -	$ -	$ -	$ -	$ -	$ -
C - Commercial & Industrial	$ -	$ 1,500	$ 3,900	$ 74,940	$ -	$ 80,340
Grand Total	**$ -**	**$ 15,000**	**$ 39,000**	**$ 749,392**		**$ 803,392**

Eversource PA-Specific Materials

Demand Reductions

Eversource recognizes the importance and need to achieve demand reductions due to their numerous benefits such as the possibility to delay or defer transmission and distribution projects, mitigating spikes in electric prices, and lowering emissions. Eversource is committed to the research and customer engagement necessary to implement demand reductions properly. During the 2016-2018 Three Year Plan, Eversource will investigate these opportunities.

The Company has had tremendous success in its previous Three Year Plans by building a deliberate, systematic go-to-market strategy for its offerings that provide real value to its customers. Eversource will continue working to understand customers' needs and how best to serve them. It is important to note that not all customers consume electricity in the same manner and as such there is no "one size fits all" path to demand reductions. The Company will continue to take a customer first approach when exploring and subsequently introducing new technologies and offerings geared towards demand reduction. Eversource will kick off the 2016-2018 Plan with in-depth research to ensure demand reduction initiatives are aligned with customer and Company objectives.

This effort will be informed by activities already underway at Eversource. The Company is a regional participant in the additional Avoided Energy Supply Cost (AESC) study geared towards determining critical peak costs. This is a key first step in determining which demand reduction measures may be cost effective and appropriate for customers. Eversource has also teamed with the Fraunhofer Center for Sustainable Energy Systems and Navigant Consulting to better understand how customers' energy use coincides with peak demand at the system level and what technologies might alleviate that coincident demand.

Within its current portfolio of energy efficiency offerings, Eversource has identified several measures that are focused at reducing demand which it will emphasize during the 2016-2018 Three Year Plan. LED bulbs and lighting controls have the potential to significantly lower peak demand. Eversource will continue to push LED bulbs and lighting controls to its customers and work towards influencing the lighting market through its upstream programs. The Company intends to pursue a similar strategy with efficient HVAC equipment. Also within its existing portfolio, the Company plans to continue aggressively pursuing combined heat and power (CHP) opportunities, for both small and large units.

A new way the Company plans to help reduce demand is by offering a training program to building operators so that they use their existing equipment and systems as efficiently as possible. These trainings should help reduce demand by allowing existing systems to run more efficiently, encourage customers to add additional efficient equipment, and ensure the persistence of demand reductions by educating building operators on how to use their equipment properly over a long period of time.

Another new way the Company plans to promote demand reduction is by educating its customers about their peak demand consumption through its Customer Engagement Platform (CEP). The CEP will offer customers visualizations and high level analytics around their consumption patterns through its ability to pull in historical usage and interval data (where available). Demand reductions will be driven by the CEP's ability to offer custom behavioral and widget based solutions to reducing consumption.

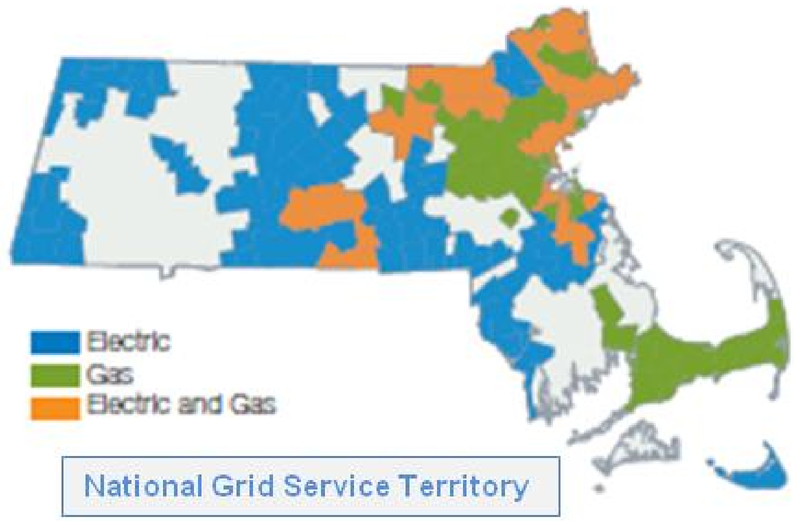
As always, Eversource is committed to exploring and advancing new technologies. Given the increased interest in demand reductions, the Company will be searching for promising technologies that can reduce demand in a cost effective manner and meet customers' needs. Eversource has a history of promoting new technologies where appropriate and intends to continue this strategy.

Lastly, it is important to note that energy efficiency is only one channel for reducing demand and the Company will leverage alternative channels to achieve its goal of lowering peak demand as well. To that end, Eversource has proposed spending over $100 million for advanced meters, over $7 million for storage technologies, and nearly $10 million for Volt VAR Optimization in its Grid Modernization plan. Opt-in time of use (TOU) rates have also been shown to reduce peak demand and are included in the Company's Grid Modernization plan. It is anticipated that energy efficiency will work in tandem with other grid modernization initiatives to maximize the impact the Company can have on reducing peak demand.

2016-2018 Energy Efficiency Plan:
National Grid Specific Elements

A. Overview

National Grid is committed to providing its customers with comprehensive energy efficiency solutions which drive economic and environmental benefits in support of the principles of the Green Communities Act, the Global Warming Solutions Act, and energy policy in the Commonwealth. The Company fully supports the efforts outlined in the 2016-2018 Massachusetts Statewide Three-Year Electric and Gas Energy Efficiency Plan and will supplement those efforts to take into account the unique communities it serves.



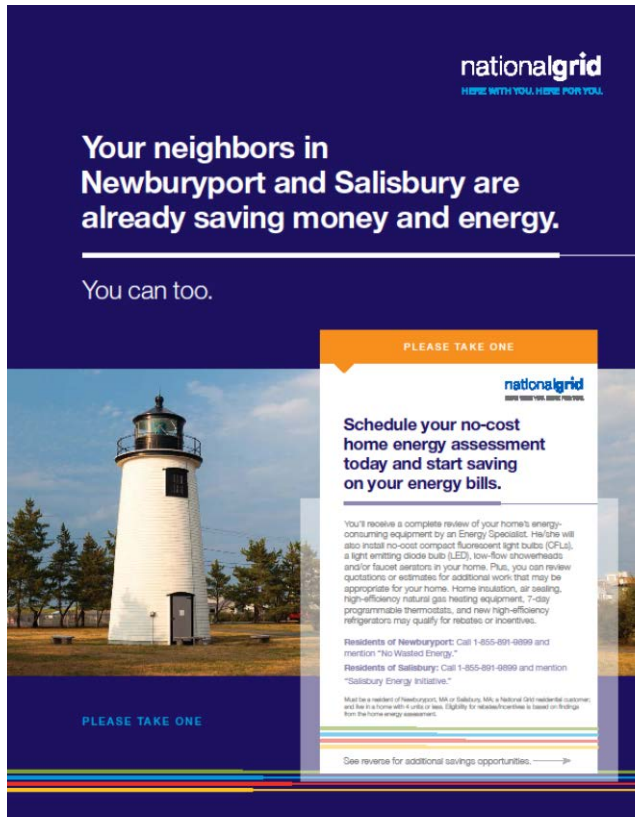
National Grid's service territory spans the full breadth of the state from Suffolk to Worcester to Berkshire counties. Thus, our 1.2 million electric customers in 172 communities and 850,000 gas customers in 116 communities represent a unique array of diverse demographic and economic circumstances. Our vision as a company is to create a more resilient, reliable, agile, efficient, and environmentally-sound energy network for all our customers, while connecting people, innovative technologies, and energy information. In light of this, National Grid has developed a variety of initiatives described below which collectively lay the groundwork to create this future.

B. Customer Partnerships

Communities Initiative: During 2013-2015, National Grid deployed a Communities Initiative in which the Company partnered directly with municipalities. National Grid began the program in 2013 with Medford, and expanded it in 2014 with Chelmsford, Malden, Newburyport, Salisbury, and Shirley. The Company plans to continue with this grant program in 2016-2018.

The Communities Initiative is designed specifically to accommodate the special circumstances of any community, regardless of demographic or socioeconomic characteristics. Each municipality is given participation and savings goals based upon past program performance levels in that specific town, creating a level playing field for achieving goals. Participating municipalities are provided with start-up funding and supported with training in education and outreach to their residents. Regular check-in calls allow municipalities to share their outreach tactics with each other and provide some sense of competition. Specific phone numbers and key words are set up for each municipality in order to track participation due to the program, and additional rewards are based on audits performed and additional measures completed, such as insulation and heating systems. The approach specifically rewards communities for increasing the volume of not just home energy assessments, but also measure installations, such as weatherization and heating systems.

For the 2013-2015 initiative, selection for the Communities Initiative was based on responses to an open request for information (RFI) to all of National Grid's dual-fuel communities. In 2016-2018, the Company anticipates coordinating efforts with other PAs so that initiatives like this can be expanded to communities where National Grid is either the electric provider or the gas provider, but not always both.



Geotargeting/Non-wires Alternatives: One consideration in choosing communities will be whether locations have projected high congestion and/or future planned infrastructure investments. The increase of energy efficiency in those areas due to the concentrated marketing tactics and/or enhanced incentives of the Communities Initiative may be able to alleviate the congestion.

The idea of geotargeting energy efficiency is not new to National Grid. In a 2011 study[1] on the Aquidneck Island area of Rhode Island, Opinion Dynamics Corporation found that National Grid efforts to target marketing to specific towns resulted in measurable increases to the energy efficiency participation in those areas above and beyond what would have otherwise been expected. In addition, a number of steps have been taken toward exploring non-wires alternatives (NWAs) in New England. National Grid defines NWAs as projects that combine multiple technologies, including energy efficiency, in a specific, geographical area with a goal of deferring a transmission or distribution investment. As part of its 2012 System Reliability Procurement Report[2], National Grid began implementing its first non-wires alternative (NWA) pilot in Little Compton and parts of Tiverton Rhode Island in an effort to reduce 1 MW of load (primarily through energy efficiency but also with some demand response efforts) during the area's peak times in order to defer a $2.9 million investment in an additional distribution feeder to serve the area. This pilot is now in the fourth year of its six-year

[1] *Evaluation of National Grid's Community Pilot Program - Energy Action: Aquidneck and Jamestown Final Report*. Prepared by Opinion Dynamics Corporation in October 2011.
[2] *2012 System Reliability Plan Report – Supplement*. Prepared by National Grid in February 2012.

planned lifetime, and the distribution investment, originally planned for 2014, has still not been constructed.

National Grid has also started to explore NWAs in Massachusetts on Nantucket. In 2015, implementation began on an initial plan, primarily composed of energy efficiency. In the long term, the goal of this project will be to defer 18 MW over 17 years to defer the construction of a third cable to serve the island's load by at least ten years. About 5-7 MW of this total reduction is projected to come from energy efficiency. The larger effort is projected to include renewables, energy storage, demand response and potentially time varying rates as potential sources of load reduction during peak hours.

In its 2016-2018 Plan, National Grid would like to expand on its experience with NWAs by employing targeted efforts to geographically concentrate some energy efficiency efforts in areas of greater need, i.e. areas that are projected to have higher load congestion over time or that are projected to need a distribution or transmission upgrade related to load growth. While no areas of need beyond Nantucket are projected for implementation in 2016-2018 at the time of this filing, screening for areas will take place on a rolling basis, and projects will be proposed as they are identified.

Nonprofit Referrals: While municipal partnerships are one way to diversify our marketing channels, nonprofit partnerships are another means to potentially reach more customers. In 2016-2018 National Grid intends to begin a Nonprofit Referral program, partnering with small, local nonprofits to reach their membership. This initiative will also reward nonprofits based on completed audits and installed measures.

D. Demand Response

National Grid proposes to offer broad demand response (DR) solutions to reduce customer demand through peak shaving solutions and load shifting opportunities. National Grid also plans to explore opportunities for gas DR. Demonstration projects will provide insights and help develop best practices and strategies to guide the deployment of solutions at scale. The Company, in consultation with the Council and other PAs, will develop a common framework for cost-effectiveness and proposed performance incentives for all demand response programs.

Commercial and Industrial Demand Response

Multi Year Strategy: Commercial and Industrial (C&I) demand response demonstration projects will be deployed to explore options for direct load control, as well as customer initiated interruptible load demand response in 2016 with further demonstration activities in 2017 and 2018, as appropriate. National Grid will analyze data collected from the demonstration projects to assess the market potential, test delivery strategies, identify market barriers, and develop the framework for cost-effectiveness for the screening of demand response (DR) programs. Findings from these demonstration projects and related evaluations, along with additional research and analysis, will inform and refine any future implementation of DR. National Grid plans to propose performance incentives for DR-related efforts after incremental DR-related benefits are better understood and determined through the demonstration projects.

Proposed Initiatives: For small commercial customers where interval meters do not currently exist, National Grid will focus on direct load control demand response. This initiative will explore opportunities to reduce peak load by providing incentives for the installation of technologies that automatically reduce energy usage during demand response events. Some of the potential technologies under consideration, where applicable, include Wi-Fi thermostats that control air conditioners, heat pumps, smart plugs, and smart water heaters. In addition, National Grid will research opportunities for other demand response-enabled technologies for small commercial customers, such as network lighting.

For large commercial and industrial customers with interval meters, National Grid will focus on interruptible load demand response. Here, customer meter data allows for measuring actual curtailment. Facility-specific assessments will be used to identify the most appropriate curtailment strategies for each customer, and could include HVAC system controls, network lighting controls, energy management systems (EMS), and other demand reducing opportunities specific to each customer facility. National Grid will coordinate energy efficiency assessments to include demand response opportunities where appropriate.

Technology Deployment: National Grid will provide incentives for demand response enabled technologies such as Wi-Fi thermostats, open automated demand response (ADR) enabled equipment, and network lighting controls through the ongoing energy efficiency programs to position the market for larger deployment of demand response in the future. Future investments in grid modernization, enabling widespread use of time varying rates and including a scalable demand response management system, could further enhance demand response capabilities. As new demand response-enabled technologies emerge, National Grid will continue to evaluate those technologies and, as appropriate, incorporate them into to its portfolio offerings.

Residential Demand Response

Multi-Year Strategy: Similar to the commercial and industrial demand response strategy, the residential demand response strategy will explore demonstration projects and seek to position the marketplace for broad deployment of demand response in the future. Lessons from planned demonstration projects in 2016 will be used to further develop and enhance residential demand response initiatives in 2017 and 2018.

Proposed Initiatives: For residential customers, National Grid intends to pursue full scale deployment of mature demand response-enabled technologies such as Wi-Fi thermostats, while also testing new technologies and progressively scaling those that prove successful. In 2016, National Grid plans to demonstrate the benefits of automated demand response with Wi-Fi thermostats. This technology allows the house to be pre-cooled prior to a demand response event and manages the indoor temperature during such an event, so that it is always within a given range to maximize customer comfort. This control strategy uses two-way communication through the in-home Wi-Fi network to maximize potential savings for customers with minimal impact on comfort. Also in 2016, National Grid plans to implement small-scale demand response with connected washers and dryers, and smart window air conditioning. In 2017 and 2018, National Grid plans to explore connected electric hot water heaters, heat pump water heaters, dishwashers, pool pumps and electric vehicle charging stations. Most of these technologies have both energy efficiency and demand response savings, and therefore the company intends to promote them though the existing energy efficiency programs.

Communication, Education and Engagement: National Grid strives to deliver customer solutions that optimize customer benefits. Therefore, significant efforts will be made to educate and engage customers with information through direct mail, email, and online portals. The company is currently exploring the best means to leverage existing customer communication channels such as our home energy reports and our in-person home energy assessments. Specific topics of focus may include the benefits of demand response, and the automatic smart control that allows National Grid to maximize in-home comfort and demand savings.

Budgets and Expected Results: National Grid is proposing budgets for demand response initiatives and has estimated the expected MW reduction associated with these efforts. The MW reduction targets are estimates based on the learnings from the Smart Energy Solutions pilot in Worcester and demand response programs from across the country. These MW reduction estimates will be refined and revised in the subsequent years based on findings from the demonstration projects.

The demand savings presented in the table below should not be considered formal goals. Rather, they are intended to provide a preliminary estimate of incremental demand savings from contemplated DR efforts. Goals for efforts that prove to be cost-effective will be set after the results of the proposed demonstration projects can be considered.

The demand response savings presented in the "Preliminary Estimate of Expected Demand Savings" table below reflect the average reduction in capacity per hour during a demand response event from residential and C&I demand response strategies that may be deployed in 2016 – 2018. These estimates are dependent on the expected time and length of a demand response event. The preliminary DR savings provided in the table are based on an average of 87 hours of residential demand response hours for each customer and 40 C&I demand response hours in a year for commercial customers. The assumed length of the demand response events will vary from 2-4 hours for residential customers.

NATIONAL GRID DR BUDGETS							
Year	**Program**	**Program Planning and Admin.**	**Marketing and Advertising**	**Participant Incentive**	**Sales, Technical & Training**	**Evaluation and Market Research**	**Total PA Costs**
2016	**Residential**	$187,375	$210,000	$596,282	$1,778,956	$110,904	**$2,883,517**
	Commercial and Industrial	$198,104	$31,500	$99,750	$642,664	$38,881	**$1,010,899**
	Total	**$385,478**	**$241,500**	**$696,032**	**$2,421,620**	**$149,785**	**$3,894,415**
2017	**Residential**	$214,411	$210,000	$1,497,254	$2,618,084	$181,590	**$4,721,339**
	Commercial and Industrial	$206,617	$57,750	$3,139,500	$3,527,500	$277,255	**$7,208,621**
	Total	**$421,028**	**$267,750**	**$4,636,754**	**$6,145,584**	**$458,845**	**$11,929,960**
2018	**Residential**	$238,601	$210,000	$2,698,890	$3,519,067	$266,662	**$6,933,221**
	Commercial and Industrial	$366,163	$57,750	$3,294,375	$3,518,187	$444,494	**$7,680,969**
	Total	**$604,764**	**$267,750**	**$5,993,265**	**$7,037,254**	**$711,156**	**$14,614,190**
2016-2018	**Residential**	**$640,387**	**$630,000**	**$4,792,426**	**$7,916,107**	**$559,157**	**$14,538,077**
	Commercial and Industrial	**$770,883**	**$147,000**	**$6,533,625**	**$7,688,351**	**$760,629**	**$15,900,489**
	TOTAL	**$1,411,270**	**$777,000**	**$11,326,051**	**$15,604,458**	**$1,319,786**	**$30,438,566**

Preliminary Estimate of Expected Demand Savings

NATIONAL GRID DR SAVINGS		
Year	**Program**	**Average hourly MW Reduction during an event**
2016	**Residential**	**2.6**
	Commercial	**0.3**
2017	**Residential**	**6.5**
	Commercial	**40.5**
2018	**Residential**	**11.0**
	Commercial	**41.0**

E. Electric Vehicle Charging Stations

National Grid believes that there is a unique opportunity to leverage the Company's energy efficiency related customer interactions to help the Commonwealth achieve its Clean Energy and Climate Plan transportation objectives. Promoting electrical vehicle (EV) charging stations along-side energy efficiency could increase customer interest and program participation while introducing a new tool to help manage energy loads over the long term. As part of its 2016-2018 Plan, the Company would like to explore the promotion of EV charging stations through the energy efficiency programs by examining potential funding mechanisms and quantifying the energy savings that could result from these efforts. Should this exploration show that the addition of EV charging stations can deliver program and customer benefits, National Grid would like to implement an integrated strategic promotion of this technology.

F. R&D and Technical Demonstration

National Grid is committed to evaluating new and innovative technologies to provide Massachusetts customers with enhanced savings and benefits. It is essential to develop and test next generation products to ensure they meet claimed economic benefits as well as the highest standards of reliability and safety

National Grid works with the Massachusetts Technical Assessment Committee (MTAC) in a collaborative manner that enables all stakeholders to consider the technologies demonstrated for future program design and implementation. The projects are both proactive and reactive in the marketplace as solutions develop.

The Company is planning the following residential demonstrations in 2016-2018: Smart Appliance Control and Multi-Channel Communication Platform for Connected Home; micro combined heat and power (MCHP); and other technologies as they emerge in the marketplace.

In addition, National Grid will be examining the following commercial demonstrations for 2016-2018: Performance Lighting Existing to Code -Tier Zero; Lighting Controls with Demand Response; Adaptive LED Troffer –Enhanced Controls Logic; Lighting Designer Incentive (LDI); Lighting Re-Specification Incentive; Building Tune Up (BTU_p); Lab Buildings Retrocommissioning (RCx) and/or Deep Dive; and Distributed Refrigeration.

G. Education

National Grid has been a long-term supporter of the National Energy Education Development (NEED) Project, bringing energy efficiency curricula and trainings to teachers in Massachusetts. In 2016-2018, the Company will supplement the NEED trainings with take-home energy-efficiency kits. Teachers who participate in the trainings will be able to request these kits, which contain instant-savings measures such as light bulbs, showerheads, and faucet aerators, as well as educational materials. After in-class lessons about energy-efficiency, students will bring the kits home and complete surveys regarding which measures their families install. In this way, the Company can capture additional savings and expand the reach of the education program beyond teachers and students, and to parents as well.

National Grid will continue offering a school lighting fundraiser in 2016-2018. In much the same style as other school fundraisers, in which students sell magazines, candy, or wrapping paper, students can sell light bulbs, smart power strips, and showerheads to family and friends, with all profits from the sale going to the school. This motivates students to not only learn about energy efficiency, but also to share what they have learned within their community.

It is the hope that the increased awareness and commitment represented by installing instant savings measures through the take home kits and lighting fundraiser will encourage families to pursue additional energy efficiency opportunities while fostering a culture of sustainability.

M. **Studies of Remaining Potential**

berkshire® gas

A **UIL HOLDINGS** COMPANY

GDS Associates, Inc.
ENGINEERS & CONSULTANTS

Berkshire Gas – Remaining Potential Study
Final Report

February 2nd, 2015

Table of Contents

Executive Summary - Purpose

This report presents Berkshire Gas-specific results from a comprehensive, six month assessment of remaining energy efficiency potential within Berkshire Gas, NEGC (now Liberty Utilities), Unitil Gas and Unitil Electric service territories

Executive Summary - Order

- In addition to assisting the small PAs in quantifying remaining potential within their service territories, this effort was conducted in accordance with the Massachusetts Department of Public Utilities' January 31, 2013 Order D.P.U. 12-100 through D.P.U. 12-111 (sections IV.B.2.a & 4.a – pages 18, 19 & 40) and subsequent DOER Consultant feedback
- Specifically, Section IV.B.2.a states:
  - "The Program Administrators with an aggregate three-year savings goal of greater than 20 percent below the statewide three-year aggregate goal will conduct a study, either jointly or individually, during the upcoming three-year term to document the penetration of energy efficiency within its service territory and the remaining cost-effective energy efficiency opportunities available.."

Executive Summary – Savings Goals

For the 2013-2015 Energy Efficiency Plan, Berkshire's three-year savings goals fell short of the statewide average:

Program Administrator	2013	2014	2015	Total 2013-2015
Berkshire Gas	0.70%	0.76%	0.81%	0.76%
Statewide	1.08%	1.17%	1.19%	1.14%
Variance from Statewide Aggregate				**33.3%**

Executive Summary – Key Tasks

Three major task areas were pursued:

1. Secondary data collection/data mining and data gap analysis, including review of ongoing work of the Evaluation Management Committee.
2. Primary data collection sample design, work plan development and implementation of telephone surveys (residential and small/medium C&I customers) and on site data collection (larger C&I customers).
3. Data analysis and reporting of likely achievable and high case remaining potential results.

Executive Summary – Scope/Timing

This was a fast tracked (approx. six month) effort coordinated across four Program Administrators (PAs) culminating in development of four separate, territory-specific reports – one for each PA (Berkshire Gas, Liberty Gas, Unitil Gas and Unitil Electric).

Executive Summary - Savings Potential Results

- The Likely Achievable savings potential across Berkshire's service territory is estimated to be 0.70% of 2016 annual sales (0.77% by 2018)
  - This is consistent with Berkshire's current three-year(2013-2015) territory-wide target of 0.76%
- The sectors with greatest potential for savings as a % of sector sales remain with Berkshire's residential and small/medium commercial customers (0.87% and .085% by 2018 respectively)
- Less potential remains within the large commercial sector (0.51% by 2018)

Summary Likely Achievable Scenario	2016	2017	2018
Residential			
Annual Therm Savings	272,624	280,745	287,083
Forecast Sales	31,195,551	32,108,411	32,839,013
Savings as % of sales	**0.87%**	**0.87%**	**0.87%**
PA Cost to Achieve	$ 3,434,278	$ 3,536,087	$ 3,605,746
Total Cost to Achieve	$ 5,507,737	$ 5,668,283	$ 5,792,784
Small and Med C&I			
Annual Therm Savings	138,418	169,043	194,922
Forecast Sales	22,434,695	23,022,680	23,018,703
Savings as % of sales	**0.62%**	**0.73%**	**0.85%**
PA Cost to Achieve	$ 424,287	$ 476,065	$ 515,842
Total Cost to Achieve	$ 788,834	$ 892,315	$ 972,856
Large C&I			
Annual Therm Savings	96,193	97,100	97,911
Forecast Sales	19,344,322	19,344,322	19,344,322
Savings as % of sales	**0.50%**	**0.50%**	**0.51%**
PA Cost to Achieve	$ 386,793	$ 388,640	$ 389,983
Total Cost to Achieve	$ 581,962	$ 585,539	$ 589,373
TOTAL			
Annual Therm Savings	507,235	546,889	579,916
Forecast Sales	72,974,568	74,475,413	75,202,039
Savings as % of sales	**0.70%**	**0.73%**	**0.77%**
PA Cost to Achieve	$ 4,245,359	$ 4,400,792	$ 4,511,571
Total Cost to Achieve	$ 6,878,534	$ 7,146,138	$ 7,355,013

Executive Summary - Top Savings Sources

Residential Sector	Total Savings 272,624	% of Savings
Improved Wall Insulation	92,809	34.0%
Behavior	21,529	7.9%
Air Sealing	19,055	7.0%
Boiler 95%	16,701	6.1%
Heating System Replacement	16,521	6.1%
Furnace w/ECM 97%	16,054	5.9%
Improved Attic/Roof Insulation	15,954	5.9%
Early Retirement (Steam) - Retire	9,926	3.6%
Early Retirement (FHW) - Retire	8,880	3.3%
Furnace w/ECM 95%	8,268	3.0%

Top 3 Residential Measures:

- Wall insulation
- Behavior
- Air sealing

Large Commercial	Total Savings 96,193	% of Savings
Custom - Large	38,057	39.6%
Condensing Boiler 500-999 mbh (.90 TE)	16,530	17.2%
Kitchen equipment	10,585	11.0%
Steam Traps	9,766	10.2%
Showerhead	7,904	8.2%
Faucet Aerator	4,435	4.6%
Boiler Reset Controls (retrofit only)	2,917	3.0%
Condensing Boiler 301-499 mbh (.90 TE)	2,399	2.5%
DHW systems	1,192	1.2%
Programmable Thermostat	633	0.7%

Small/Medium Commercial	Total Savings 138,418	% of Savings
Kitchen equipment	36,356	26.3%
Custom - Small & Medium	29,114	21.0%
Steam Traps	26,658	19.3%
Faucet Aerator	10,790	7.8%
Showerhead	8,331	6.0%
Condensing Boiler <= 300 mbh (.96 TE)	5,996	4.3%
Programmable Thermostat	4,903	3.5%
DHW systems	3,956	2.9%
Combo Condensing Boiler/DHW 90%	3,537	2.6%
Boiler Reset Controls (retrofit only)	2,917	2.1%

Top 3 Small/Medium Commercial Measures

- Kitchen equipment
- Custom measures
- Steam traps

Top 3 Large Commercial Measures:

- Custom measures
- Condensing boilers (500-999 mbh (.90 TE)
- Kitchen equipment

Executive Summary – Key Findings

Results from review of secondary and primary data sources suggest:

- A somewhat limited market exists for cost effective energy efficiency savings projects within Berkshire's large commercial sector over the next 3 to 5 years
  - A majority Berkshire's 103 largest customers have already participated, with few additional major projects on their near-term planning horizon
- Economic challenges within Berkshire's service territory are making it difficult for residential and business customers to prioritize and pursue energy efficiency projects
- The sectors with greatest potential for savings as a % of sector sales remain with Berkshire's residential and small/medium commercial customers
  - Although customers within these sectors are typically cash constrained, increased focus on Berkshire's residential, small & medium sized customers could yield additional savings

Service Territory Characterization

Residential – 890 average annual therms/customer (36,008 customers)

- 965 average annual therms/customer (32,639 heat customers)
- 170 average annual therms/customer (3,369 non-heat customers)
- 5,928 (16.5%) of Berkshire's residential customers have been program participants within the past 3 years (including repeat participants and low income customers)

Actual	R1			R2			R3			R4			Total		
Split-Year 7/1-6/30	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust
2009-2010	824,149	4,605	179	72,253	406	178	20,979,387	22,048	952	3,504,873	3,916	895	**25,380,662**	**30,974**	**819**
2010-2011	785,761	4,413	178	77,831	420	185	22,629,573	21,872	1,035	4,274,824	4,474	955	**27,767,989**	**31,179**	**891**
2011-2012	707,047	4,102	172	85,035	470	181	18,832,902	21,975	857	3,847,453	4,845	794	**23,472,437**	**31,392**	**748**
2012-2013	666,349	3,834	174	77,304	414	187	23,452,119	23,558	996	3,676,845	4,289	857	**27,872,617**	**32,095**	**868**
2013-2014	641,022	3,531	182	74,527	411	182	27,056,436	24,646	1,098	4,309,084	4,488	960	**32,081,069**	**33,076**	**970**
% Change	**-22%**	**-23%**	**1%**	**3%**	**1%**	**2%**	**29%**	**12%**	**15%**	**23%**	**15%**	**7%**	**26%**	**7%**	**18%**

Forecast	R Non-Heat			R Heat			Total		
	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust
2016	602,101	3,542	170	30,593,450	31,534	970	**31,195,551**	**35,076**	**889**
2017	572,783	3,369	170	31,535,628	32,640	966	**32,108,411**	**36,009**	**892**
2018	538,901	3,197	169	32,300,112	33,743	957	**32,839,013**	**36,940**	**889**
% Change	**-10%**	**11%**	**-1%**	**6%**	**11%**	**-1%**	**5%**	**11%**	**0%**
Average	**571,262**	**3,369**	**170**	**31,476,397**	**32,639**	**965**	**32,047,658**	**36,008**	**890**

Residential Rate Designations

R-1	Residential/Non-Heating
R-2	Low-Income Residential/Non-Heating
R-3	Residential/Heating
R-4	Low-Income Residential/Heating

Service Territory Characterization

Commercial – 7,641 average annual therms/customer (5,520 customers)

- 4,214 average annual therms/customer (5,417 small and medium customers)
- 187,809 average annual therms/customer (103 large customers)
- 445 (8%) of Berkshire's commercial customers have been program participants within the past 3 years (including repeat participants and a majority of Berkshire's largest customers)

Actual	G-41			G-42			G-43			G-51			G-52		
Split-Year 7/1-6/30	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust
2009-2010	6,297,605	3,257	1,933	7,723,648	379	20,388	6,555,642	57	116,029	2,246,665	945	2,378	3,581,566	190	18,834
2010-2011	7,313,234	3,365	2,174	9,129,497	389	23,494	8,177,610	61	134,426	2,214,222	877	2,525	3,220,596	175	18,360
2011-2012	6,000,404	3,441	1,744	7,725,707	388	19,903	7,288,684	64	113,149	2,166,850	866	2,501	3,041,104	170	17,845
2012-2013	7,768,812	3,565	2,179	8,555,652	384	22,309	8,710,157	69	126,847	2,346,867	840	2,793	3,158,878	170	18,627
2013-2014	9,390,568	3,655	2,569	9,725,312	383	25,415	9,548,827	68	140,424	2,585,367	848	3,048	3,234,549	165	19,574
% Change	**49%**	**12%**	**33%**	**26%**	**1%**	**25%**	**46%**	**20%**	**21%**	**15%**	**-10%**	**28%**	**-10%**	**-13%**	**4%**

G-53		
Therms	Customers	Therm/Cust
8,243,169	32	260,997
10,025,694	30	330,517
10,769,648	32	341,894
10,507,408	34	308,286
9,795,495	35	277,231
19%	**12%**	**6%**

Forecast	Small & Medium			Large			Total		
	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust
2016	22,434,695	5,325	4,213	19,344,322	103	187,809	**41,779,017**	**5,428**	**7,697**
2017	23,022,680	5,430	4,240	19,344,322	103	187,809	**42,367,002**	**5,533**	**7,657**
2018	23,018,703	5,495	4,189	19,344,322	103	187,809	**42,363,025**	**5,598**	**7,568**
% Change	**3%**	**3%**	**-1%**	**0%**	**0%**	**0%**	**1%**	**3%**	**-2%**
Average	**22,825,359**	**5,417**	**4,214**	**19,344,322**	**103**	**187,809**	**42,169,681**	**5,520**	**7,641**

Commercial Rate Designations

G-41	Low annual use, low load
G-42	Medium use, low load
G-43	High annual use, low load
G-51	Low annual use, high load
G-52	Medium use, high load
G-53	High annual use, high load

METHODOLOGY

There were three major tasks completed as a part of this effort:

1. Secondary Data Collection/Data Mining
2. Primary Data Collection
3. Data Analysis and Reporting

Methodology – Secondary Data

Task 1 – Secondary Data Collection Activities:

- Reviewed existing evaluation reports including ongoing evaluation planning and implementation activities assessments
  - Participated as Berkshire's representative in relevant Evaluation Management Committee meetings including: Residential, C&I and Cross-Cutting working groups
- Reviewed utility specific data
  - Customer data and program data provided by Berkshire

METHODOLOGY – SECONDARY DATA

Findings:

- Very little territory-specific data available from statewide evaluation efforts
- Utility specific data from Berkshire was used in Task 3 – Data Analysis

Methodology – Primary Data

Task 2 – Primary Data Collection Activities:

- Used to fill gaps identified through Task 1 effort
- Used to develop savings estimates for Task 3 data analysis and reporting
  - Telephone Surveys
  - On-Site Surveys

Methodology – Sample Design

- Residential – A sample size of 41 was targeted to obtain a confidence and precision of 80/10 at the Residential sector level.
- Commercial and Industrial – A sample size of 41- split between small and medium commercial phone surveys and larger commercial/industrial site visits - was targeted to obtain a confidence and precision of 80/10 at the C&I sector level.
- Territory Level – Overall, a goal of 82 surveys was targeted to achieve statistical significance of at least 90/10 across the Berkshire service territory.

Methodology – Sample Selection

- Residential – A random sample of 41households was ultimately selected for phone surveys by study team member RKM Research & Communications.
  - The sample was drawn from a randomized list of Residential Customers (Rates R1, R2, R3 & R4) provided by Berkshire Gas.
- Small Commercial – A random sample of 44 customers was ultimately selected for phone surveys by study team member RKM Research & Communications.
  - The sample was drawn from a randomized list of Small Commercial Customers (Rates: G41, G42, G51 & G52) provided by Berkshire Gas.
- Large Commercial & Industrial – A randomly selected sample of 17 customers were ultimately recruited for on-site data collection by GDS field staff.
  - The sample was drawn from a randomized list of Berkshire's total pool of Large Commercial & Industrial Customers (Rates: G43 & G53).
  - A randomized list of customers was provided and called through, in order, to avoid sample bias and procure a representative mix of participating and non-participating customers.
  - Soft leads were recruited with the help of utility representatives. GDS then contacted the customer and set-up a time to complete the site visit. Some coordination with DNV-GL was also required to avoid duplication of effort with their simultaneous site data collection efforts for another ongoing evaluation project and to minimize customer confusion.

METHODOLOGY – FINAL SAMPLE SIZES

Final Sample Sizes				
	Residential Customer Population	# Phone Surveys Targeted	# Phone Surveys Completed	Achieved Confidence/Precision
Residential Telephone Surveys	33,076	41	41	80/10
C&I Customer Surveys*	5,153	21 (phone) / 20 (site)	44 (phone)/ 17 (site)	80/8.2
Territory Level	38,229	62 (phone) / 20 (site)	85 (phone) / 17 (site)	90/8.1

* Includes a mix of on -site data collection and telephone surveys

During fielding of the small commercial telephone surveys, the target sample size was increased to from 21 to 41 to collect more data on smaller to medium sized commercial customers.

METHODOLOGY – PHONE SURVEYS

Residential Response Rates:

- The overall response rate of the Residential phone surveys was ***13.8%.***
- A total of 607 customers were dialed, and 41 surveys were completed.
- Only 2 calls experienced a language barrier ***(0.33%)***

Call Code	Disposition	Total	%TOTAL DIALINGS
1	Complete	41	6.75%
2	No Answer	33	5.44%
3	Answering machine	253	41.68%
4	Busy	6	0.99%
5	Bad number	34	5.60%
6	Fax number	0	0.00%
7	Call intercept	0	0.00%
8	Appointment	27	4.45%
9	First refusal	150	24.71%
10	Second refusal	5	0.82%
11	Language barrier	2	0.33%
12	No eligible respondent	7	1.15%
13	Business - NPR	33	5.44%
14	Never call	9	1.48%
15	Quota full	0	0.00%
16	Partial - Callback	4	0.66%
17	Partial - Refusal	3	0.49%
	TOTAL DIALINGS	**607**	**100%**
	RESPONSE RATE(%)	***13.8***	

Methodology – Phone Surveys

Commercial Response Rates:

- The overall response rate of the Small Commercial phone surveys was ***14.7%.***
- A total of 439 customers were dialed, and 44 surveys were completed.
- Only 1 call experienced a language barrier ***(0.23%)***

Call Code	Disposition	Total	%TOTAL DIALINGS
1	Complete	44	10.02%
2	No Answer	27	6.15%
3	Answering machine	137	31.21%
4	Busy	10	2.28%
5	Bad number	11	2.51%
6	Fax number	2	0.46%
7	Call intercept	0	0.00%
8	Appointment	14	3.19%
9	First refusal	126	28.70%
10	Second refusal	19	4.33%
11	Language barrier	1	0.23%
12	No eligible respondent	15	3.42%
13	Business - NPR	0	0.00%
14	Never call	0	0.00%
15	Quota full	1	0.23%
16	Partial - Callback	5	1.14%
17	Partial - Refusal	27	6.15%
	TOTAL DIALINGS	**439**	**100%**
	RESPONSE RATE(%)		***14.7***

Methodology – Data Analysis

Task 3 – Data Analysis Activities:

- Reviewed raw survey data
- Determined end-use saturation and efficiency penetrations by customer sector
- Developed remaining energy efficiency potential savings estimates

Methodology – Survey Data Review

- Raw telephone survey and on-site data collection results were reviewed, analyzed and summarized
- Sector specific presentations were developed to document detailed results and identify key findings from each research area including:
  - Demographics/firmography
  - Individual energy end-use findings
  - Past purchases and practices
  - Attitudes
  - Program awareness, participation and satisfaction
- Survey and site-visit data was then used to develop estimates of Potential Savings

Methodology – Savings Estimates

A combination of data sources were used to develop factors for calculating remaining potential energy savings:

- Survey and site visit results
- Customer counts
- Existing efficiency program measures
- Existing program data on energy savings
- Massachusetts 2013 Report Technical Reference Manual
- Current utility Net-To-Gross (NTG) ratios
- Benefit/Cost modeling (Total Resource Cost Test – TRC)

Methodology – Savings Estimates

Equation of Potential Energy Savings

Participation × Savings (therms) × NTG Ratio

Methodology – Participation Est.

Participation

GDS used a number of factors to arrive at an annual estimate of measure participation

- Estimate of base homes
  - Customers with gas heating and percent of customers with the baseline measure (i.e. boiler, furnace)
- Applicability factor
  - Split between competing measures (i.e. 90% AFUE boiler, 95% AFUE boiler)
  - Accounts for consumer choice
  - Used past program installations to estimate future installation ratios
  - Benefit/Cost modeling was conducted using the TRC test to assess cost-effectiveness of individual measures. However, measures with B/C ratios less than 1.0 were not dropped from the analysis because cost-effectiveness is not assessed at the measure level in MA, but at the program level . B/C ratios were used, where appropriate, to prioritize installations among competing measures → greater factor weight applied to measures with a higher B/C ratio.
- Burnout rate of measure (1/measure life)
  - What percentage of the market is expected to need replacing
- Convertibility factor
  - What percent might not be physically convertible to new technology or other limitation (i.e. wall insulation improvements would not be available for brick, stone or asbestos siding exteriors)

METHODOLOGY – PARTICIPATION EST.

Participation

GDS used a number of factors to arrive at an annual estimate of measure participation

- Energy Efficiency Saturation
  - Percentage of market that is selecting efficient equipment
  - Based on survey data
- Willingness to Participate
  - Included only in the "likely achievable potential scenario"
  - Not included in the "high-case" scenario (i.e., before consideration of territory-specific realities, customer behaviors and measure installation barriers)
  - Reflects survey response assessed percentage of customers likely to move forward with a project

Methodology – Measure Savings

Savings (therms)

GDS used a number of sources to estimate measure specific savings

- 2013 Report Massachusetts Technical Reference Manual
  - Included deemed savings values for many measures
- Utility Specific Program Data
  - Used for New Construction Program
- REM Rate Energy Modeling
  - Calibrated to utility climate and average annual heating usage

Methodology – NTG Ratios

NTG Ratios

GDS used current NTG ratios to adjust savings estimates

- NTG Ratios
  - Utility specific or statewide where applicable
  - Included or adjusted for free-ridership and spillover rates in some cases, but not all
  - Typically developed through rigorous evaluation efforts

METHODOLOGY - SCENARIOS

When estimating remaining potential, two modeling scenarios were run:

1. Likely achievable potential scenario – This scenario represents the study team's best estimate of the remaining potential within Berkshire's service territory and applies a "customer willingness" factor derived from telephone survey and site visit responses, along with sector-level budget constraints where applicable.
2. High-case scenario – This scenario represents the study team's estimated upper bound of the remaining potential without consideration of territory-specific realities, including customer behaviors and budget constraints.

High-Case Scenario - Savings Potential Results

- The total High-Case savings potential across Berkshire's service territory is estimated to be 1.17% of 2016 annual sales (1.34% by 2018).
  - The PA cost to achieve this potential is substantial at nearly $7.5M in 2016 ($8.1M in 2018) vs $5.3M current budget.
- Greatest potential, as % of sector sales, is in the residential customer sector (1.60% of 2016 sales, 1.62% by 2018).
- Very little change in potential exists within the large commercial sector when compared to the Likely Achievable Potential scenario (0.50% to 0.51% in both cases).

Summary - High-Case	2016	2017	2018
Residential			
Annual Therm Savings	499,646	516,883	533,104
Forecast Sales	31,195,551	32,108,411	32,839,013
Savings as % of sales	**1.60%**	**1.61%**	**1.62%**
PA Cost to Achieve	$ 6,289,846	$ 6,506,230	$ 6,700,408
Total Cost to Achieve	$10,089,730	$10,436,861	$10,753,358
Small and Med C&I			
Annual Therm Savings	259,157	319,862	374,853
Forecast Sales	22,434,695	23,022,680	23,018,703
Savings as % of sales	**1.16%**	**1.39%**	**1.63%**
PA Cost to Achieve	$ 800,909	$ 899,612	$ 984,505
Total Cost to Achieve	$ 1,450,588	$ 1,650,071	$ 1,821,056
Large C&I			
Annual Therm Savings	96,193	97,100	97,911
Forecast Sales	19,344,322	19,344,322	19,344,322
Savings as % of sales	**0.50%**	**0.50%**	**0.51%**
PA Cost to Achieve	$ 386,793	$ 388,640	$ 389,983
Total Cost to Achieve	$ 581,962	$ 585,539	$ 589,373
TOTAL			
Annual Therm Savings	854,996	933,845	1,005,869
Forecast Sales	72,974,568	74,475,413	75,202,039
Savings as % of sales	**1.17%**	**1.25%**	**1.34%**
PA Cost to Achieve	$ 7,477,548	$ 7,794,482	$ 8,074,897
Total Cost to Achieve	$12,122,280	$12,672,471	$13,163,788

Territory-Specific Insights - Residential

- Program awareness, participation & satisfaction
  - Although a large majority of respondents stated awareness of Berkshire's programs, a much smaller percentage reported participating – leaving a solid pool of potential new participating customers
- Demographics
  - Berkshire's residential telephone survey respondents included a large proportion of older (55+), educated and English-speaking residents
- Home characteristics
  - A majority of Berkshires' residential customer respondents live in older, single family homes that they own – excellent targets for potential building envelope improvements
- ENERGY STAR® awareness
  - While the majority of respondents are familiar with ENERGY STAR®, there is potential opportunity in reaching out to the 17% who are still unfamiliar
- Past purchase practices
  - A majority of respondents appear to have energy efficiency features on their radar screens
- Attitudes
  - Although cost is a major reason cited for not pursuing energy efficiency opportunities, a large majority of respondents express interest in purchasing energy efficient equipment for a multitude of reasons

Territory-Specific Insights - Residential

- Building envelope
  - There remains some likely achievable potential for building envelope improvements within Berkshire's residential customer sector.
- Space heating
  - Potential for heating system replacements exists in homes with older systems, where owners may be looking for replacements within the next five years. Savings associated with controllable thermostats may be limited.
- Water heating
  - Potential for water heater replacements exists in homes with older units, where owners may be looking for replacements within the next five years. Additional opportunities may exist for water saving devices.
- Clothes washing
  - Potential for energy efficient clothes washer and dryers exists in homes with older units, where owners may be looking for replacements within the next five years.
- Dishwashing
  - Potential for energy efficient dishwashers exists in homes with older units, where owners may be looking for replacements within the next five years.
- Hot tubs and heated pools
  - Based on survey responses, there does not appear to be much of a market for efficiency improvements within the pool and hot tub end-use.

Territory-Specific Insights – Small/Medium Commercial

- Program awareness, participation & satisfaction
  - A majority (52%) of Berkshire small business customers are non-participants and nearly all of those who have participated(48%) would be interested in doing so again.
- Firmographics
  - Berkshire's small commercial business base appears stable, with potential opportunities for energy efficiency investments in both leased and owned buildings. Small business owners would be best target for decisions.
- Building size, age & use
  - The make-up of Berkshire's small commercial building stock (relatively old, large square footage, small number of employees, sufficient hours of operation, somewhat efficiency conscious), suggests potential opportunities for targeted efficiency improvements.
- Past purchase practices
  - 27% of small commercial customer respondents stated they had purchased energy efficient products in the past, and 67% of those customers said they had plans to do so again over the next 12 months – suggesting additional potential for efficiency projects within Berkshire's small commercial customer sector.
- Attitudes
  - Rebates remain a major motivator for customer action in the small business sector.

TERRITORY-SPECIFIC INSIGHTS – SMALL/MEDIUM COMMERCIAL

- Building envelope
  - Good opportunities exist for building envelope improvements within Berkshire's small commercial business sector.
- Space heating
  - Based on survey responses, there does not appear to be much potential for replacement heating systems, heating system tune-ups or programmable thermostats within Berkshire's small commercial business sector.
- Water heating
  - Based on survey responses, only a small potential for water heater replacements currently appears to exist within Berkshire's small commercial business sector, but a majority (61%) of Berkshire's small business customer respondents are not taking advantage of other water saving measures (i.e., faucet aerators).
- Commercial kitchen and laundry
  - A small, but high energy use market exists within Berkshire's small business sector for commercial kitchen and laundry customers.
- On-site generation
  - 9% of Berkshire's small commercial customer respondents reported having onsite generation (emergency backup generators). There could be an opportunity to explore this market.

Territory-Specific Insights – Large Commercial

- Program awareness, participation and satisfaction
  - A majority (73%) of large business customer respondents are aware of and have participated in Berkshire's energy efficiency programs and are interested in doing so again.
- Past purchase practices
  - 47% of respondents have completed renovation projects in the past 5 years
  - 18% are planning a renovation in the next 12 months.
  - A small market for efficiency projects (18% of respondents) may exist within Berkshire's large commercial customer sector over the next 12 months.
- Attitudes
  - Lower bills and receipt of rebates remain major motivators for customer action in the large business sector.
  - These attitudes are also impacted by the number of businesses that have moved, sold, gone out of business or otherwise have cut back due to recession.

Territory-Specific Insights – Large Commercial

- HVAC
  - Energy savings potential remains for replacement of inefficient unit heaters.
- Water heating
  - Potential appears to exist for efficient water heating equipment, with greater opportunities for pre-rinse spray valves.
- Cooking and laundry equipment
  - Potential appears to exist for efficient C&I cooking and laundry equipment.
- Process equipment
  - There could be some opportunities for process efficiency improvements – but given the small number of large customers, limited availability of new projects on the planning horizon and unique characteristics of individual business processes, such determinations are best assessed on a custom/case-by-case basis.
- On-site generation
  - There appears to be an opportunity to explore the potential to include renewably-fueled process–related heating and power generation systems and efficient back-up generation systems.

ACTUAL EE SAVINGS CHARACTERIZATION

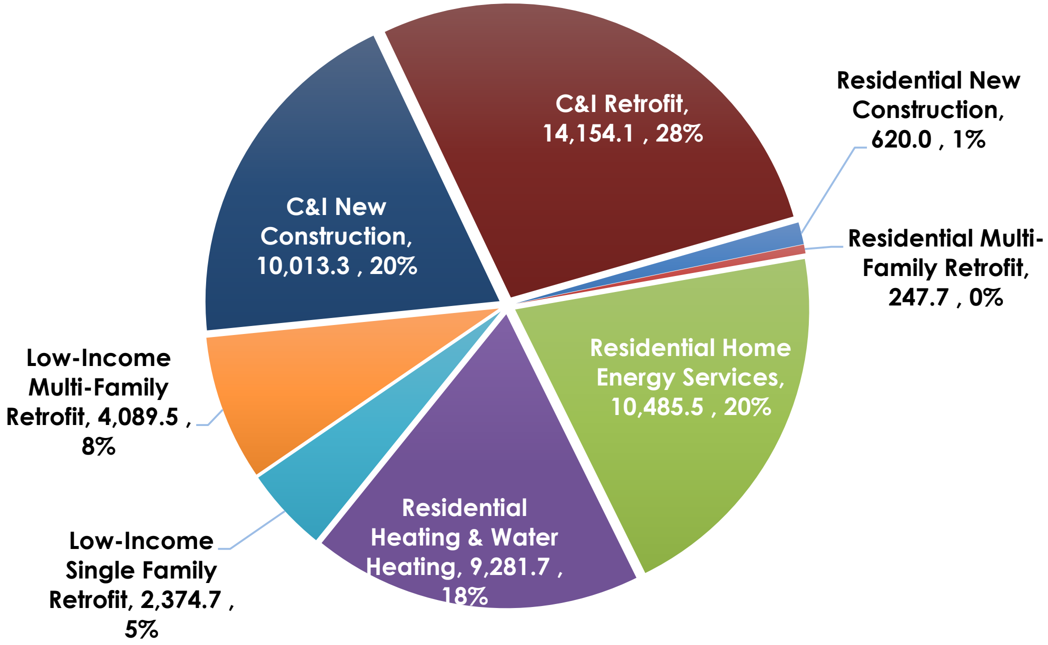
Program	2011		2012		2013		Three Year Total	
	Participants	Therms	Participants	Therms	Participants	Therms	Participants	Therms
Residential	*1,332*	**151,996**	*1,710*	**225,159**	*2,017*	**206,349**	*5,059*	**583,503**
New Construction	19	4,520	31	6,849	26	6,200	76	17,570
Home Energy Services (HES)	216	36,330	399	86,778	1,141	104,855	1,756	227,963
MF Retrofit	22	1,669	24	2,578	**43**	2,477	89	6,723
Heating and Water Heating Equipment	1,075	109,477	1,256	128,954	807	92,817	3,138	331,248
Sales[1]		19,539,949		24,118,468		27,697,458		71,355,875
Savings as a % of Sector Sales		***0.78%***		***0.93%***		***0.75%***		***0.82%***
Low Income	*91*	**24,950**	*75*	**107,093**	*101*	**64,642**	*869*	**196,685**
Single Family Retrofit	52	14,158	58	13,796	101	23,747	211	51,701
MF Retrofit	39	10,792	17	93,297	602*	40,895	658	144,984
Sales[1]		3,932,488		3,754,149		4,383,611		12,070,248
Savings as a % of Sector Sales		***0.63%***		***2.85%***		***1.47%***		***1.63%***
C&I	*151*	**144,404**	*161*	**154,375**	*133*	**241,674**	*445*	**540,454**
C&I NC & Major Rennovation	83	46,935	84	72,624	84	100,133	251	219,692
C&I Retrofit	62	95,709	64	78,706	49	141,541	175	315,956
C&I Direct Install	6	1,760	13	3,046	-	-	19	4,806
Sales[1]		36,992,397		41,047,774		44,280,118		122,320,289
Savings as a % of Sector Sales		***0.39%***		***0.38%***		***0.55%***		***0.44%***

* Several MF LI buildings are under commercial rate. Each unit is counted as one participant.

[1] For 2011, sales from 2011-2012 split year used; for 2012, sales from 2012-2013 split year used; for 2013 sales from 2013-2014 split year used.

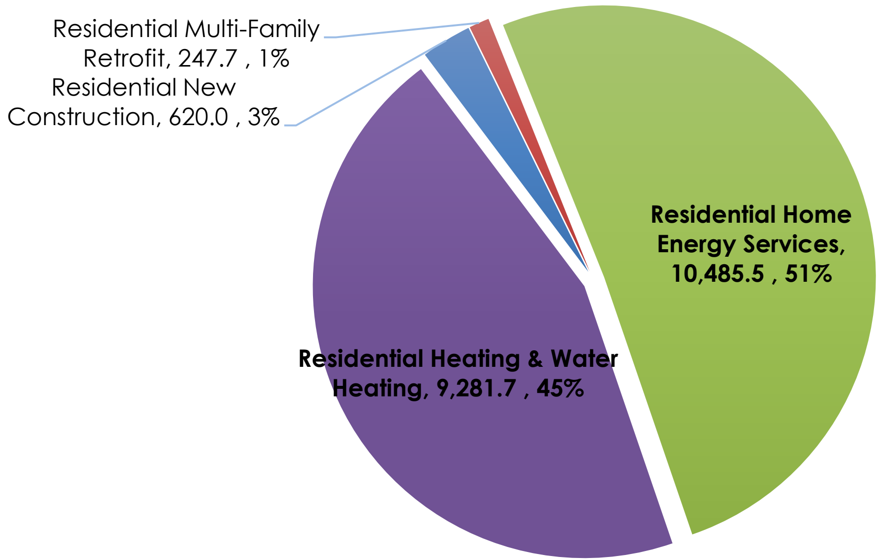
2013 EE Savings Characterization

2013 Evaluated Energy Savings by Initiative, MMBtu



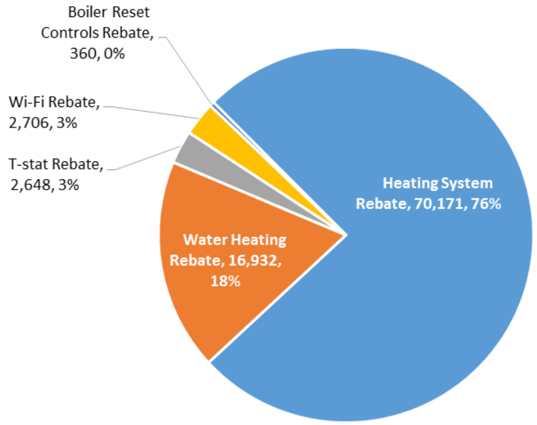
2013 EE Savings - Residential

2013 Evaluated Energy Savings Residential Initiatives, MMBtu



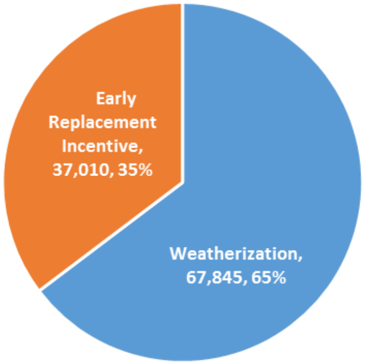
2013 EE Savings-Residential

- Residential Heating & Water Heating (HEHE)
  - 76% of savings from heating systems
    - 67% or 47,049 therms from Boilers
    - 33% or 23,112 therms from Furnaces
  - 18% from water heating
  - 3% Wi-Fi T-Stat
  - 3% Programmable T-Stat
  - <1% Boiler Reset Controls



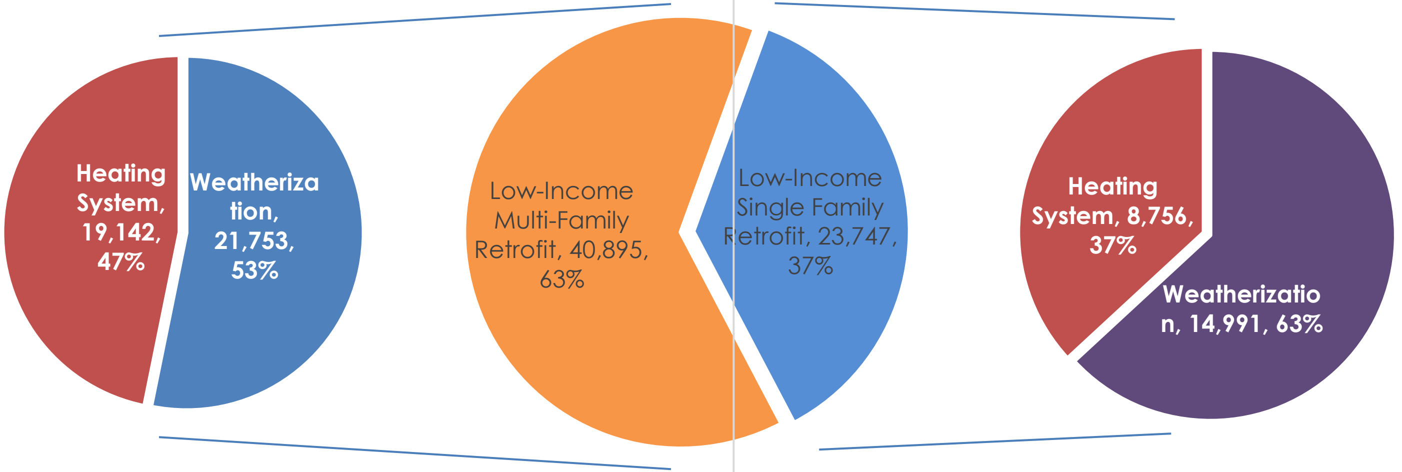
2013 EE Savings-Residential

- Home Energy Services
  - 65% of savings comes from weatherization
    - 67,845 therms from weatherization
  - 35% from Early Boiler Replaceme
    - 37,010 therms
  - <1% Boiler Reset Controls
  - *Total Audits 1,141*
    - *Early Boiler Replacements 99 (8.75%*
    - *Weatherization 310 (27%)*



2013 EE Savings – Low Income

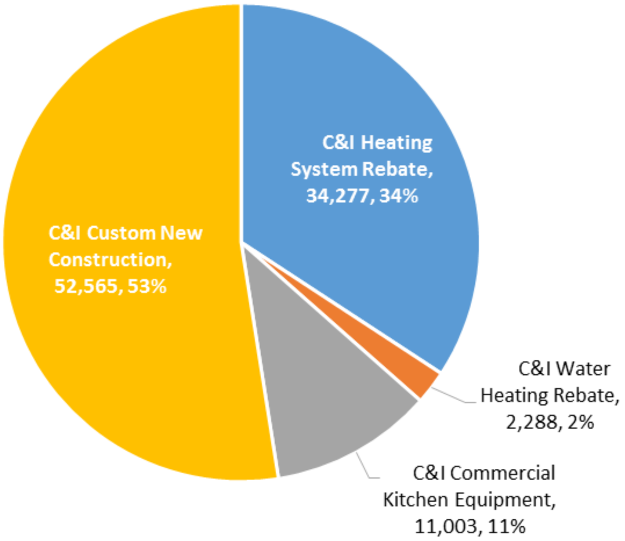
Low Income Programs



Overall the LI Program exceeded Savings goals, by nearly 52%. The Multifamily Retrofit program exceeded its goal by over 150%, while the Single Family program was lightly under its target (met 90.3% of goal).

2013 EE Savings – C&I NC

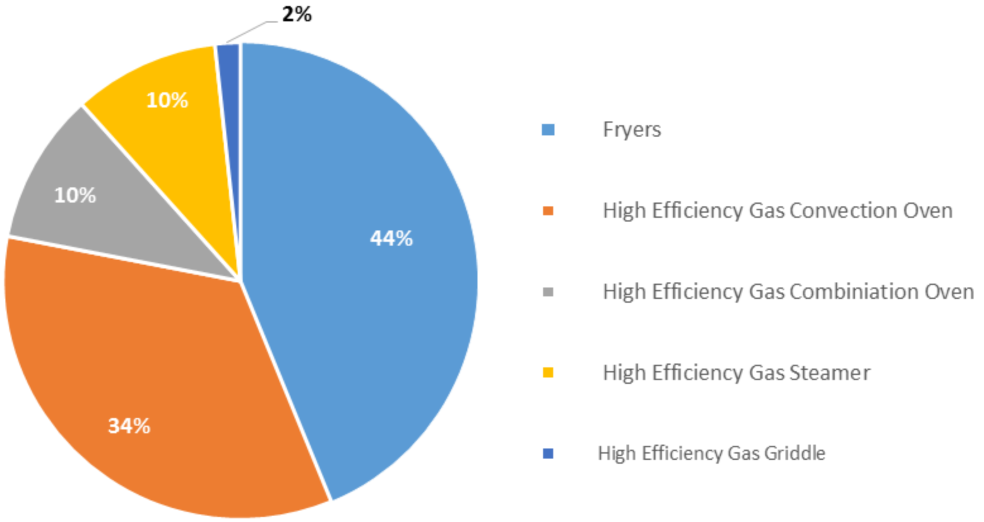
- Of the Total Savings from the C&I New Construction sector, over half was from custom installations. The rest is broken out as follows:
  - Heating Systems 34%
  - Commercial Kitchen 11%
  - Water Heating 2%



2013 EE Savings – C&I NC

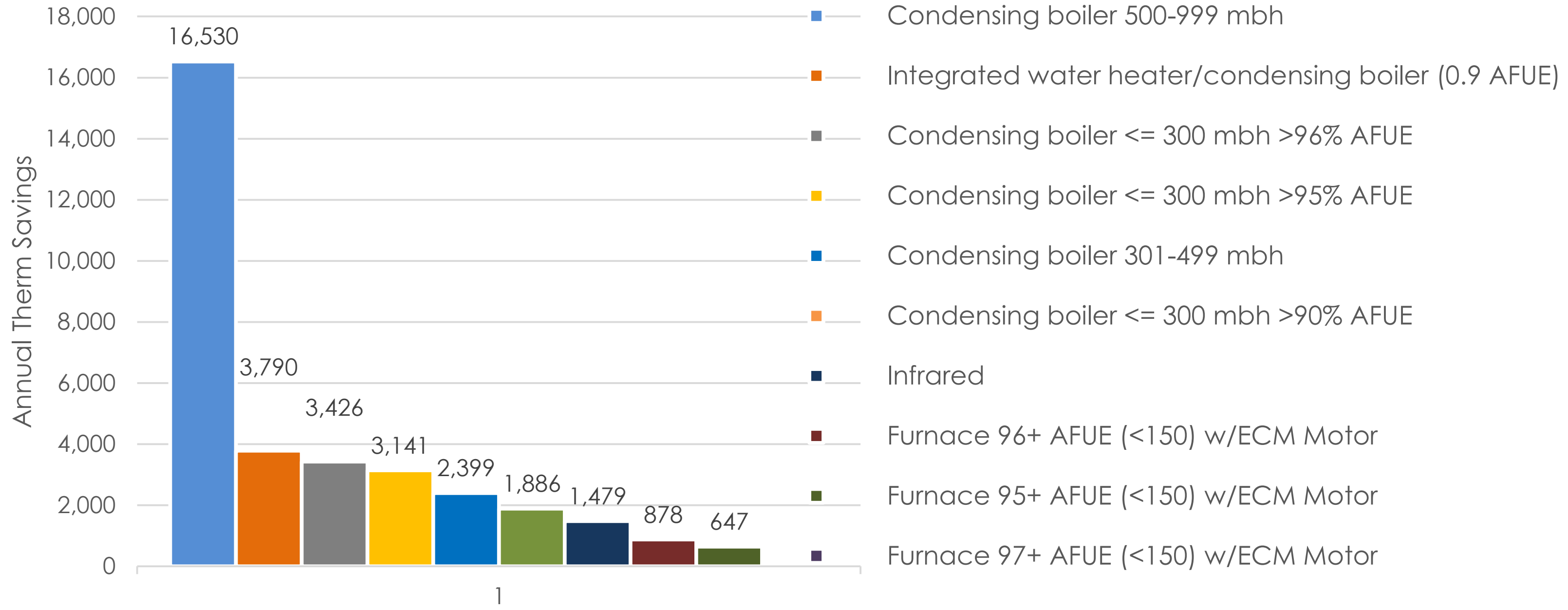
- Types of Commercial Kitchen Equipment

(percentage of total savings from kitchen equipment)



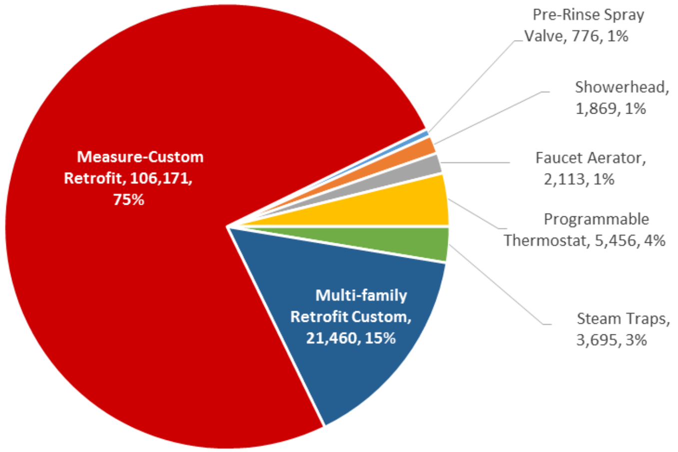
2013 EE Savings – C&I NC

- Types of Space Heating Equipment



2013 EE Savings – C&I Retrofit

- Of the Total Savings from the C&I New Construction sector, about three quarters was from custom installation.



Custom retrofit measures included steam traps, Boilers, Dryers, EMS, Kitchen Hood Controls and an Industrial Dryer. The Industrial Dryer comprised more than half of the custom measure savings.

APPENDICES

- Appendix A – Survey Instruments
- Appendix B – Site Visit Data Collection Forms
- Appendix C – Supplemental Information
- Appendix D – Sector Surveys Raw Data Results

Liberty Utilities

GDS Associates, Inc.
ENGINEERS & CONSULTANTS

Liberty Utilities – Remaining Potential Study Final Report

February 2nd, 2015

Table of Contents

Executive Summary - Purpose

This report presents Liberty Utilities-specific results from a comprehensive, six month assessment of remaining energy efficiency potential within Liberty Utilities (formerly NEGC), Berkshire Gas, Unitil Gas and Unitil Electric service territories.

Executive Summary - Order

- In addition to assisting the small PAs in quantifying remaining potential within their service territories, this effort was conducted in accordance with the Massachusetts Department of Public Utilities' January 31, 2013 Order D.P.U. 12-100 through D.P.U. 12-111 (sections IV.B.2.a & 4.a – pages 18, 19 & 40) and subsequent DOER Consultant feedback.
- Specifically, Section IV.B.2.a states:
  - "The Program Administrators with an aggregate three-year savings goal of greater than 20 percent below the statewide three-year aggregate goal will conduct a study, either jointly or individually, during the upcoming three-year term to document the penetration of energy efficiency within its service territory and the remaining cost-effective energy efficiency opportunities available.."

Executive Summary – Savings Goals

For the 2013-2015 Energy Efficiency Plan, Liberty's three-year savings goals fell short of the statewide average:

Program Administrator	2013	2014	2015	Total 2013-2015
Liberty Utilities	0.83%	0.84%	0.85%	0.84%
Statewide	1.08%	1.17%	1.19%	1.14%
Variance from Statewide Aggregate				**26.3%**

Executive Summary – Key Tasks

Three major task areas were pursued:

1. Secondary data collection/data mining and data gap analysis, including review of ongoing work of the Evaluation Management Committee.
2. Primary data collection sample design, work plan development and implementation of telephone surveys (residential and small/medium C&I customers) and on site data collection (larger C&I customers).
3. Data analysis and reporting of likely achievable and high case remaining potential results.

Executive Summary – Scope/Timing

This was a fast tracked (approx. six month) effort coordinated across four Program Administrators (PAs) culminating in development of four separate, territory-specific reports – one for each PA (Berkshire Gas, Liberty Gas, Unitil Gas and Unitil Electric).

Executive Summary - Savings Potential Results

- The Likely Achievable potential across Liberty's service territory is estimated to be 0.49% of 2016 annual sales (0.48% by 2018)
  - This is much lower than Liberty's current three-year(2013-2015) territory-wide target of 0.84%
- The sector with greatest potential for savings as a % of sector sales remains with Liberty's small commercial customers (0.51% of 2016 sales, 0.60% by 2018)
- Slightly less potential remains within Liberty's residential and largest commercial customer sectors (0.48% & 0.50% respectively by 2018)

Summary Likely Achievable Scenario	2016	2017	2018
Residential			
Annual Therm Savings	185,340	185,629	187,331
Forecast Sales	38,098,740	38,506,920	38,777,850
Savings as % of sales	**0.49%**	**0.48%**	**0.48%**
PA Cost to Achieve	$ 2,429,332	$ 2,423,384	$ 2,436,638
Total Cost to Achieve	$ 3,759,344	$ 3,755,204	$ 3,782,864
Small and Med C&I			
Annual Therm Savings	75,978	83,250	90,700
Forecast Sales	14,939,619	15,141,739	15,229,403
Savings as % of sales	**0.51%**	**0.55%**	**0.60%**
PA Cost to Achieve	$ 281,690	$ 297,149	$ 315,376
Total Cost to Achieve	$ 571,173	$ 602,550	$ 639,010
Largest Customers C&I			
Annual Therm Savings	51,009	51,009	51,009
Forecast Sales	11,299,971	11,479,211	11,368,657
Savings as % of sales	**0.45%**	**0.44%**	**0.45%**
PA Cost to Achieve	$ 134,644	$ 134,644	$ 134,644
Total Cost to Achieve	$ 256,662	$ 256,662	$ 256,662
TOTAL			
Annual Therm Savings	312,326	319,887	329,040
Forecast Sales	64,338,330	65,127,870	65,375,910
Savings as % of sales	**0.49%**	**0.49%**	**0.50%**
PA Cost to Achieve	$ 2,845,665	$ 2,855,177	$ 2,886,657
Total Cost to Achieve	$ 4,587,179	$ 4,614,415	$ 4,678,536

Executive Summary - Top Savings Sources

Residential Sector	Total Savings 185,340	% of Savings
Improved Wall Insulation	45,231	24.4%
Improved Attic/Roof Insulation	23,306	12.6%
Heating System Replacement	11,940	6.4%
Showerhead	10,044	5.4%
RNC New Homes (Heating)	8,800	4.7%
Combo Condensing Boiler/DHW 90%	8,354	4.5%
Boiler Reset Control	5,490	3.0%
Boiler 95%	5,443	2.9%
Early Retirement (FHW) - Retire	4,884	2.6%
DHW - Indirect	3,917	2.1%

Top 3 Residential Measures:

- Wall insulation
- Attic Insulation
- Heating system replacement

Small/Medium Commercial	Total Savings 75,978	% of Savings
Custom - Small & Medium	39,568	52.1%
Kitchen equipment	9,398	12.4%
Condensing Boiler 500-999 mbh (.90 TE)	4,989	6.6%
Showerhead	4,352	5.7%
Steam Traps	3,984	5.2%
Faucet Aerator	2,213	2.9%
Programmable Thermostat	2,029	2.7%
Condensing Boiler 301-499 mbh (.90 TE)	1,810	2.4%
DHW systems	1,722	2.3%
Boiler Reset Controls (retrofit only)	1,101	1.4%

Large Commercial	Total Savings 51,009	% of Savings
Steam Traps	20,316	39.8%
Showerhead	5,964	11.7%
Condensing Boiler 500-999 mbh (.90 TE)	4,989	9.8%
Faucet Aerator	4,190	8.2%
Custom - Large	3,768	7.4%
Programmable Thermostat	2,268	4.4%
Kitchen equipment	2,080	4.1%
Condensing Boiler 301-499 mbh (.90 TE)	1,810	3.5%
Boiler Reset Controls (retrofit only)	1,651	3.2%
Condensing Unit Heater <= 300 mbh	951	1.9%

Top 3 Small/Medium Commercial Measures

- Custom measures
- Kitchen equipment
- Condensing boilers 500-999 mbh (0.90 TE)

Top 3 Large Commercial Measures:

- Steam traps
- Low-flow showerheads
- Condensing boilers 500-999 mbh (0.90 TE)

Executive Summary – Key Findings

Results from review of secondary and primary data sources suggest:

- A somewhat limited potential exists for cost effective energy efficiency savings projects within Liberty's small/medium and large commercial sector over the next 3 to 5 years.
  - A majority Liberty's 19 largest customers have already participated, with few additional major projects on their near-term planning horizons.
- Economic challenges within Liberty's service territory are making it difficult for residential and business customers to prioritize and pursue energy efficiency projects.
- The sector with greatest potential for savings as a % of sector sales remains with Liberty's small commercial customers
  - Although customers within this sector are typically cash constrained, increased focus on Liberty's small commercial customer base could yield additional savings.

Service Territory Characterization

Residential – 768 average annual therms/customer (50,056 customers)

- 805 average annual therms/customer (47,131 heat customers)
- 160 average annual therms/customer (2,925 non-heat customers)
- 3,300 (7%) of Liberty's residential customers have been program participants within the past 3 years (including multiple measures at a single participant location, repeat participants and low income customers)

Forecast	Residential - Non Heat			Residential - Heat			Total		
Split -Year	MMBTU	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust
2014-2015	48,625	3,076	158	3,721,932	46,151	806	**3,770,557**	**49,227**	766
2015-2016	47,890	3,001	160	3,761,984	46,661	806	**3,809,874**	**49,662**	767
2016-2017	47,031	2,925	161	3,803,661	47,180	806	**3,850,692**	**50,105**	769
2017-2018	45,909	2,850	161	3,831,876	47,635	804	**3,877,785**	**50,485**	768
2018-2019	44,787	2,775	161	3,856,348	48,027	803	**3,901,135**	**50,802**	768
% Change over 5 yrs	**-8%**	**-10%**	**2%**	**4%**	**4%**	**0%**	**3%**	**3%**	**0%**
Average	**46,848**	**2,925**	**160**	**3,795,160**	**47,131**	**805**	**3,842,009**	**50,056**	**768**

Service Territory Characterization

Commercial – 6,044 average annual therms/customer (4,364 customers)

- 1,779 average annual therms/customer (2,842 small customers)
- 23,326 average annual therms/customer (440 medium customers)
- 428,521 average annual therms/customer (19 large customers)
- 377 (11%) of Liberty's commercial customers have been program participants within the past 3 years (including repeat participants and a majority of Liberty's largest customers)

Forecast	LLF C&I			HLF C&I			Total		
Split -Year	MMBTU	Customers	Therm/Cust	MMBTU	Customers	Therm/Cust	MMBTU	Customers	Therm/Cust
2014-2015	1,445,208	3,583	4,034	1,140,271	706	16,151	**2,585,479**	**4,289**	**6,028**
2015-2016	1,465,592	3,626	4,042	1,158,367	708	16,361	**2,623,959**	**4,334**	**6,054**
2016-2017	1,485,354	3,666	4,052	1,176,741	709	16,597	**2,662,095**	**4,375**	**6,085**
2017-2018	1,494,398	3,694	4,045	1,165,408	708	16,461	**2,659,806**	**4,402**	**6,042**
2018-2019	1,501,329	3,716	4,040	1,157,221	706	16,391	**2,658,550**	**4,422**	**6,012**
% Change over 5 yrs	**3.9%**	**3.7%**	**0%**	**1.5%**	**0.0%**	**1%**	**2.8%**	**3.1%**	**0%**
Average	**1,478,376**	**3,657**	**4,043**	**1,159,602**	**707**	**16,392**	**2,637,978**	**4,364**	**6,044**

METHODOLOGY

There were three major tasks completed as a part of this effort:

1. Secondary Data Collection/Data Mining
2. Primary Data Collection
3. Data Analysis and Reporting

Methodology – Secondary Data

Task 1 – Secondary Data Collection Activities:

- Reviewed existing evaluation reports including ongoing evaluation planning and implementation activities assessments.
  - Participated as Liberty's representative in relevant Evaluation Management Committee meetings including: Residential, C&I and Cross-Cutting working groups.
- Reviewed utility specific data
  - Customer data and program data provided by Liberty.

Methodology – Secondary Data

Findings:

- Very little territory-specific data available from statewide evaluation efforts.
- Utility specific data from Liberty was used in Task 3 – Data Analysis.

Methodology – Primary Data

Task 2 – Primary Data Collection Activities:

- Used to fill gaps identified through Task 1 effort
- Used to develop savings estimates for Task 3 data analysis and reporting
  - Telephone Surveys
  - On-Site Surveys

Methodology – Sample Design

- Residential – A sample size of 41 was targeted to obtain a confidence and precision of 80/10 at the Residential sector level.
- Commercial and Industrial – A sample size of 41- split between small and medium commercial phone surveys and larger commercial/industrial site visits - was targeted to obtain a confidence and precision of 80/10 at the C&I sector level.
- Territory Level – Overall, a goal of 82 surveys was targeted to achieve statistical significance of at least 90/10 across the Liberty's service territory.

Methodology – Sample Selection

- Residential – A random sample of 41households was ultimately selected for phone surveys by study team member RKM Research & Communications,
  - The sample was drawn from a randomized list of Residential Customers (Rates R1, R2, R3 & R4) provided by Liberty Utilities.
- Small Commercial – A random sample of 42 customers was ultimately selected for phone surveys by study team member RKM Research & Communications.
  - The sample was drawn from a randomized list of Small Commercial Customers (Rates: G41, G42, G51 & G52) provided by Liberty Utilities.
- Large Commercial & Industrial – A randomly selected sample of 16 customers were ultimately recruited for on-site data collection by GDS field staff.
  - The sample was drawn from a randomized list of Liberty's pool of Medium and Large Commercial & Industrial Customers (Rates: G43 & G53 and several G42 & G52).
  - A randomized list of customers was provided and called through, in order, to avoid sample bias and procure a representative mix of participating and non-participating customers.
  - Soft leads were recruited with the help of utility representatives. GDS then contacted the customer and set-up a time to complete the site visit. Some coordination with DNV-GL was also required to avoid duplication of effort with their simultaneous site data collection efforts for another ongoing evaluation project and to minimize customer confusion.

Methodology – Final Sample Sizes

Final Sample Sizes				
	Residential Customer Population	# Phone Surveys Targeted	# Phone Surveys Completed	Achieved Confidence/Precision
Residential Telephone Surveys	45,402	41	41	80/10
C&I Customer Surveys*	3,319	21 (phone) / 20 (site)	42 (phone)/ 16 (site)	80/8.3
Territory Level	48,721	62 (phone) / 20 (site)	83 (phone) / 16 (site)	90/8.3

* Includes a mix of on -site data collection and telephone surveys

During fielding of the small commercial telephone surveys, the target sample size was increased to from 21 to 41 to collect more data on smaller to medium sized commercial customers.

METHODOLOGY – PHONE SURVEYS

Residential Response Rates:

- The overall response rate of the Residential phone surveys was ***8.7%.***
- A total of 1,253 customers were dialed, and 41 surveys were completed.
- 23 calls experienced a language barrier ***(1.84%)***

Call Code	Disposition	Total	%TOTAL DIALINGS
1	Complete	41	3.27%
2	No Answer	51	4.07%
3	Answering machine	468	37.35%
4	Busy	25	2.00%
5	Bad number	124	9.90%
6	Fax number	4	0.32%
7	Call intercept	0	0.00%
8	Appointment	24	1.92%
9	First refusal	377	30.09%
10	Second refusal	43	3.43%
11	Language barrier	23	1.84%
12	No eligible respondent	10	0.80%
13	Business - NPR	29	2.31%
14	Never call	22	1.76%
15	Quota full	0	0.00%
16	Partial - Callback	5	0.40%
17	Partial - Refusal	7	0.56%
	TOTAL DIALINGS	**1253**	**100%**
	RESPONSE RATE(%)	***8.7***	

METHODOLOGY – PHONE SURVEYS

Commercial Response Rates:

- The overall response rate of the Small Commercial phone surveys was ***8.8%.***
- A total of 1386 customers were dialed, and 42 surveys were completed.
- 7calls experienced a language barrier ***(0.51%)***

Call Code	Disposition	Total	%TOTAL DIALINGS
1	Complete	42	3.03%
2	No Answer	68	4.91%
3	Answering machine	424	30.59%
4	Busy	35	2.53%
5	Bad number	101	7.29%
6	Fax number	24	1.73%
7	Call intercept	1	0.07%
8	Appointment	77	5.56%
9	First refusal	405	29.22%
10	Second refusal	45	3.25%
11	Language barrier	7	0.51%
12	No eligible respondent	88	6.35%
13	Business - NPR	0	0.00%
14	Never call	11	0.79%
15	Quota full	4	0.29%
16	Partial - Callback	15	1.08%
17	Partial - Refusal	39	2.81%
	TOTAL DIALINGS	**1386**	**100%**
	RESPONSE RATE(%)	***8.8***	

Methodology – Data Analysis

Task 3 – Data Analysis Activities:

- Reviewed raw survey data
- Determined end-use saturation and efficiency penetrations by customer sector
- Developed remaining energy efficiency potential savings estimates

Methodology – Survey Data Review

- Raw telephone survey and on-site data collection results were reviewed, analyzed and summarized
- Sector specific presentations were developed to document detailed results and identify key findings from each research area including:
  - Demographics/firmography
  - Individual energy end-use findings
  - Past purchases and practices
  - Attitudes
  - Program awareness, participation and satisfaction
- Survey and site-visit data was then used to develop estimates of Potential Savings

METHODOLOGY – SAVINGS ESTIMATES

A combination of data sources were used to develop factors for calculating remaining potential energy savings:

- Survey and site visit results
- Customer counts
- Existing efficiency program measures
- Existing program data on energy savings
- Massachusetts 2013 Report Technical Reference Manual
- Current utility Net-To-Gross (NTG) ratios
- Benefit/Cost modeling (Total Resource Cost Test – TRC)

Methodology – Savings Estimates

Equation of Potential Energy Savings

Participation × Savings (therms) × NTG Ratio

Methodology – Participation Est.

Participation

GDS used a number of factors to arrive at an annual estimate of measure participation

- Estimate of base homes
  - Customers with gas heating and percent of customers with the baseline measure (i.e. boiler, furnace)
- Applicability factor
  - Split between competing measures (i.e. 90% AFUE boiler, 95% AFUE boiler)
  - Accounts for consumer choice
  - Used past program installations to estimate future installation ratios
  - Benefit/Cost modeling was conducted using the TRC test to assess cost-effectiveness of individual measures. However, measures with B/C ratios less than 1.0 were not dropped from the analysis because cost-effectiveness is not assessed at the measure level in MA, but at the program level . B/C ratios were used, where appropriate, to prioritize installations among competing measures → greater factor weight applied to measures with a higher B/C ratio.
- Burnout rate of measure (1/measure life)
  - What percentage of the market is expected to need replacing
- Convertibility factor
  - What percent might not be physically convertible to new technology or other limitation (i.e. wall insulation improvements would not be available for brick, stone or asbestos siding exteriors)

Methodology – Participation Est.

Participation

GDS used a number of factors to arrive at an annual estimate of measure participation

- Energy Efficiency Saturation
  - Percentage of market that is selecting efficient equipment
  - Based on survey data
- Willingness to Participate
  - Included only in the "likely achievable potential scenario"
  - Not included in the "high-case" scenario (i.e., before consideration of territory-specific realities, customer behaviors and measure installation barriers)
  - Reflects survey response assessed percentage of customers likely to move forward with a project

Methodology – Measure Savings

Savings (therms)

GDS used a number of sources to estimate measure specific savings

- 2013 Report Massachusetts Technical Reference Manual
  - Included deemed savings values for many measures
- Utility Specific Program Data
  - Used for New Construction Program
- REM Rate Energy Modeling
  - Calibrated to utility climate and average annual heating usage

Methodology – NTG Ratios

NTG Ratios

GDS used current NTG ratios to adjust savings estimates

- NTG Ratios
  - Utility specific or statewide where applicable
  - Included or adjusted for free-ridership and spillover rates in some cases, but not all
  - Typically developed through rigorous evaluation efforts

METHODOLOGY - SCENARIOS

When estimating remaining potential, two modeling scenarios were run:

1. Likely achievable potential scenario – This scenario represents the study team's best estimate of the remaining potential within Liberty's service territory and applies a "customer willingness" factor derived from telephone survey and site visit responses, along with sector-level budget constraints where applicable.
2. High-case scenario – This scenario represents the study team's estimated upper bound of the remaining potential without consideration of territory-specific realities, including customer behaviors and budget constraints.

High-Case Scenario - Savings Potential Results

- The total High-Case savings potential across Liberty's service territory is estimated to be 1.23% of 2016 annual sales (1.28 by 2018).
  - The PA cost to achieve this potential is substantial at over $8.7M in 2016 ($8.9M in 2018) vs $3.3M current budget.
- Greatest potential, as % of sector sales, is in the residential customer sector (1.66% of 2018 sales).
- Limited potential exists within the small/medium and large commercial sectors(0.83% & 0.60% respectively in 2018).

Summary - High-Case	2016	2017	2018
Residential			
Annual Therm Savings	631,621	637,597	642,122
Forecast Sales	38,098,740	38,506,920	38,777,850
Savings as % of sales	**1.66%**	**1.66%**	**1.66%**
PA Cost to Achieve	$ 8,280,529	$ 8,327,848	$ 8,348,820
Total Cost to Achieve	$ 12,801,978	$12,897,717	$12,959,002
Small and Med C&I			
Annual Therm Savings	98,553	113,570	126,223
Forecast Sales	14,939,619	15,141,739	15,229,403
Savings as % of sales	**0.66%**	**0.75%**	**0.83%**
PA Cost to Achieve	$ 321,314	$ 354,365	$ 385,345
Total Cost to Achieve	$ 678,199	$ 743,944	$ 804,887
Largest Customers C&I			
Annual Therm Savings	63,925	63,925	68,127
Forecast Sales	11,299,971	11,479,211	11,368,657
Savings as % of sales	**0.57%**	**0.56%**	**0.60%**
PA Cost to Achieve	$ 140,845	$ 140,845	$ 169,118
Total Cost to Achieve	$ 274,105	$ 274,105	$ 303,353
TOTAL			
Annual Therm Savings	794,099	815,092	836,473
Forecast Sales	64,338,330	65,127,870	65,375,910
Savings as % of sales	**1.23%**	**1.25%**	**1.28%**
PA Cost to Achieve	$ 8,742,688	$ 8,823,058	$ 8,903,283
Total Cost to Achieve	$ 13,754,282	$13,915,767	$14,067,242

Territory-Specific Insights - Residential

- Program awareness, participation & satisfaction
  - More than half of Liberty's residential respondents were not aware of Liberty's energy efficiency programs or products – participation appears hampered by other cash priorities or the transient nature of their accommodations
- Demographics
  - Liberty's residential telephone survey respondents include a majority of younger (18-54) , and low-income residents .
- Home characteristics
  - A large majority of Liberty's residential building stock is old (35+ years) – typically good candidates for building envelope improvements. However, nearly half of Liberty's residential customers live in apartments and/or rent their homes – making it difficult to encourage such improvements.
- ENERGY STAR® awareness
  - There is potential opportunity for reaching out to a large proportion of Liberty's residential population who, 44% based on respondent data, are not very or at all familiar with ENERGY STAR®.
- Past purchase practices
  - A majority of residential respondents appear to have energy efficiency features on their radar screens – but less than a quarter have acted on that vision in Liberty's territory.
- Attitudes
  - Although cost is a major reason cited for not pursuing energy efficiency opportunities, approximately 2/3rd of respondents express interest in purchasing energy efficient equipment for a multitude of reasons.

Territory-Specific Insights - Residential

- Building envelope
  - There remains some likely achievable potential for building envelope improvements within Liberty's residential customer sector.
- Space heating
  - Potential for heating system replacements exists in homes with older systems, where owners may be looking for replacements within the next five years. This may require targeted outreach to apartment building owners/property managers. Savings associated with controllable thermostats may be an opportunity for tenants that pay for their own fuel.
- Water heating
  - Potential for water heater replacements exists in homes with older units, where owners may be looking for replacements within the next five years. This may require targeted outreach to apartment building owners/property managers. Additional opportunities may exist for water saving devices.
- Clothes washing
  - Approximately 1/3rd of Liberty's residential customer respondents do not own a clothes washer /dryer. Potential for energy efficient clothes washer and dryers exists in homes with older units, where owners may be looking for replacements within the next five years.
- Dishwashing
  - Just over 1/3rd of Liberty's residential customer respondents reported owning a dishwasher. Potential for energy efficient dishwashers exists in homes with older units, where owners may be looking for replacements within the next five years.
- Hot tubs and heated pools
  - Based on survey responses, there does not appear to be much potential for efficiency improvements within the pool and hot tub end-use.

Territory-Specific Insights – Small/Medium Commercial

- Program awareness, participation & satisfaction
  - A majority (52%) of Liberty's small business customers are non-participants and all of those who have participated(48%) would be interested in doing so again.
- Firmographics
  - Liberty's small commercial business base appears stable, with potential opportunities for energy efficiency investments in both leased and owned buildings. Small business owners would be best target for decisions.
- Building size, age & use
  - The make-up of Liberty's small commercial building stock (relatively old, large square footage, small number of employees, sufficient hours of operation, somewhat efficiency conscious), suggests potential opportunities for targeted efficiency improvements.
- Past purchase practices
  - Based on survey responses, there does not appear to be much opportunity for efficiency projects within Liberty's small commercial customer sector over the next 12 months.
- Attitudes
  - Rebates remain a major motivator for customer action in the small business sector.

Territory-Specific Insights – Small/Medium Commercial

- Building envelope
  - Good opportunities exist for building envelope improvements within Liberty's small commercial business sector.
- Space heating
  - Potential for replacement heating systems, heating system tune-ups and programmable thermostats exists within Liberty's small commercial business sector.
- Water heating
  - Based on survey responses, only a small potential for water heater replacements currently appears to exist within Liberty's small commercial business sector, but a majority (57%) of Liberty's small business customer respondents are not taking advantage of other water saving measures (i.e., faucet aerators).
- Commercial kitchen and laundry
  - A small, but high energy use market exists within Liberty's small business sector for commercial kitchen and laundry customers.
- On-site generation
  - 12% of Liberty's small commercial customer respondents reported having onsite generation (3 emergency back-up generators, 1 onsite electric generator, 1 unsure source) . There could be an opportunity to explore this market.

Territory-Specific Insights – Large Commercial

- Program awareness, participation and satisfaction
  - A majority (94%) of large business customer respondents are aware of and have participated (84%) in Liberty's energy efficiency programs and are interested in doing so again.
- Past purchase practices
  - Over 50% of respondents have completed renovation projects in the past 5 years.
    - Over 17% of these included lighting renovations.
  - 18% of respondents are planning a renovation in the next 12 months.
    - 12% indicate potential projects, but are unsure.
  - A small market for efficiency projects (18% of respondents) may exist within Liberty's large commercial customer sector over the next 12 months.
- Attitudes
  - Lower bills and receipt of rebates remain major motivators for customer action in the large business sector.
  - These attitudes are also impacted by the number of businesses that have moved, sold, gone out of business or otherwise have cut back due to recession.

Territory-Specific Insights – Large Commercial

- HVAC
  - Energy savings potential remains for replacement of inefficient steam boilers.
- Water heating
  - Potential appears to exist for efficient water heating equipment, with greater opportunities for pre-rinse spray valves.
- Cooking and laundry equipment
  - Potential appears to exist for efficient C&I cooking and laundry equipment, although certain sites could be targeted for collecting additional information related to natural gas ranges.
- Process equipment
  - Process heating equipment is a significant end use for natural gas in the Liberty territory. There could be opportunities for process efficiency improvements – but given the small number of large customers, limited availability of new projects on the planning horizon and unique characteristics of individual business processes, such determinations are best assessed on a custom/case-by-case basis.
- On-site generation
  - There appears to be an opportunity to explore the potential to include renewably-fueled process–related heating and power generation systems and efficient back-up generation systems.

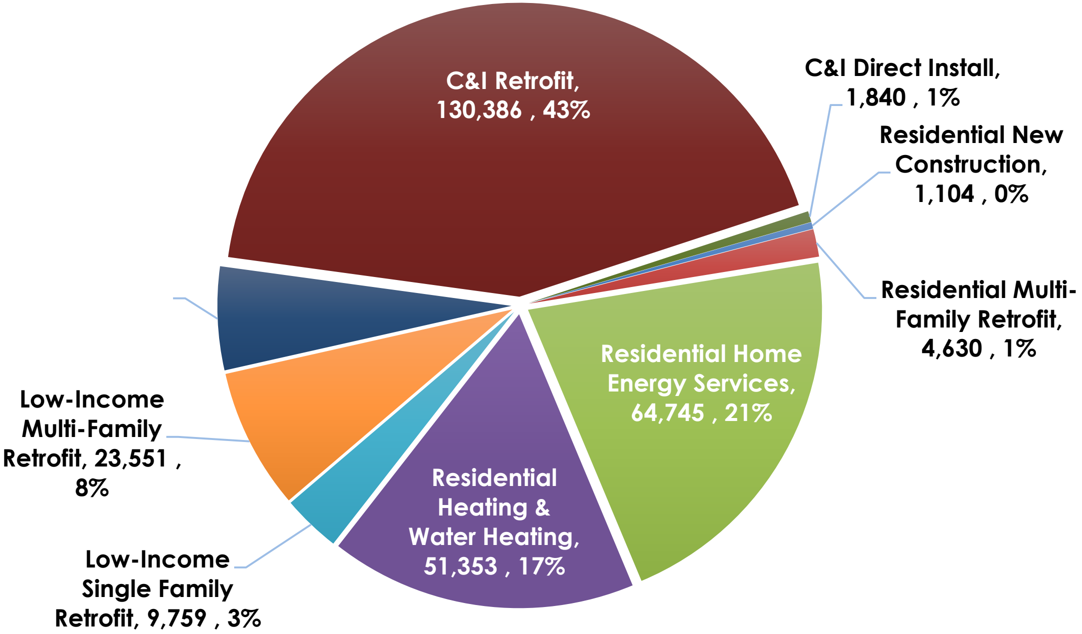
ACTUAL EE SAVINGS CHARACTERIZATION

Program	2011		2012		2013		Three Year Total	
	Participants	Therms	Participants	Therms	Participants	Therms	Participants	Therms
Residential	*931*	**97,568**	*983*	**127,338**	*1,146*	**121,832**	*3,060*	***346,738***
New Construction	14	4,073	11	2,335	8	1,104	33	7,512
Home Energy Services (HES)	542*	24,302	797*	34,918	567	64,745	1,906	123,965
MF Retrofit	1	5,144	1	303	**4**	4,630	6	10,078
Heating and Water Heating Equipment	916	64,049	971	89,782	567	51,353	2,454	205,184
Sales		24,169,740		29,714,570		34,479,240		88,363,550
Savings as a % of Sector Sales		***0.40%***		***0.43%***		***0.35%***		***0.39%***
Low Income	*59*	**19,120**	*71*	**16,777**	*110*	**33,310**	240	***69,207***
Single Family Retrofit	34	8,835			41	9,759	na	na
MF Retrofit	25	10,285	71	16,777	69	23,551	na	na
Sales		8,581,920		9,704,100		10,553,120		28,839,140
Savings as a % of Sector Sales		***0.22%***		***0.17%***		***0.32%***		***0.24%***
C&I	*147*	**68,827**	*150*	**78,129**	*80*	**149,531**	*377*	***296,487***
C&I NC & Major Rennovation	47	11,539	48	16,429	30	17,305	125	45,273
C&I Retrofit	86	54,339	91	56,784	37	130,386	214	241,509
C&I Direct Install	14	2,949	11	4,917	13	1,840	38	9,705
Sales		21,473,420		22,428,150		25,571,310		69,472,880
Savings as a % of Sector Sales		***0.32%***		***0.35%***		***0.58%***		***0.43%***

* Includes 274 participants from MassSAVE Program for 2011 and 416 from 2012.

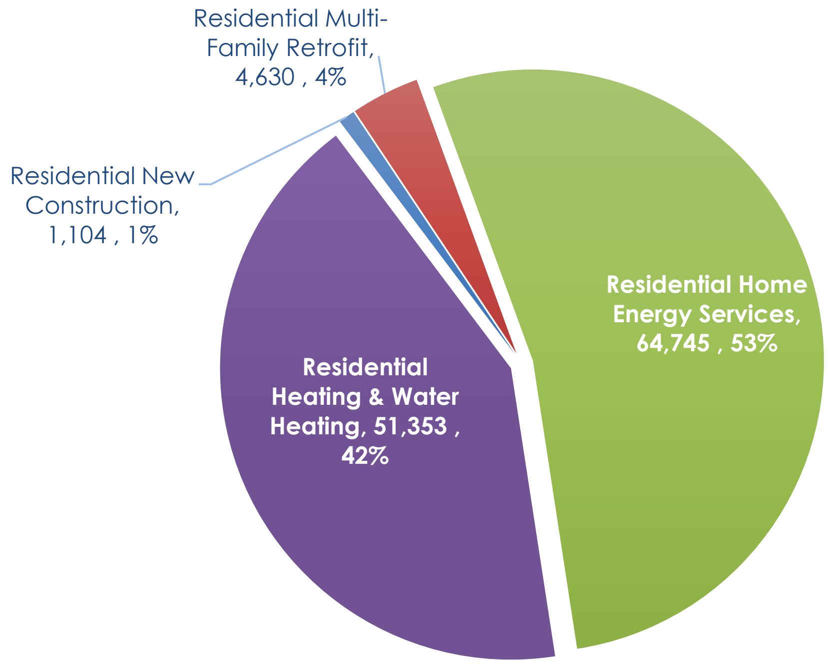
2013 EE Savings Characterization

2013 Evaluated Energy Savings by Initiative, therms



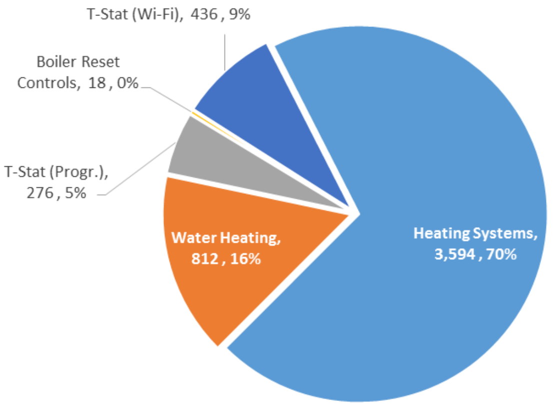
2013 EE Savings - Residential

2013 Evaluated Energy Savings Residential Initiatives, MMBtu



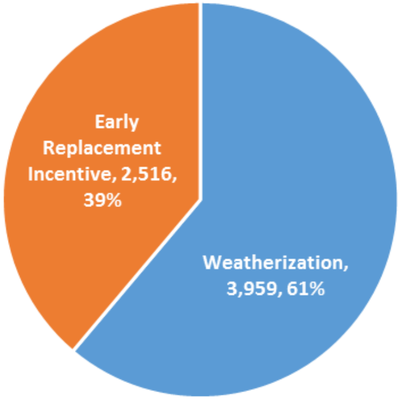
2013 EE Savings-Residential

- Residential Heating & Water Heating (HEHE)
  - 70% of savings from heating systems
    - 71% or 2,552 MMBtu from Boilers
    - 29% or 1,043 MMBtu from Furnaces
  - 16% from water heating
  - 9% Wi-Fi T-Stat
  - 5% Programmable T-Stat
  - <1% Boiler Reset Controls



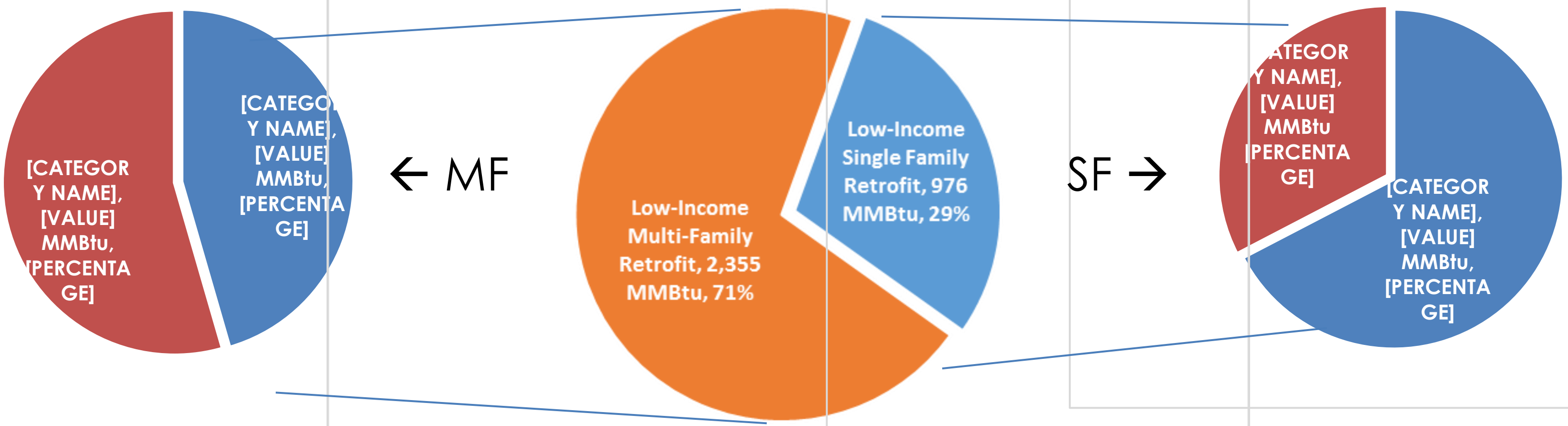
2013 EE Savings-Residential

- Home Energy Services
  - 61% of savings comes from weatherization
    - 3,959 MMBtu from weatherization
  - 39% from Early Boiler Replacement
    - 2,516 MMBtu
  - Weatherization Measures:
    - Attic, Wall, Crawl Space Insulation
    - Faucet Aerators, Showerheads
    - Thermostats



2013 EE Savings – Low Income

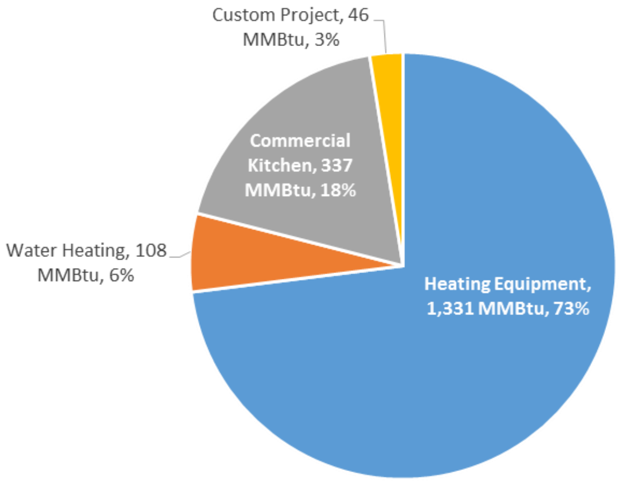
Low Income Programs



Overall the LI Program exceeded Savings goals, by nearly 52%. The Multifamily Retrofit program exceeded its goal by over 150%, while the Single Family program was lightly under its target (met 90.3% of goal).

2013 EE Savings – C&I NC

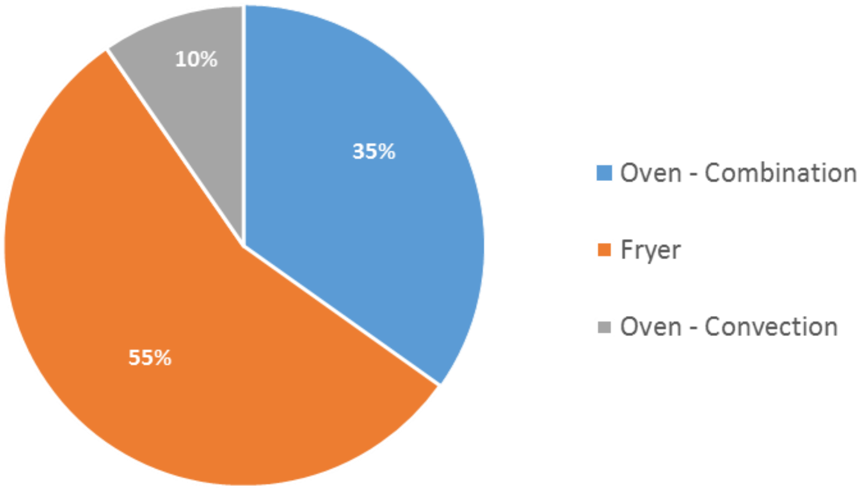
- Of the Total Savings from the C&I New Construction sector, nearly three quarters was from heating equipment. The rest is broken out as follows:
  - Commercial Kitchen 18%
  - Water Heating 6%
  - Custom Projects 3%



2013 EE Savings – C&I NC

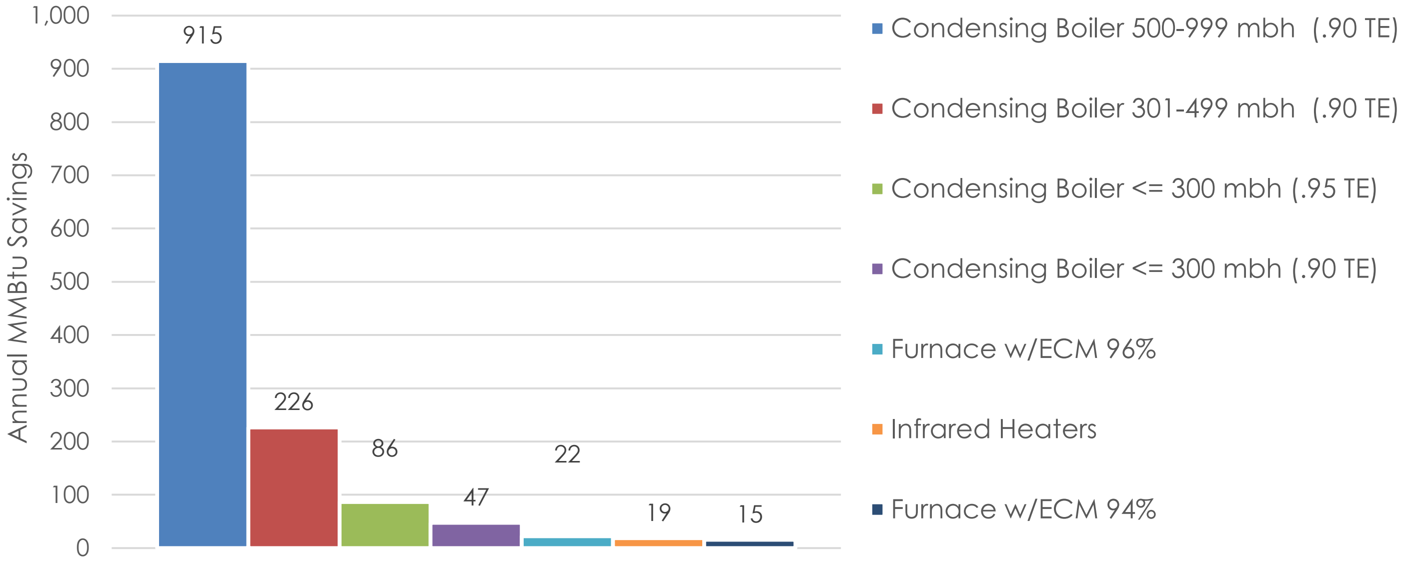
- Types of Commercial Kitchen Equipment

(percentage of total savings from kitchen equipment)



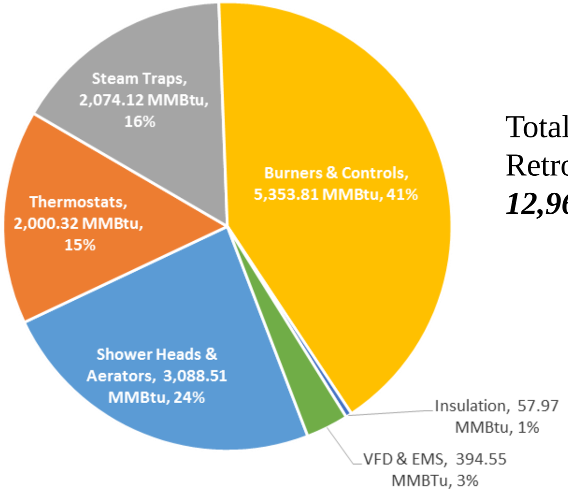
2013 EE Savings – C&I NC

- Types of Space Heating Equipment



2013 EE Savings – C&I Retrofit

- C&I Retrofit and C&I Direct Installation accounted for 13,223 MMBtu in annual savings. 98% came from the C&I Retrofit Program (13,039). Custom retrofit measures accounted for almost all of the C&I Retrofit savings.



Total Custom Retrofit C&I Savings
12,969 MMBtu

Custom retrofit measures included burners & controls, steam traps, faucet and shower aerators, thermostats, insulation and VFDs.

APPENDICES

- Appendix A – Survey Instruments
- Appendix B – Site Visit Data Collection Forms
- Appendix C – Supplemental Information
- Appendix D – Sector Surveys Raw Data Results

Unitil

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GDS Associates, Inc.
ENGINEERS & CONSULTANTS

UNITIL GAS – REMAINING POTENTIAL STUDY
FINAL REPORT

February 2nd, 2015

Table of Contents

Executive Summary - Purpose

This report presents Unitil Gas-specific results from a comprehensive, six month assessment of remaining energy efficiency potential within Unitil Gas, Unitil Electric, Berkshire Gas and Liberty Utilities (formerly NEGC)service territories.

EXECUTIVE SUMMARY - ORDER

- In addition to assisting the small PAs in quantifying remaining potential within their service territories, this effort was conducted in accordance with the Massachusetts Department of Public Utilities' January 31, 2013 Order D.P.U. 12-100 through D.P.U. 12-111 (sections IV.B.2.a & 4.a – pages 18, 19 & 40) and subsequent DOER Consultant feedback.
- Specifically, Section IV.B.2.a states:
  - "The Program Administrators with an aggregate three-year savings goal of greater than 20 percent below the statewide three-year aggregate goal will conduct a study, either jointly or individually, during the upcoming three-year term to document the penetration of energy efficiency within its service territory and the remaining cost-effective energy efficiency opportunities available.."

EXECUTIVE SUMMARY – SAVINGS GOALS

For the 2013-2015 Energy Efficiency Plan, Unitil Gas's three-year savings goals fell short of the statewide average:

Program Administrator	2013	2014	2015	Total 2013-2015
Unitil Gas	0.70%	0.77%	0.85%	0.77%
Statewide	1.08%	1.17%	1.19%	1.14%
Variance from Statewide Aggregate				**32.5%**

Executive Summary – Key Tasks

Three major task areas were pursued:

1. Secondary data collection/data mining and data gap analysis, including review of ongoing work of the Evaluation Management Committee.
2. Primary data collection sample design, work plan development and implementation of telephone surveys (residential and small/medium C&I customers) and on site data collection (larger C&I customers).
3. Data analysis and reporting of likely achievable and high case remaining potential results.

Executive Summary – Scope/Timing

This was a fast tracked (approx. six month) effort coordinated across four Program Administrators (PAs) culminating in development of four separate, territory-specific reports – one for each PA (Berkshire Gas, Liberty Gas, Unitil Gas and Unitil Electric).

Executive Summary - Savings Potential Results

- The Likely Achievable savings potential across Unitil Gas's service territory is estimated to be 0.68% of 2016 annual sales (0.69% by 2018).
  - This is lower than Unitil Gas's current three-year(2013-2015) territory-wide target of 0.77%.
- The sector with greatest potential for savings as a % of sector sales remains with Unitil Gas's large commercial customers (0.81% of 2016 and 2018 sales).
- Less potential remains within Unitil Gas's residential and small/ medium commercial customer sectors (0.59% and 0.66% respectively by 2018).

Summary Likely Achievable Scenario	2016	2017	2018
Residential			
Annual Therm Savings	62,106	63,056	64,459
Forecast Sales	10,540,042	10,693,893	10,856,776
Savings as % of sales	**0.59%**	**0.59%**	**0.59%**
PA Cost to Achieve	$ 960,139	$ 976,036	$ 993,790
Total Cost to Achieve	$ 1,577,546	$ 1,601,097	$ 1,633,048
Small and Med C&I			
Annual Therm Savings	19,246	20,550	21,530
Forecast Sales *	3,218,656	3,231,372	3,249,858
Savings as % of sales	**0.60%**	**0.64%**	**0.66%**
PA Cost to Achieve	$ 116,676	$ 120,040	$ 122,094
Total Cost to Achieve	$ 171,533	$ 177,597	$ 181,611
Large C&I			
Annual Therm Savings	81,956	82,150	82,386
Forecast Sales *	10,111,225	10,151,173	10,209,244
Savings as % of sales	**0.81%**	**0.81%**	**0.81%**
PA Cost to Achieve	$ 279,290	$ 279,373	$ 280,240
Total Cost to Achieve	$ 612,305	$ 612,588	$ 614,245
TOTAL			
Annual Therm Savings	163,308	165,757	168,374
Forecast Sales *	23,869,923	24,076,439	24,315,878
Savings as % of sales	**0.68%**	**0.69%**	**0.69%**
PA Cost to Achieve	$ 1,356,105	$ 1,375,449	$ 1,396,125
Total Cost to Achieve	$ 2,361,385	$ 2,391,282	$ 2,428,904

* Forecast sales data was revised subsequent to initial draft

Executive Summary - Top Savings Sources

Top 3 Residential Measures:

- Wall insulation
- Boilers 95%
- Air sealing

Residential Sector	Total Savings 63,900	% of Savings
Improved Wall Insulation	16,361	25.6%
Boiler 95%	7,794	12.2%
Air Sealing	5,774	9.0%
RNC New Homes (Heating)	5,688	8.9%
Improved Attic/Roof Insulation	4,513	7.1%
Heating System Replacement - ER FHW Custom	3,996	6.3%
Heating System Replacement	2,985	4.7%
Furnace w/ECM 95%	2,544	4.0%
Combo Condensing Boiler/DHW 90%	2,056	3.2%
Faucet Aerator	1,851	2.9%

Executive Summary - Top Savings Sources

Top 3 Small/Medium Commercial Measures:

- Condensing boilers 1701+ mbh (0.90 TE)
- Kitchen equipment
- Programmable thermostats

	Total Savings	
Small/Medium Commercial	**19,246**	**% of Savings**
Condensing Boiler 1701+ mbh (.90 TE)	5,225	27.1%
Kitchen Equipment	4,438	23.1%
Programmable Thermostat	1,749	9.1%
Custom - Small & Medium	1,507	7.8%
Condensing Boiler 1000-1700 mbh (.90 TE)	1,493	7.8%
Faucet Aerator	991	5.1%
Showerhead	984	5.1%
Condensing Boiler 500-999 mbh (.90 TE)	812	4.2%
Condensing Boiler <= 300 mbh (.96 TE)	631	3.3%
Boiler Reset Controls (retrofit only)	537	2.8%

Executive Summary - Top Savings Sources

Top 3 Large Commercial Measures:

- Custom measures
- Condensing boilers 1701+ mbh (0.90 TE)
- Low-flow showerheads

Large Commercial	Total Savings 81,956	% of Savings
Custom - Large	65,947	80.5%
Condensing Boiler 1701+ mbh (.90 TE)	5,225	6.4%
Showerhead	2,913	3.6%
Faucet Aerator	2,072	2.5%
Programmable Thermostat	1,749	2.1%
Condensing Boiler 1000-1700 mbh (.90 TE)	1,493	1.8%
Condensing Boiler 500-999 mbh (.90 TE)	812	1.0%
Condensing Boiler <= 300 mbh (.96 TE)	631	0.8%
Boiler Reset Controls (retrofit only)	269	0.3%
Oven - Convection	232	0.3%

Executive Summary – Key Findings

Results from review of secondary and primary data sources suggest:

- A somewhat limited potential exists for cost effective energy efficiency savings projects within Unitil Gas's residential and business sectors over the next 3 to 5 years.
  - A majority Unitil Gas's 25 largest customers have already participated, with few additional major projects on their near-term planning horizons.
- Economic challenges within Unitil's service territory are making it difficult for residential and small business customers to prioritize and pursue energy efficiency projects.
  - Although customers within these sectors are typically cash constrained, increased focus on Unitil's residential and small business customer base could yield additional savings.

SERVICE TERRITORY CHARACTERIZATION

Residential – 751 average annual therms/customer (14,226 customers)

- 855 average annual therms/customer (11,697 heat customers)
- 267 average annual therms/customer (2,530 non-heat customers)
- 1,284 (9%) of Unitil Gas's residential customers have been program participants within the past 3 years (including multiple measures at a single participant location, repeat participants and low income customers)

Actual Year	Non-Heat			LI Non-Heat			Heat			LI Heat			Total		
	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust
2009	559,230	2,472	226	139,880	474	295	7,238,568	8,781	824	1,884,401	1,931	976	9,822,079	13,658	719
2010	525,202	2,370	222	133,502	519	257	7,003,343	8,749	800	1,811,163	2,090	867	9,473,210	13,728	690
2011	520,451	2,300	226	177,820	557	319	7,055,817	8,736	808	2,087,806	2,173	961	9,841,894	13,766	715
2012	494,065	2,255	219	166,137	544	305	6,189,973	8,769	706	1,873,722	2,315	809	8,723,897	13,883	628
2013	514,810	2,136	241	165,793	578	287	7,137,024	8,828	808	2,196,185	2,465	891	10,013,812	14,007	715
% Change over 5 yrs	-8%	-14%	**7%**	19%	22%	**-3%**	-1%	1%	**-2%**	17%	28%	**-9%**	2%	3%	**-1%**
Average	**522,752**	**2,307**	**227**	**156,626**	**534**	**293**	**6,924,945**	**8,773**	**789**	**1,970,655**	**2,195**	**901**	**9,574,978**	**13,808**	**693**

Forecast Year	Non-Heat			LI Non-Heat			Heat			LI Heat			Total		
	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust
2014	529,823	2,088	254	180,051	583	309	7,772,099	8,739	889	2,462,391	2,536	971	10,944,363	13,946	785
2015	511,659	2,015	254	181,099	585	309	7,293,410	8,860	823	2,381,960	2,626	907	10,368,128	14,086	736
2016	495,270	1,941	255	182,703	588	311	7,396,242	8,980	824	2,465,827	2,717	908	10,540,042	14,226	741
2017	474,609	1,868	254	182,700	591	309	7,491,094	9,100	823	2,545,490	2,807	907	10,693,893	14,366	744
2018	456,085	1,795	254	183,500	593	309	7,589,936	9,221	823	2,627,255	2,897	907	10,856,776	14,507	748
% Change over 5 yrs	-14%	-14%	**0%**	2%	2%	**0%**	-2%	6%	**-7%**	7%	14%	**-7%**	-1%	4%	**-5%**
Average	**493,489**	**1,941**	**254**	**182,010**	**588**	**310**	**7,508,556**	**8,980**	**836**	**2,496,585**	**2,717**	**920**	**10,680,641**	**14,226**	**751**
											Heating Customers		**10,005,141**	**11,697**	**855**
											Non-Heat Customers		**675,500**	**2,530**	**267**

SERVICE TERRITORY CHARACTERIZATION

Commercial – 8,411 average annual therms/customer (1,697 customers)

- 2,071 average annual therms/customer (1,441 small customers – rate codes: G41/G51)
- 21,650 average annual therms/customer (232 medium customers – rate codes: G42/G53)
- 227,052 average annual therms/customer (24 large customers – rate codes: G43/G53)
- 203 (12%) of Unitil Gas's commercial customers have been program participants within the past 3 years (including repeat participants and a majority of Unitil Gas's largest customers)

	Small			Medium			Large			Total		
Actual Year	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust
2009	2,744,010	1,323	2,074	4,515,309	250	18,061	4,536,952	24	189,040	11,796,271	1,597	7,387
2010	2,436,249	1,338	1,821	4,561,167	252	18,100	4,769,635	21	227,125	11,767,051	1,611	7,304
2011	2,618,054	1,339	1,955	4,661,823	261	17,861	6,158,602	25	246,344	13,438,479	1,625	8,270
2012	2,386,285	1,406	1,697	4,277,701	209	20,467	5,736,215	21	273,153	12,400,201	1,636	7,580
2013	2,918,230	1,402	2,081	4,960,407	237	20,930	5,785,011	25	231,400	13,663,648	1,664	8,211
% Change over 5 yrs	**6%**	**6%**	**0%**	**10%**	**-5%**	**16%**	**28%**	**4%**	**22%**	**16%**	**4%**	**11%**
Average	**2,620,566**	**1,362**	**1,926**	**4,595,281**	**242**	**19,084**	**5,397,283**	**23**	**233,413**	**12,613,130**	**1,627**	**7,750**

	Small			Medium			Large			Total		
Forecast Year *	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust	Therms	Customers	Therm/Cust
2014	3,039,653	1,387	2,192	5,245,662	229	22,885	5,620,551	24	230,982	13,905,867	1,641	8,472
2015	2,884,103	1,414	2,040	4,923,321	230	21,364	5,422,008	24	225,917	13,229,432	1,669	7,926
2016	2,942,475	1,441	2,042	4,950,787	232	21,369	5,436,619	24	226,526	13,329,881	1,697	7,853
2017	2,993,449	1,468	2,040	4,967,088	233	21,325	5,422,008	24	225,917	13,382,545	1,726	7,755
2018	3,048,122	1,495	2,039	4,988,971	234	21,307	5,422,008	24	225,917	13,459,102	1,754	7,674
% Change over 5 yrs	**0%**	**8%**	**-7%**	**-5%**	**2%**	**-7%**	**-4%**	**-1%**	**-2%**	**-3%**	**7%**	**-9%**
Average	**2,981,561**	**1,441**	**2,071**	**5,015,166**	**232**	**21,650**	**5,464,639**	**24**	**227,052**	**13,461,365**	**1,697**	**7,936**

* Forecast sales data was revised subsequent to initial draft

Source: FGE G 2009-2020 Cust & Sales 8-11-14.xlsx

METHODOLOGY

There were three major tasks completed as a part of this effort:

1. Secondary Data Collection/Data Mining.
2. Primary Data Collection.
3. Data Analysis and Reporting.

Methodology – Secondary Data

Task 1 – Secondary Data Collection Activities:

- Reviewed existing evaluation reports including ongoing evaluation planning and implementation activities assessments.
  - Participated as Unitil's representative in relevant Evaluation Management Committee meetings and working groups, when requested.
- Reviewed utility specific data
  - Customer data and program data provided by Unitil.

Methodology – Secondary Data

Findings:

- Very little territory-specific data available from statewide evaluation efforts.
- Utility specific data from Unitil was used in Task 3 – Data Analysis.

METHODOLOGY – PRIMARY DATA

Task 2 – Primary Data Collection Activities:

- Telephone surveys.
- On-site data collection.
- Used to fill gaps identified through Task 1 effort.
- Used to develop savings estimates for Task 3 data analysis and reporting.

METHODOLOGY – SAMPLE DESIGN

- Residential – A sample size of 41 was targeted to obtain a confidence and precision of 80/10 at the Residential sector level. 41 completes were targeted for Unitil’s Gas territory and an additional 41 for Unitil’s Electric territory.
- Commercial and Industrial – A sample size of 41, split between small and medium commercial phone surveys and large industrial site visits was targeted to obtain a confidence and precision of 80/10 at the C&I sector level.
  - 41 completes were targeted for Unitil’s Gas territory and an additional 41 for Unitil’s Electric territory.
- Territory Level – Overall a goal of 164 surveys was targeted to achieve a statistical significance of 90/9 across the two Unitil service territories (electric and gas – 82 surveys in each).

METHODOLOGY – SAMPLE SELECTION

- Residential – A random sample of 45 (gas) and 74 (electric) households was ultimately selected for phone surveys by study team member RKM Research & Communications.
  - The sample was drawn from a randomized list of Residential Customers (Rates R1, R2, R3 & R4) provided by Unitil.
- Small Commercial – A random sample of 52 (gas) and 65 (electric) customers was ultimately selected for phone surveys by RKM Research & Communications.
  - The sample was drawn from a randomized list of Small Commercial Customers (Rates: G41, G42, G51 & G52) provided by Unitil.
- Large Commercial & Industrial – A randomly selected sample of 17 (gas and electric) customers were ultimately recruited for on-site data collection by GDS staff.
  - The sample was drawn from a randomized list of Unitil's pool of Medium and Large Commercial & Industrial Customers (Rates: G43 & G53 and several G42 & G52). Medium customers included in the on-site sample frame were removed from the telephone survey sample frame.
  - A randomized list of customers was provided and called through, in order, to avoid sample bias and to procure a representative mix of participating and non-participating customers.
  - Soft leads were recruited with the help of utility representatives. GDS then contacted the customer and set-up a time to complete the site visit. Some coordination with DNV-GL was also required to avoid duplication of effort with their simultaneous site data collection efforts for another ongoing evaluation project and to minimize customer confusion.

Methodology – Final Sample Sizes

Final Sample Sizes				
	Customer Population	# Phone Surveys Targeted	# Phone Surveys Completed	Achieved Confidence/Precision
Residential Telephone Surveys (Gas)	14,007	41	45	80/9.5
Residential Telephone Surveys (Electric)	24,903	41	74	80/7.4
Residential Telephone Surveys (Total)	na	82	119	na
C&I Customer Surveys (Gas)*	1,664	21 (phone) / 20 (site)	52 (phone) / 17 (site)	80/7.6
C&I Customer Surveys (Electric)*	3,708	21 (phone) / 20 (site)	65 (phone) / 17 (site)	80/7.0
C&I Customer Surveys (Total)*	na	42 (phone) / 40	117 (phone) / 34 (site)	na
Territory Level (Gas)	15,671	61 (phone) / 20 (site)	97 (phone) / 17 (site)	90/7.7
Territory Level (Electric)	28,611	61 (phone) / 20 (site)	139 (phone) / 17 (site)	90/6.6

* Includes a mix of on -site data collection and telephone surveys

Please note that overlap exists in the phone and onsite surveys. For example if one customer was a Unitil Gas and Electric customer their phone survey was counted as one complete for gas and one complete for electric.

During fielding of small commercial telephone surveys, the target sample size was increased from 21 to 41 to collect more data on smaller to medium-sized commercial customers.

METHODOLOGY – PHONE SURVEYS

Residential Response Rates:

- The overall response rate of the Residential phone surveys was ***17.9%.***
- A total of 1,980 customers were dialed, and 119 surveys were completed.
- 27 calls experienced a language barrier ***(1.36%).***

Call Code	Disposition	Total	%TOTAL DIALINGS
1	Complete	119	6.01%
2	No Answer	81	4.09%
3	Answering	810	40.91%
4	Busy	15	0.76%
5	Bad number	198	10.00%
6	Fax number	3	0.15%
7	Call intercept	0	0.00%
8	Appointment	14	0.71%
9	First refusal	241	12.17%
10	Second refusal	325	16.41%
11	Language barrier	27	1.36%
12	No eligible	34	1.72%
13	Business - NPR	61	3.08%
14	Never call	17	0.86%
15	Quota full	0	0.00%
16	Partial - Callback	29	1.46%
17	Partial - Refusal	6	0.30%
	TOTAL DIALINGS	**1980**	**100%**
	RESPONSE RATE(%)	**17.9**	

Methodology – Phone Surveys

Commercial Response Rates:

- The overall response rate of the Small Commercial phone surveys was ***11.7%.***
- A total of 1,841 customers were dialed, and 84 surveys were completed.
- 11calls experienced a language barrier ***(0.61%)***

Call Code	Disposition	Total	%TOTAL DIALINGS
1	Complete	84	4.63%
2	No Answer	36	1.98%
3	Answering	401	22.11%
4	Busy	25	1.38%
5	Bad number	131	7.22%
6	Fax number	16	0.88%
7	Call intercept	1	0.06%
8	Appointment	81	4.47%
9	First refusal	675	37.21%
10	Second refusal	74	4.08%
11	Language barrier	11	0.61%
12	No eligible	160	8.82%
13	Business - NPR	0	0.00%
14	Never call	21	1.16%
15	Quota full	23	1.27%
16	Partial - Callback	12	0.66%
17	Partial - Refusal	63	3.47%
	TOTAL DIALINGS	**1814**	**100%**
	RESPONSE RATE(%)	**11.7**	

METHODOLOGY – DATA ANALYSIS

Task 3 – Data Analysis Activities:

- Reviewed raw survey data.
- Determined end-use saturation and efficiency penetrations by customer sector.
- Developed remaining energy efficiency potential savings estimates.

Methodology – Survey Data Review

- Raw telephone survey and on-site data collection results were reviewed, analyzed and summarized.
- Sector specific presentations were developed to document detailed results and identify key findings from each research area including:
  - Demographics/firmography
  - Individual energy end-use findings
  - Past purchases and practices
  - Attitudes
  - Program awareness, participation and satisfaction
- Survey and site-visit data was then used to develop estimates of Potential Savings.

METHODOLOGY – SAVINGS ESTIMATES

A combination of data sources were used to develop factors for calculating remaining potential energy savings:

- Survey and site visit results
- Customer counts
- Existing efficiency program measures
- Existing program data on energy savings
- Massachusetts 2013 Report Technical Reference Manual
- Current utility Net-To-Gross (NTG) ratios
- Benefit/Cost modeling (Total Resource Cost Test – TRC)

Methodology – Savings Estimates

Equation of Potential Energy Savings

Participation × Savings (therms) × NTG Ratio

METHODOLOGY – PARTICIPATION EST.

Participation

GDS used a number of factors to arrive at an annual estimate of measure participation

- Estimate of base homes
  - Customers with gas heating and percent of customers with the baseline measure (i.e. boiler, furnace)
- Applicability factor
  - Split between competing measures (i.e. 90% AFUE boiler, 95% AFUE boiler)
  - Accounts for consumer choice
  - Used past program installations to estimate future installation ratios
  - Benefit/Cost modeling was conducted using the TRC test to assess cost-effectiveness of individual measures. However, measures with B/C ratios less than 1.0 were not dropped from the analysis because cost-effectiveness is not assessed at the measure level in MA, but at the program level . B/C ratios were used, where appropriate, to prioritize installations among competing measures → greater factor weight applied to measures with a higher B/C ratio.
- Burnout rate of measure (1/measure life)
  - What percentage of the market is expected to need replacing
- Convertibility factor
  - What percent might not be physically convertible to new technology or other limitation (i.e. wall insulation improvements would not be available for brick, stone or asbestos siding exteriors)

Methodology – Participation Est.

Participation

GDS used a number of factors to arrive at an annual estimate of measure participation

- Energy Efficiency Saturation
  - Percentage of market that is selecting efficient equipment
  - Based on survey data
- Willingness to Participate
  - Included only in the "likely achievable potential scenario"
  - Not included in the "high-case" scenario (i.e., before consideration of territory-specific realities, customer behaviors and measure installation barriers)
  - Reflects survey response assessed percentage of customers likely to move forward with a project

Methodology – Measure Savings

Savings (therms)

GDS used a number of sources to estimate measure specific savings

- 2013 Report Massachusetts Technical Reference Manual
  - Included deemed savings values for many measures
- Utility Specific Program Data
  - Used for New Construction Program
- REM Rate Energy Modeling
  - Calibrated to utility climate and average annual heating usage

METHODOLOGY – NTG RATIOS

NTG Ratios

GDS used current NTG ratios to adjust savings estimates

- NTG Ratios
  - Utility specific or statewide where applicable
  - Included or adjusted for free-ridership and spillover rates in some cases, but not all
  - Typically developed through rigorous evaluation efforts

Methodology - Scenarios

When estimating remaining potential, two modeling scenarios were run:

1. Likely achievable potential scenario – This scenario represents the study team's best estimate of the remaining potential within Unitil Gas's service territory and applies a "customer willingness" factor derived from telephone survey and site visit responses, along with sector-level budget constraints where applicable.
2. High-case scenario – This scenario represents the study team's estimated upper bound of the remaining potential without consideration of territory-specific realities, including customer behaviors and budget constraints.

HIGH-CASE SCENARIO - SAVINGS POTENTIAL RESULTS

- The total High-Case savings potential across Unitil Gas's service territory is estimated to be 1.07% of 2016 annual sales (1.15% by 2018).
  - The PA cost to achieve this potential is nearly $2.3M in 2016 ($2.4M in 2018) vs $1.9M current budget.
- Greatest potential savings, as % of sector sales, is in the residential and small/medium commercial customer sectors (1.18% and 1.42% of 2018 sales).
- Less potential exists within the large commercial sector(0.99% in 2016 and 1.04% by 2018).

Summary - High-Case	2016	2017	2018
Residential			
Annual Therm Savings	122,004	124,797	127,764
Forecast Sales	10,540,042	10,693,893	10,856,776
Savings as % of sales	**1.16%**	**1.17%**	**1.18%**
PA Cost to Achieve	$ 1,743,291	$ 1,773,486	$ 1,804,779
Total Cost to Achieve	$ 2,812,379	$ 2,859,991	$ 2,914,034
Small and Med C&I			
Annual Therm Savings	34,126	39,415	46,143
Forecast Sales *	3,218,656	3,231,372	3,249,858
Savings as % of sales	**1.06%**	**1.22%**	**1.42%**
PA Cost to Achieve	$ 211,315	$ 221,306	$ 241,968
Total Cost to Achieve	$ 345,633	$ 364,875	$ 403,341
Large C&I			
Annual Therm Savings	99,801	100,848	105,893
Forecast Sales *	10,111,225	10,151,173	10,209,244
Savings as % of sales	**0.99%**	**0.99%**	**1.04%**
PA Cost to Achieve	$ 327,731	$ 330,499	$ 339,835
Total Cost to Achieve	$ 663,690	$ 668,784	$ 687,235
TOTAL			
Annual Therm Savings	255,931	265,060	279,800
Forecast Sales *	23,869,923	24,076,439	24,315,878
Savings as % of sales	**1.07%**	**1.10%**	**1.15%**
PA Cost to Achieve	$ 2,282,337	$ 2,325,292	$ 2,386,582
Total Cost to Achieve	$ 3,821,702	$ 3,893,650	$ 4,004,610

* Forecast sales data was revised subsequent to initial draft

Territory-Specific Insights - Residential

- Program awareness, participation & satisfaction
  - Approximately a third (38%) of Unitil Gas's residential customer respondents stated they were not aware of Unitil's energy efficiency programs and products, and around half of those that are aware have never participated – leaving a solid pool of potential new participating customers.
- Home characteristics
  - A majority of Unitil Gas's residential customer respondents live in older, single family homes that they own – excellent targets for potential building envelope improvements.
- ENERGY STAR® awareness
  - While the majority of respondents are familiar with ENERGY STAR®, there is potential opportunity in reaching out to the 20% who are still completely unfamiliar.
- Past purchase practices
  - A majority of residential respondents appear to have energy efficiency features on their radar screens.
- Attitudes
  - Although cost is a major reason cited for not pursuing energy efficiency opportunities, over 2/3rd of respondents express interest in purchasing energy efficient equipment for a multitude of reasons.

TERRITORY-SPECIFIC INSIGHTS - RESIDENTIAL

- Building envelope
  - There remains some likely achievable potential for building envelope improvements within Unitil's residential customer sector.
- Space heating
  - Potential for heating system replacements exists in homes with older systems, where owners may be looking for replacements within the next five years. Additional savings associated with controllable thermostats may also exist.
- Water heating
  - Potential for water heater replacements exists in homes with older units, where owners may be looking for replacements within the next five years. Additional opportunities may exist for water saving devices.
- Clothes washing
  - Potential for energy efficient clothes washer and dryers exists in homes with older units, where owners may be looking for replacements within the next five years.
- Dishwashing
  - Potential for energy efficient dishwashers exists in homes with older units, where owners may be looking for replacements within the next five years.
- Hot tubs and heated pools
  - Based on survey responses, there does not appear to be much potential for efficiency improvements within the pool and hot tub end-use.

Territory-Specific Insights – Small/Medium Commercial

- Program awareness, participation & satisfaction
  - A majority of Unitil Gas's small business customers are non-participants and nearly all of those who have participated would be interested in doing so again.
- Firmographics
  - Unitil Gas's small commercial business base appears solid, with potential opportunities for energy efficiency investments in both leased and owned buildings. Small business owners would be best target for decisions.
- Building size, age & use
  - The make-up of Unitil Gas's small commercial building stock (relatively old, large square footage, small number of employees, sufficient hours of operation, somewhat efficiency conscious), suggests potential opportunities for targeted efficiency improvements.
- Past purchase practices
  - 10% of small commercial customer respondents stated they had purchased energy efficient products in the past, and 60% of those customers said they had plans to do so again over the next 12 months – suggesting additional potential for efficiency projects within Unitil Gas's small commercial customer sector.
- Attitudes
  - Rebates remain a major motivator for customer action in the small business sector.

Territory-Specific Insights – Small/Medium Commercial

- Building envelope
  - Good opportunities exist for building envelope improvements within Unitil Gas's small commercial business sector.
- Space heating
  - Potential for replacement heating systems, heating system tune-ups and programmable thermostats exists within Unitil Gas's small commercial business sector.
- Water heating
  - Based on survey responses, only a small potential for water heater replacements currently appears to exist within Unitil Gas's small commercial business sector, but a majority (70%) of Unitil's small business customer respondents are not taking advantage of other water saving measures (i.e., faucet aerators)
- Commercial kitchen and laundry
  - A small, but high energy use market exists within Unitil Gas's small business sector for commercial kitchen and laundry customers.
- On-site generation
  - 16% of Unitil Gas's small commercial customer respondents reported having onsite generation (6 emergency back-up generators and 1 onsite electric generator) . There could be an opportunity to explore this market.

Territory-Specific Insights – Large Commercial

- Program awareness, participation and satisfaction
  - A majority of Unitil Gas's large business customer respondents are aware of (75%) and have participated in (81%) Unitil's energy efficiency programs and are interested in doing so again.
- Past purchase practices
  - 42% of respondents are planning a renovation in the next 12 months.
  - A market for efficiency projects may exist within Unitil's large commercial customer sector if coupled with these respondents' planned renovation activities.
- Attitudes
  - Lower bills and receipt of rebates remain major motivators for customer action in Unitil Gas's large business sector.
  - These attitudes are also impacted by the number of businesses that have moved, sold, gone out of business or otherwise have cut back due to recession.

Territory-Specific Insights – Large Commercial

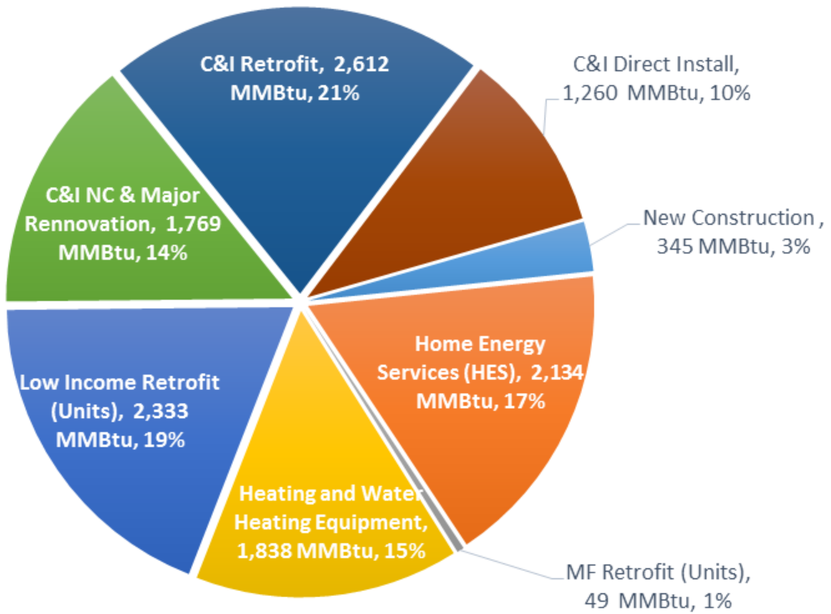
- Building Envelope
  - Opportunities likely exist for building envelope improvements within Unitil Gas's largest business customer sector.
- HVAC
  - Energy savings potential remains for replacement of some aging hot water boilers. Opportunities may also exist for greater use of EMS and boiler reset controls.
- Water heating
  - Potential appears to exist for efficient water heating equipment, with greater opportunities for pre-rinse spray valves, low flow showerheads and faucet aerators.
- Process equipment
  - Process heating equipment is a significant end use for natural gas in the Unitil territory. There could be opportunities for additional process efficiency improvements – but given the small number of large customers, limited availability of new projects on the planning horizon and unique characteristics of individual business processes, such determinations are best assessed on a custom/case-by-case basis.
- Cooking and laundry equipment
  - Based on conditions observed during large C&I customer site visits, potential appears to exist for efficient cooking and laundry equipment.
- On-site generation
  - There appears to be some potential to explore this market given that on-site natural gas-powered generation equipment was not identified during the site visits.

THREE YEAR SAVINGS SUMMARY - GAS

Program	2011		2012		2013		Three Year Total	
	Participants	Therms	Participants	Therms	Participants	Therms	Participants	Therms
Residential	*119*	**24,516**	*216*	**26,716**	*391*	**43,657**	*726*	***94,889***
New Construction	1	3,656	12	1,876	61	3,453	74	8,985
Home Energy Services (HES)	13	6,664	35	3,845	69	21,342	117	31,851
MF Retrofit (Units)	-	-	14	2,210	7	485	21	2,695
Heating and Water Heating Equipment	105	14,196	155	18,785	254	18,377	514	51,358
Sales		7,576,268		6,684,038		7,651,834		21,912,140
Savings as a % of Sector Sales		***0.32%***		***0.40%***		***0.57%***		***0.43%***
Low Income	*170*	**24,145**	*185*	**37,017**	*203*	**23,326**	558	***84,488***
Low Income Retrofit (Units)	170	24,145	185	37,017	203	23,326	558	84,488
Sales		2,265,626		2,039,859		2,361,978		6,667,463
Savings as a % of Sector Sales		***1.07%***		***1.81%***		***0.99%***		***1.27%***
C&I	*28*	**131,619**	*91*	**405,386**	*84*	**56,405**	*203*	***593,410***
C&I NC & Major Rennovation	10	17,065	45	13,928	26	17,686	81	48,679
C&I Retrofit	6	106,434	8	389,243	3	26,118	17	521,795
C&I Direct Install	12	8,120	38	2,215	55	12,601	105	22,936
Sales		13,438,479		12,400,201		13,663,648		39,502,328
Savings as a % of Sector Sales		***0.98%***		***3.27%***		***0.41%***		***1.50%***

2013 Savings Characterization – Gas

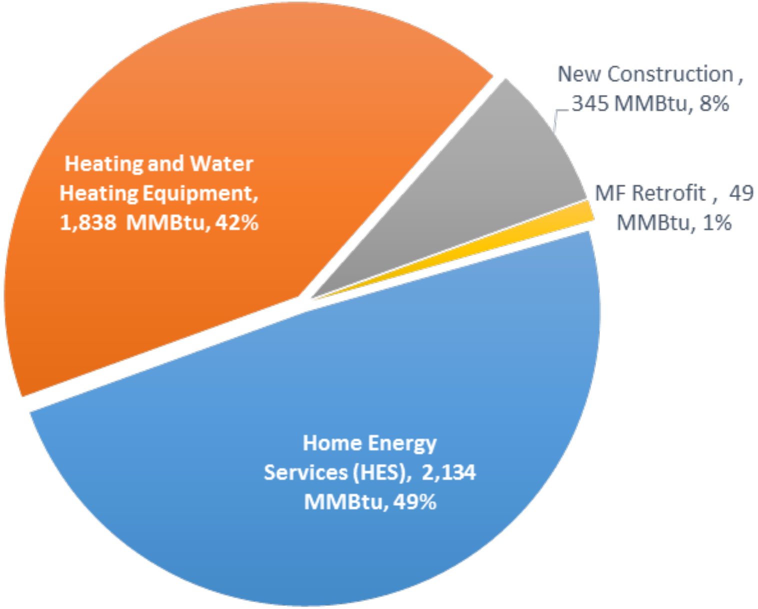
2013 ***Evaluated*** Energy Savings by Initiative, MMBtu



2013 EE Savings – Res. Gas

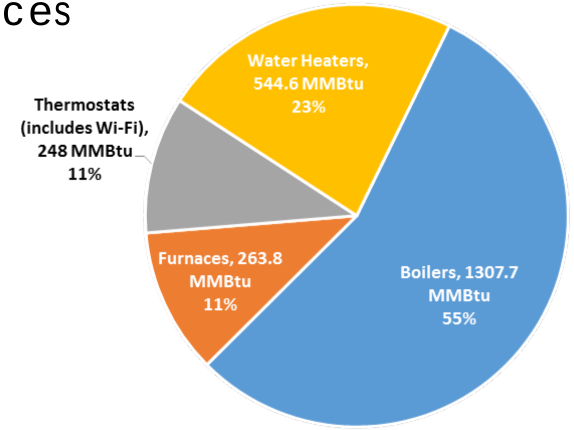
2013 *Evaluated* Energy Savings Residential Initiatives, MMBtu

*Please note that savings reported in the remaining slides is derived from program tacking data which is reported as ***Gross*** MMBtu savings and will not match to this figure or the figure on the previous slide as these are reported as ***Evaluated*** savings.



2013 EE Savings-Residential

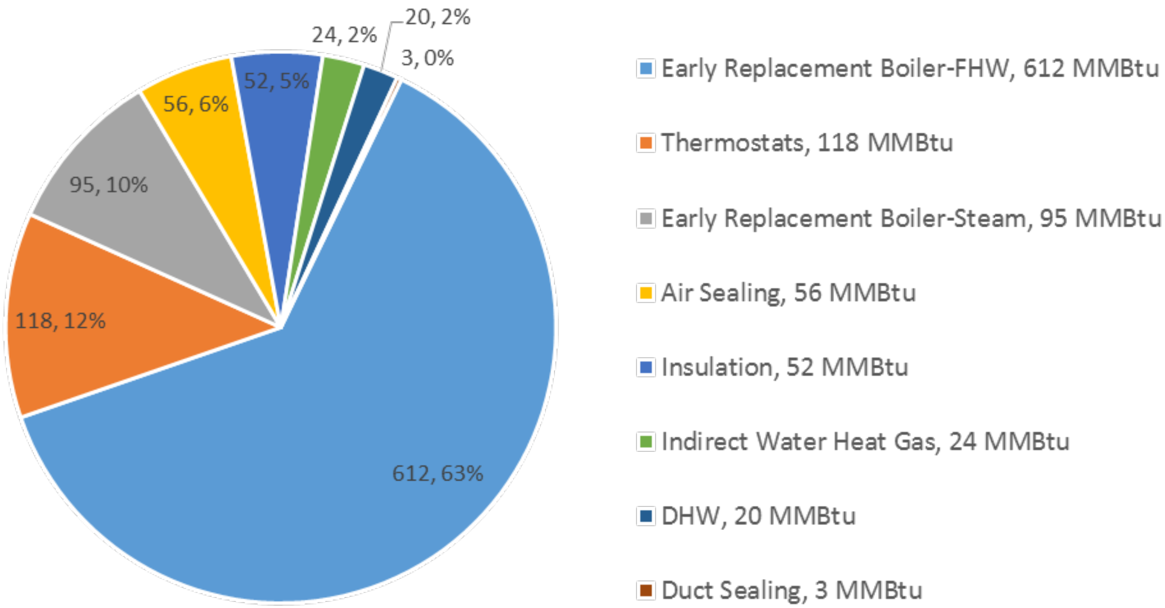
- Residential Heating & Water Heating (HEHE)
  - 66% of savings from heating systems
    - 55% or 1,307 MMBtu from Boilers
    - 11% or 263 MMBtu from Furnaces
  - 23% from water heating
  - 11%Wi-Fi T-Stat & programmable T-Stat



*Please note that savings reported is derived from program tacking data which is reported as ***Gross*** MMBtu savings and will not match figure on previous slide of ***Evaluated*** savings.

2013 EE Savings-Residential

2013 ***Gross*** Energy Savings Single Family Retrofit (1-4 Units)



2013 EE Savings-Residential

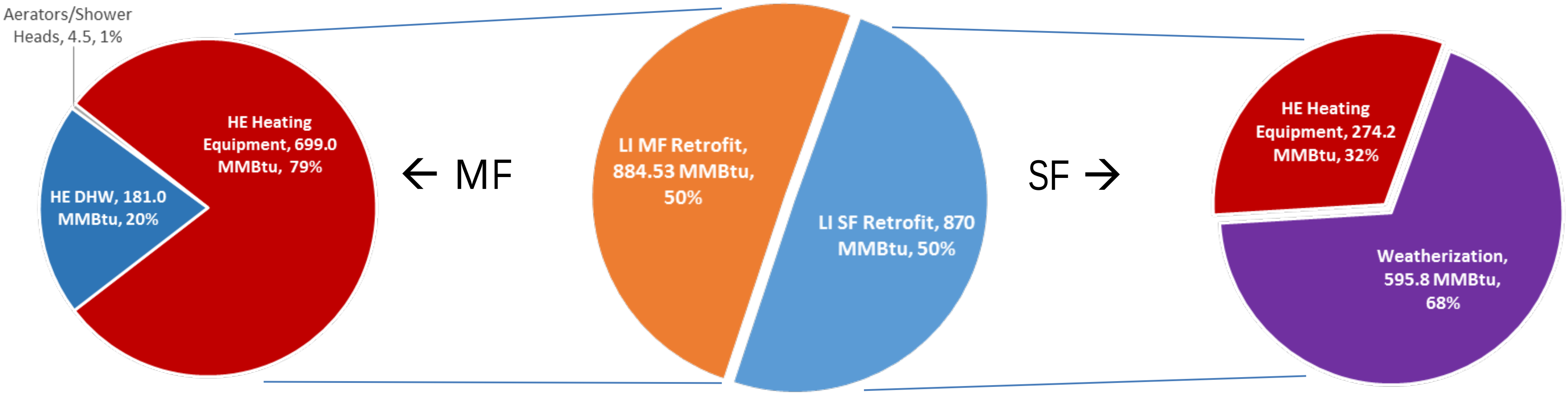
- Single Family Retrofit (1-4 Units)
  - 73% of savings comes from early boiler replacement
    - 63% (612 MMBtu) from FHW boiler
    - 10% (95 MMBtu) from steam boiler
  - 12% from thermostats
    - 118 MMBtu
  - 11% from air sealing, insulation and duct sealing
    - 111 MMBtu
  - 4% from DHW
    - 24 MMBtu from indirect water heating
    - 20 MMBTU from DHW

2013 EE Savings - Residential

- New Construction
  - Shell heating measures accounted for 98.7% of savings (341 MMBtu).
  - Water heating accounted for the balance of savings (4.3 MMBtu)

2013 EE Savings – Low Income

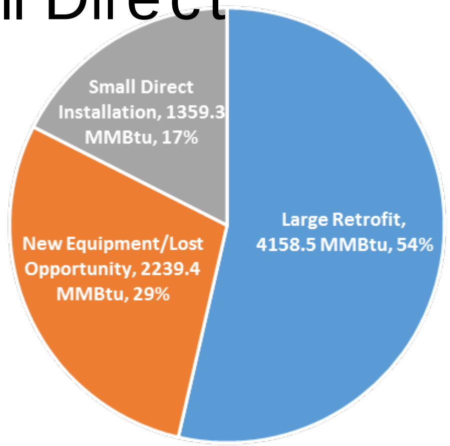
Low Income Programs



Savings for the Low Income program was split between the SF and MF Programs. In the SF program 68% of savings came from Wx measures and 32% from heating equipment. In the MF program, 79% of savings came from heating equipment and 21% from DHW equipment and low flow shower heads and aerators.

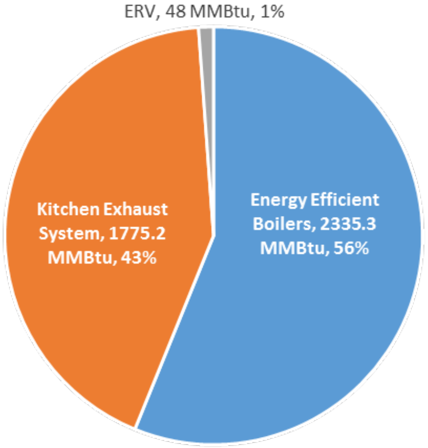
2013 EE Savings – C&I Sector

- Of the Total Savings from the C&I sector, over half (54%) came from the Large Retrofit Program, 29% came from the New Equipment Program, and the remaining 17% came from the Small Direct Installation Program.
  - Large Retrofit – 4,159 MMBtu
  - New Equipment – 2,239 MMBtu
  - Direct Installation – 1,359 MMBtu



2013 EE Savings – C&I Large Retrofit

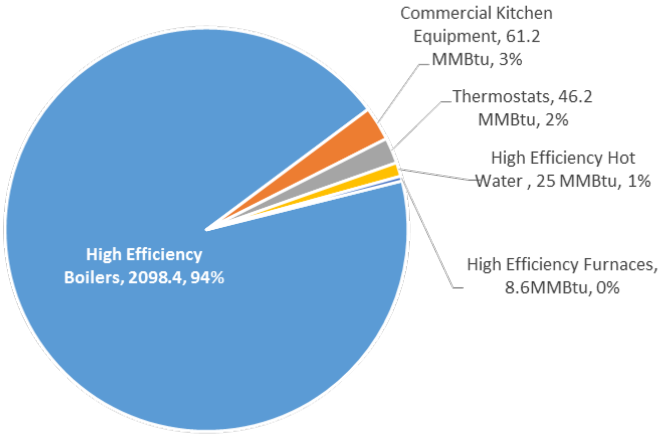
- All of the C&I Large Retrofit measures were classified as custom projects. These custom projects included Energy Efficient Boilers (2,335 MMBtu), Kitchen Exhaust Systems (1,775 MMBtu), and ERVs (48 MMBtu).



Custom retrofit measures included energy efficient boilers, a kitchen exhaust system, and ERVs.

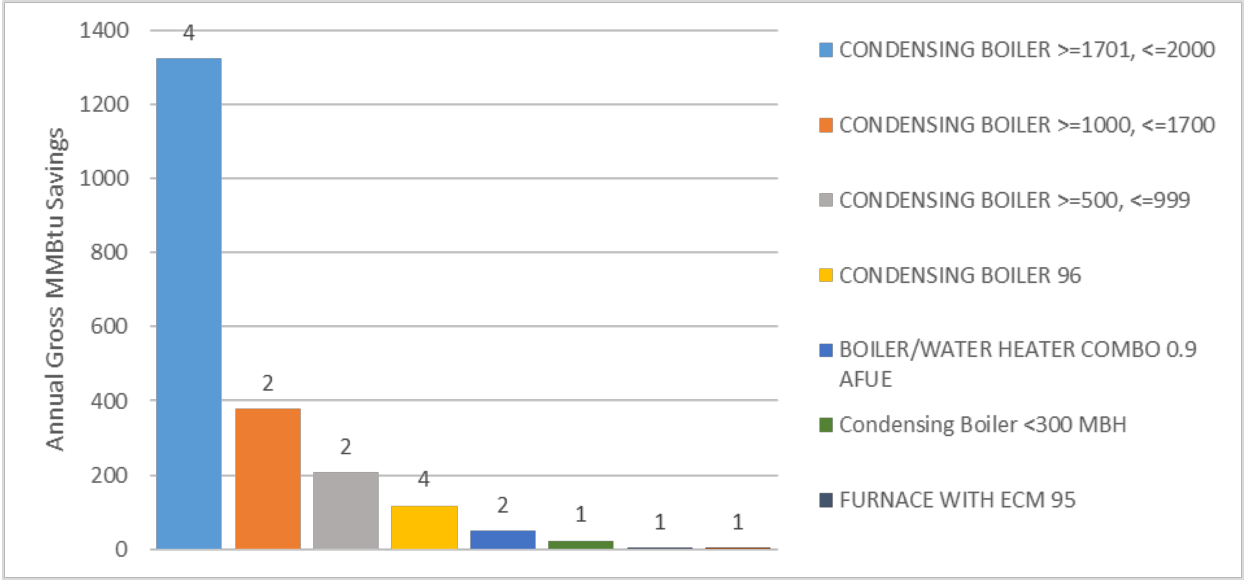
2013 EE Savings – C&I New Equip.

- Of the Total Savings from the C&I New Equipment program, ninety-four percent was from high efficiency boilers. The remaining 6% of savings came from:
  - Commercial Kitchen 3%
  - Thermostats 2%
  - High Efficiency Hot Water 1%
  - High Efficiency Furnaces >1%



2013 EE Savings – C&I New Equip.

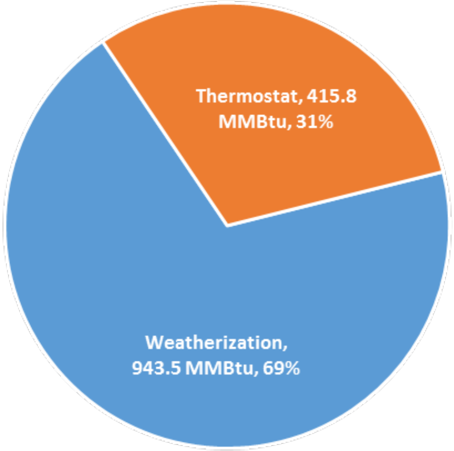
- Types of Space Heating Equipment and quantities rebated



2013 EE Savings – C&I Direct Install

- The C&I Direct Installation Program savings is split between weatherization measure savings and thermostat measure savings. One weatherization project was completed though the program and accounts or 69% of program savings for 2013.

The weatherization measure completed was for an energy shade screen for a farm greenhouse.



APPENDICES

- Appendix A – Survey Instruments
- Appendix B – Site Visit Data Collection Forms
- Appendix C – Supplemental Information
- Appendix D – Sector Surveys Raw Data Results

Unitil
energy for life.

GDS Associates, Inc.
ENGINEERS & CONSULTANTS

UNITIL ELECTRIC – REMAINING POTENTIAL STUDY
FINAL REPORT

February 24th, 2015

TABLE OF CONTENTS

Executive Summary - Purpose

This report presents Unitil Electric-specific results from a comprehensive, six month assessment of remaining energy efficiency potential within Unitil Electric, Unitil Gas, Berkshire Gas and Liberty Utilities (formerly NEGC)service territories.

Executive Summary - Order

- In addition to assisting the small PAs in quantifying remaining potential within their service territories, this effort was conducted in accordance with the Massachusetts Department of Public Utilities' January 31, 2013 Order D.P.U. 12-100 through D.P.U. 12-111 (sections IV.B.2.a & 4.a – pages 18, 19 & 40) and subsequent DOER Consultant feedback.
- Specifically, Section IV.B.2.a states:
  - "The Program Administrators with an aggregate three-year savings goal of greater than 20 percent below the statewide three-year aggregate goal will conduct a study, either jointly or individually, during the upcoming three-year term to document the penetration of energy efficiency within its service territory and the remaining cost-effective energy efficiency opportunities available.."

EXECUTIVE SUMMARY – SAVINGS GOALS

For the 2013-2015 Energy Efficiency Plan, Unitil Electric's three-year savings goals fell short of the statewide average:

Program Administrator	2013	2014	2015	Total 2013-2015
Unitil Electric	1.91%	1.95%	1.96%	1.94%
Statewide	2.50%	2.55%	2.60%	2.55%
Variance from Statewide Aggregate				**23.9%**

Executive Summary – Key Tasks

Three major task areas were pursued:

1. Secondary data collection/data mining and data gap analysis, including review of ongoing work of the Evaluation Management Committee.
2. Primary data collection sample design, work plan development and implementation of telephone surveys (residential and small/medium C&I customers) and on site data collection (larger C&I customers).
3. Data analysis and reporting of likely achievable and high case remaining potential results.

Executive Summary – Scope/Timing

This was a fast tracked (approx. six month) effort coordinated across four Program Administrators (PAs) culminating in development of four separate, territory-specific reports – one for each PA (Unitil Electric, Unitil Gas, Berkshire Gas and Liberty).

Executive Summary - Savings Potential Results

- The Likely Achievable savings potential across Unitil Electric's service territory is estimated to be 1.65% of 2016 annual sales (1.70% by 2018).
  - This is slightly lower than Unitil Electric's current three-year(2013-2015) territory-wide target of 1.94%.
- The sector with greatest potential for savings as a % of sector sales remains with Unitil Electric's commercial/industrial customers (2.02% of 2016 sales & 2.08% by 2018).
- Less potential remains within Unitil Electric's residential customer sector (1.11% 2016 & 1.16% 2018).

Likely Achievable	2016	2017	2018
Residential			
Annual kWh Savings	2,002,433	2,052,648	2,107,381
Forecast Sales	180,229,213	181,144,875	182,429,709
Savings as % of sales	**1.11%**	**1.13%**	**1.16%**
PA Cost to Achieve	$ 2,116,832	$ 2,137,887	$ 2,186,225
Total Cost to Achieve	$ 2,848,283	$ 2,884,654	$ 2,951,069
Commercial/Industrial			
Annual kWh Savings	5,255,694	5,393,637	5,422,060
Forecast Sales	259,855,732	260,332,321	261,118,104
Savings as % of sales	**2.02%**	**2.07%**	**2.08%**
PA Cost to Achieve	$ 2,245,192	$ 2,296,216	$ 2,306,657
Total Cost to Achieve	$ 4,306,875	$ 4,426,191	$ 4,442,523
TOTAL			
Annual kWh Savings	7,258,127	7,446,285	7,529,441
Forecast Sales	440,084,945	441,477,197	443,547,813
Savings as % of sales	**1.65%**	**1.69%**	**1.70%**
PA Cost to Achieve	$ 4,362,024	$ 4,434,103	$ 4,492,883
Total Cost to Achieve	$ 7,155,158	$ 7,310,844	$ 7,393,592

Executive Summary - Top Savings Sources

Residential Sector	Total Savings 2,002,433	% of Savings
Lighting (CFLs, LEDs, T8s, Torchiers, Indoor/Outdoor)	1,471,780	73.5%
Building envelope & duct sealing (elec/non-electric)	129,554	6.5%
ENERGY STAR TVs & Smart Power Strips	94,152	4.7%
Refrigerator & Freezer replacement & rebates	61,497	3.1%
HP Water Heaters (50 & 80 gallon)	55,922	2.8%
New Construction (heating, cooling & lighting)	53,075	2.7%
CoolSmart Ductless MS HP (SEER 16/18 & QIV)	42,077	2.1%
Refrigerator & Freezer recycle	34,269	1.7%
CoolSmart AC SEER 16 & Room/Window ACs	28,901	1.4%
DHW ISMs (electric/non-electric, indirect/on demand)	7,836	0.4%

Lighting measure mix based on Unitil 2013 actual program data and likely overstates potential savings from CFLs, while understating LED savings potential.

Executive Summary - Top Savings Sources

	Total Savings	
Small/Medium Commercial	**1,274,206**	**% of Savings**
Custom Lighting measure	841,730	66.1%
Custom HVAC	271,900	21.3%
Custom Compressed Air measure	63,162	5.0%
Custom Motors and Drives	52,694	4.1%
Custom Process measure	32,918	2.6%
Lighting - LED Lamps (upstream)	6,732	0.5%
Lighting - T8 U-Bends (upstream)	3,009	0.2%
Lighting - LED MR-16, PAR 20, 30, 38 (upstream)	1,618	0.1%
Lighting - T5 (upstream)	330	0.0%
Lighting - T8 25W (upstream)	111	0.0%

Executive Summary - Top Savings Sources

	Total Savings	
Top 100 Largest Commercial Customers	**3,981,488**	**% of Savings**
Custom Lighting measure	1,364,997	34.3%
Custom Motors and Drives	733,905	18.4%
Lighting - LED Lamps (upstream)	625,076	15.7%
Custom HVAC	544,930	13.7%
Lighting - LED MR-16, PAR 20, 30, 38 (upstream)	299,474	7.5%
Custom Compressed Air measure	234,376	5.9%
Custom Process measure	119,066	3.0%
Lighting - T8 U-Bends (upstream)	58,181	1.5%
Lighting - T5 (upstream)	1,259	0.0%
Lighting - T8 25W (upstream)	223	0.0%

Executive Summary – Key Findings

Results from review of secondary and primary data sources have confirmed:

- A somewhat limited potential exists for cost effective energy efficiency savings projects within Unitil Electric's residential and business sectors over the next 3 to 5 years.
  - A majority Unitil Electric's 25 largest customers have already participated, with few additional major projects on their near-term planning horizons.
- Economic challenges within Unitil's service territory are making it difficult for residential and small business customers to prioritize and pursue energy efficiency projects.
  - Although customers within these sectors are typically cash constrained, increased focus on Unitil's residential and small business customer base could yield additional savings.

SERVICE TERRITORY CHARACTERIZATION

Residential – 7,150 kWh/customer annual average (25,363 customers)

- 2,172 (9%) of Unitil Electric's residential customers have been program participants within the past 3 years (including multiple measures at a single participant location, repeat participants and low income customers, but excluding lighting and appliance participants).

Actual	R1			R2			HA			Total		
2009-2013	kWh	Customers	kWh/cust	kWh	Customers	kWh/cust	kWh	Customers	kWh/cust	kWh	Customers	kWh/cust
2009	138,552,982	20,761	6,674	23,393,243	3,607	6,486	3,179,160	3	1,059,720	165,279,622	24,371	6,782
2010	148,127,362	20,664	7,168	26,809,169	3,921	6,837	3,120,760	3	1,040,253	178,057,291	24,588	7,242
2011	145,858,140	20,456	7,130	31,000,432	4,177	7,422	2,994,720	2	1,497,360	179,853,292	24,635	7,301
2012	143,608,229	20,317	7,068	31,151,538	4,371	7,127	2,286,000	2	1,143,000	177,045,767	24,690	7,171
2013	143,954,743	20,113	7,157	33,603,461	4,788	7,018	2,368,440	2	1,184,220	179,926,644	24,903	7,225
% Change	**4%**	**-3%**	**7%**	**30%**	**25%**	**8%**	**-34%**	**-50%**	**11%**	**8%**	**2%**	**6%**
Average	**144,020,291**	**20,462**	**7,038**	**29,191,569**	**4,173**	**6,996**	**2,789,816**	**2**	**1,162,423**	**176,032,523**	**24,637**	**7,145**

Forecast	R1			R2			HA			Total		
2014-2020	kWh	Customers	kWh/cust	kWh	Customers	kWh/cust	kWh	Customers	kWh/cust	kWh	Customers	kWh/cust
2014	142,938,602	20,006	7,145	35,442,688	4,890	7,248	2,528,562	2	1,264,281	180,909,852	24,897	7,266
2015	141,108,712	20,006	7,053	36,228,951	5,071	7,145	2,446,211	2	1,223,105	179,783,874	25,078	7,169
2016	140,394,607	20,006	7,018	37,384,808	5,252	7,118	2,449,798	2	1,224,899	180,229,213	25,259	7,135
2017	141,107,888	20,006	7,053	37,574,743	5,433	6,916	2,462,244	2	1,231,122	181,144,875	25,441	7,120
2018	142,108,745	20,006	7,103	37,841,255	5,614	6,740	2,479,709	2	1,239,854	182,429,709	25,622	7,120
2019	142,108,745	20,006	7,103	37,841,255	5,614	6,740	2,479,709	2	1,239,854	182,429,709	25,622	7,120
2020	142,108,745	20,006	7,103	37,841,255	5,614	6,740	2,479,709	2	1,239,854	182,429,709	25,622	7,120
% Change	**-1%**	**0%**	**-1%**	**6%**	**13%**	**-8%**	**-2%**	**0%**	**-2%**	**1%**	**3%**	**-2%**
Average	**141,696,578**	**20,006**	**7,083**	**37,164,994**	**5,355**	**6,950**	**2,475,134**	**2**	**1,237,567**	**181,336,706**	**25,363**	**7,150**

SERVICE TERRITORY CHARACTERIZATION

Commercial – 68,505 kWh/customer annual average (3,835 customers)

- 361 (9.4%) of Unitil Electric's commercial customers have been program participants within the past 3 years (including multiple measures at a single participant location, repeat participants and a majority of Unitil's largest customers)

Actual	Total Commercial & Industrial		
2009-2013	kWh	Customers	kWh/cust
2009	275,117,456	3,588	76,677
2010	289,096,095	3,644	79,335
2011	284,136,118	3,670	77,421
2012	262,988,789	3,708	70,925
2013	265,146,758	3,734	71,009
% Change	-4%	4%	-8%
Average	**275,297,043**	**3,669**	**75,073**

Forecast	Total Commercial & Industrial		
2014-2020	kWh	Customers	kWh/cust
2014	269,401,712	3,744	71,962
2015	265,375,067	3,779	70,222
2016	259,855,732	3,815	68,122
2017	260,332,321	3,850	67,618
2018	261,118,104	3,886	67,203
2019	261,118,104	3,886	67,203
2020	261,118,104	3,886	67,203
% Change	-3%	4%	-7%
Average	**262,617,021**	**3,835**	**68,505**

METHODOLOGY

There were three major tasks completed as a part of this effort:

1. Secondary Data Collection/Data Mining.
2. Primary Data Collection.
3. Data Analysis and Reporting.

METHODOLOGY – SECONDARY DATA

Task 1 – Secondary Data Collection Activities:

- Reviewed existing evaluation reports including ongoing evaluation planning and implementation activities assessments.
  - Participated as Unitil's representative in relevant Evaluation Management Committee meetings and working groups, when requested.
- Reviewed utility specific data
  - Customer data and program data provided by Unitil.

METHODOLOGY – SECONDARY DATA

Findings:

- Very little territory-specific data available from statewide evaluation efforts.
- Utility specific data from Unitil was used in Task 3 – Data Analysis.

Methodology – Primary Data

Task 2 – Primary Data Collection Activities:

- Telephone surveys.
- On-site data collection.
- Used to fill gaps identified through Task 1 effort.
- Used to develop savings estimates for Task 3 data analysis and reporting.

METHODOLOGY – SAMPLE DESIGN

- Residential – A sample size of 41 was targeted to obtain a confidence and precision of 80/10 at the Residential sector level. 41 completes were targeted for Unitil's Electric territory and an additional 41 for Unitil's Gas territory.
- Commercial and Industrial – A sample size of 41, split between small and medium commercial phone surveys and larger customer site visits was targeted to obtain a confidence and precision of 80/10 at the C&I sector level.
  - 41 completes were targeted for Unitil's Electric territory and an additional 41 for Unitil's Gas territory.
- Territory Level – Overall a goal of 164 surveys was targeted to achieve a statistical significance of 90/9 across the two Unitil service territories (electric and gas – 82 surveys in each).

Methodology – Sample Selection

- Residential – A random sample of 74 (electric) and 45 (gas) households was ultimately selected for phone surveys by study team member RKM Research & Communications.
  - The sample was drawn from a randomized list of Residential Customers (Rates R1, R2, R3 & R4) provided by Unitil.
- Small and Medium Commercial – A random sample of 65 (electric) and 52 (gas) customers was ultimately selected for phone surveys by RKM Research & Communications.
  - The sample was drawn from a randomized list of Small and Medium Commercial Customers (Rates G41, G42, G51 & G52) provided by Unitil.
- Larger Commercial & Industrial – A randomly selected sample of 17 (electric and gas) customers were ultimately recruited for on-site data collection by GDS staff.
  - The sample was drawn from a randomized list of Unitil's Medium and Large Commercial & Industrial Customers (Rates G43 & G53 and several G42 & 52) to achieve a total sample frame representing Unitil's largest 100 electric customers. Medium customers included in the on-site sample frame were removed from the telephone survey sample frame.
  - A randomized list of customers was provided and called through, in order, to avoid sample bias and to procure a representative mix of participating and non-participating customers.
  - Soft leads were recruited with the help of utility representatives. GDS then contacted the customer and set-up a time to complete the site visit. Some coordination with DNV-GL was also required to avoid duplication of effort with their simultaneous site data collection efforts for another ongoing evaluation project and to minimize customer confusion.

METHODOLOGY – FINAL SAMPLE SIZES

Final Sample Sizes				
	Customer Population	# Phone Surveys Targeted	# Phone Surveys Completed	Achieved Confidence/Precision
Residential Telephone Surveys (Gas)	14,007	41	45	80/9.5
Residential Telephone Surveys (Electric)	24,903	41	74	80/7.4
Residential Telephone Surveys (Total)	na	82	119	na
C&I Customer Surveys (Gas)*	1,664	21 (phone) / 20 (site)	52 (phone) / 17 (site)	80/7.6
C&I Customer Surveys (Electric)*	3,708	21 (phone) / 20 (site)	65 (phone) / 17 (site)	80/7.0
C&I Customer Surveys (Total)*	na	42 (phone) / 40	117 (phone) / 34 (site)	na
Territory Level (Gas)	15,671	61 (phone) / 20 (site)	97 (phone) / 17 (site)	90/7.7
Territory Level (Electric)	28,611	61 (phone) / 20 (site)	139 (phone) / 17 (site)	90/6.6

* Includes a mix of on -site data collection and telephone surveys

Please note that overlap exists in the phone and onsite surveys. For example if one customer was a Unitil Gas and Electric customer their phone survey was counted as one complete for gas and one complete for electric.

During fielding of small commercial telephone surveys, the target sample size was increased from 21 to 41 to collect more data on smaller to medium-sized commercial customers.

METHODOLOGY – PHONE SURVEYS

Residential Response Rates:

- The overall response rate of the Residential phone surveys was ***17.9%.***
- A total of 1,980 customers were dialed, and 119 surveys were completed.
- 27 calls experienced a language barrier ***(1.36%).***

Call Code	Disposition	Total	%TOTAL DIALINGS
1	Complete	119	6.01%
2	No Answer	81	4.09%
3	Answering	810	40.91%
4	Busy	15	0.76%
5	Bad number	198	10.00%
6	Fax number	3	0.15%
7	Call intercept	0	0.00%
8	Appointment	14	0.71%
9	First refusal	241	12.17%
10	Second refusal	325	16.41%
11	Language barrier	27	1.36%
12	No eligible	34	1.72%
13	Business - NPR	61	3.08%
14	Never call	17	0.86%
15	Quota full	0	0.00%
16	Partial - Callback	29	1.46%
17	Partial - Refusal	6	0.30%
	TOTAL DIALINGS	**1980**	**100%**
	RESPONSE RATE(%)	**17.9**	

METHODOLOGY – PHONE SURVEYS

Commercial Response Rates:

- The overall response rate of the Small Commercial phone surveys was ***11.7%.***
- A total of 1,841 customers were dialed, and 84 surveys were completed.
- 11calls experienced a language barrier ***(0.61%)***

Call Code	Disposition	Total	%TOTAL DIALINGS
1	Complete	84	4.63%
2	No Answer	36	1.98%
3	Answering	401	22.11%
4	Busy	25	1.38%
5	Bad number	131	7.22%
6	Fax number	16	0.88%
7	Call intercept	1	0.06%
8	Appointment	81	4.47%
9	First refusal	675	37.21%
10	Second refusal	74	4.08%
11	Language barrier	11	0.61%
12	No eligible	160	8.82%
13	Business - NPR	0	0.00%
14	Never call	21	1.16%
15	Quota full	23	1.27%
16	Partial - Callback	12	0.66%
17	Partial - Refusal	63	3.47%
	TOTAL DIALINGS	**1814**	**100%**
	RESPONSE RATE(%)	**11.7**	

METHODOLOGY – DATA ANALYSIS

Task 3 – Data Analysis Activities:

- Reviewed raw survey data.
- Determined end-use saturation and efficiency penetrations by customer sector.
- Developed remaining energy efficiency potential savings estimates.

Methodology – Survey Data Review

- Raw telephone survey and on-site data collection results were reviewed, analyzed and summarized.
- Sector specific presentations were developed to document detailed results and identify key findings from each research area including:
  - Demographics/firmography
  - Individual energy end-use findings
  - Past purchases and practices
  - Attitudes
  - Program awareness, participation and satisfaction
- Surveys and site-visit data were then used to develop territory-specific inputs necessary for estimating Potential Savings.

METHODOLOGY – SAVINGS ESTIMATES

A combination of data sources were used to develop factors for calculating remaining potential energy savings:

- Survey and site visit results
- Customer counts
- Existing efficiency program measures
- Existing program data on energy savings
- Massachusetts 2013 Report Technical Reference Manual
- Current utility Net-To-Gross (NTG) ratios
- Benefit/Cost modeling (Total Resource Cost Test – TRC)

METHODOLOGY – SAVINGS ESTIMATES

Equation of Potential Energy Savings

Participation × Savings (therms) × NTG Ratio

METHODOLOGY – PARTICIPATION EST.

Participation

GDS used a number of factors to arrive at an annual estimate of measure participation

- Estimate of base homes
  - Electric customers and percent of customers with the baseline measure
- Applicability factor
  - Split between competing measures
  - Accounts for consumer choice
  - Used past program installations to estimate future installation ratios
  - Benefit/Cost modeling was conducted using the TRC test to assess cost-effectiveness of individual measures. However, measures with B/C ratios less than 1.0 were not dropped from the analysis because cost-effectiveness is not assessed at the measure level in MA, but at the program level . B/C ratios were used, where appropriate, to prioritize installations among competing measures → greater factor weight applied to measures with a higher B/C ratio.
- Burnout rate of measure (1/measure life)
  - What percentage of the market is expected to need replacing
- Convertibility factor
  - What percent might not be physically convertible to new technology or other limitation (i.e. wall insulation improvements would not be available for brick, stone or asbestos siding exteriors)

METHODOLOGY – PARTICIPATION EST.

Participation

GDS used a number of factors to arrive at an annual estimate of measure participation

- Energy Efficiency Penetration
  - Percentage of market that is selecting efficient equipment
  - Based on survey data
- Willingness to Participate
  - Included only in the "likely achievable potential scenario"
  - Not included in the "high-case" scenario (i.e., before consideration of territory-specific realities, customer behaviors and measure installation barriers)
  - Reflects survey response assessed percentage of customers likely to move forward with a project

Methodology – Measure Savings

Savings (kWh)

GDS used a number of sources to estimate measure specific savings

- 2013 Report Massachusetts Technical Reference Manual
  - Included deemed savings values for many measures
- Utility Specific Program Data
  - Used for New Construction Program
- REM Rate Energy Modeling
  - Calibrated to utility climate and average annual heating usage (where applicable)

METHODOLOGY – NTG RATIOS

NTG Ratios

GDS used current NTG ratios to adjust savings estimates

- NTG Ratios
  - Utility specific or statewide where applicable
  - Included or adjusted for free-ridership and spillover rates in some cases, but not all
  - Typically developed through rigorous evaluation efforts

Methodology - Scenarios

When estimating remaining potential, two modeling scenarios were run:

1. Likely achievable potential scenario – This scenario represents the study team's best estimate of the remaining potential within Unitil Electric's service territory and applies a "customer willingness" factor derived from telephone survey and site visit responses, along with sector-level budget constraints where applicable.
2. High-case scenario – This scenario represents the study team's estimated upper bound of the remaining potential without consideration of territory-specific realities, including customer behaviors and budget constraints.

High-Case Scenario - Savings Potential Results

- The total High-Case savings potential across Unitil Electric's service territory is estimated to be 2.36% of 2016 annual sales (2.56% by 2018).
  - The PA cost to achieve this potential is over $7.8M in 2016 ($8.2M in 2018), compared with Unitil Electric's current budget of $5.3M in 2015.
- Greatest potential savings, as % of sector sales, is in the commercial/ industrial customer sector (2.76% of 2016 & 2.99% of 2018 sales).
- Less potential exists within the residential sector(1.79% in 2016 and 1.94% by 2018).

Summary - High-Case	2016	2017	2018
Residential			
Annual kWh Savings	3,222,071	3,378,379	3,537,300
Forecast Sales	180,229,213	181,144,875	182,429,709
Savings as % of sales	**1.79%**	**1.87%**	**1.94%**
PA Cost to Achieve	$ 4,781,330	$ 4,855,528	$ 4,993,830
Total Cost to Achieve	$ 6,279,046	$ 6,415,635	$ 6,613,722
Commercial/Industrial			
Annual kWh Savings	7,179,409	7,491,441	7,805,437
Forecast Sales	259,855,732	260,332,321	261,118,104
Savings as % of sales	**2.76%**	**2.88%**	**2.99%**
PA Cost to Achieve	$ 3,026,556	$ 3,135,801	$ 3,240,548
Total Cost to Achieve	$ 6,104,256	$ 6,357,353	$ 6,607,036
TOTAL			
Annual kWh Savings	10,401,480	10,869,820	11,342,736
Forecast Sales	440,084,945	441,477,197	443,547,813
Savings as % of sales	**2.36%**	**2.46%**	**2.56%**
PA Cost to Achieve	$ 7,807,886	$ 7,991,329	$ 8,234,379
Total Cost to Achieve	$ 12,383,302	$ 12,772,989	$ 13,220,758

Territory-Specific Insights - Residential

- Program awareness, participation & satisfaction
  - Over 40% of Unitil's residential customer respondents stated they were not aware of Unitil's energy efficiency programs and products, and nearly half (47%) of those that are aware have never participated – leaving a solid pool of potential new participating customers.
- Home characteristics
  - A majority of Unitil's residential customer respondents live in older, single family homes that they own – excellent targets for potential building envelope improvements.
- ENERGY STAR® awareness
  - While the majority of respondents are familiar with ENERGY STAR®, there is potential opportunity in reaching out to the 14% who are still completely unfamiliar.
- Past purchase practices
  - A majority of residential respondents appear to have energy efficiency features on their radar screens.
- Attitudes
  - Although cost is a major reason cited for not pursuing energy efficiency opportunities, a large majority of respondents express interest in purchasing energy efficient equipment for a multitude of reasons.

Territory-Specific Insights - Residential

- Lighting
  - Potential exists for electric energy savings from interior and exterior CFLs & LED lighting measures.
- Building envelope
  - Potential exists for electric and non-electric energy savings from building envelope improvements within Utility's residential electric customer sector.
- Televisions & Computers
  - Potential exists for ENERGY STAR televisions and smart power strips for use with televisions and computer equipment.
- Refrigerators & Freezers
  - Potential exists for replacement of older primary refrigerators and for removal /recycling of primary standalone freezers and second refrigerators.
- Space heating and cooling
  - Given the nearly 50% of respondents that heat their homes primarily with oil and a small additional percentage (11%) of respondents heating their homes primarily with electricity (10% use electricity as a secondary heating source), there could be potential for fuel switching opportunities – i.e., ductless mini-split systems.
  - Potential may also exist within Unitil's service territory for central air conditioner system tune-ups and room/wall ACs.
- Water heating
  - Potential for energy efficient electric water heaters may exist within Unitil's residential sector specifically for customers that have older systems.
- Clothes washing
  - Potential may exist for energy efficient clothes washer and dryers in homes with older units, where owners may be looking for replacements within the next five years.
- Dishwashing, dehumidifiers & air purifiers
  - Potential may exist for energy efficient dishwashers exists in homes with older units, where owners may be looking for replacements within the next five years.
  - Based on survey responses, there does not appear to be much potential for efficiency improvements within the dehumidifiers & air purifiers end-use.
- Hot tubs & heated pools
  - Based on survey responses, there does not appear to be much potential for efficiency improvements within the pool & hot tub end-use.

Territory-Specific Insights – Small/Medium Commercial

- Program awareness, participation & satisfaction
  - A majority of Unitil Electric's small business customers are non-participants and nearly all of those who have participated would be interested in doing so again.
- Firmographics
  - Unitil Electric's small commercial business base appears solid with potential opportunities for energy efficiency investments in both leased and owned buildings. Small business owners would be best target for decisions.
- Building size, age & use
  - The make-up of Unitil Electric's small commercial building stock (relatively old, large square footage, small number of employees, sufficient hours of operation), suggests a potential opportunities for targeted efficiency improvements.
- Past purchase practices
  - 10% of small commercial respondents stated they had purchased energy efficient products in the past, and 60% of those customers said they had plans to do so again over the next 12 months – suggesting additional potential for energy efficiency projects within Unitil Electric's small commercial customer sector.
- Attitudes
  - Rebates remain a major motivator for customer action in the small business sector.

Territory-Specific Insights – Small/Medium Commercial

- Lighting
  - Substantial potential continues to exist for lighting improvements within Unitil Electric's small commercial business sector
- Space heating, cooling, mechanical ventilation
  - Based on survey responses, there appears to be some potential for replacement heating systems (fuel switching), heating system tune-ups and programmable thermostats within Unitil Electric's small commercial business sector.
  - Similarly, there appears to be potential for replacement cooling systems and system tune-ups within Unitil Electric's small commercial business sector.
- Specialty equipment (including motors, computers/servers , process, laundry, kitchens & pools)
  - Potential exists within Unitil Electric's small business sector for process and other specialty equipment efficiency improvements.
  - In addition, potential exists for replacement mechanical ventilation, commercial kitchen ventilation and energy management systems.
- Building envelope
  - Based on survey responses, there appears to be some potential for building envelope improvements within Unitil Electric's small commercial business sector.
- Refrigeration
  - Based on survey responses, there appears to be some potential for refrigeration and freezer improvements within Unitil Electric's small commercial business sector.
- Water heating
  - Only a small potential exists within Unitil's small commercial business sector for water heating efficiency improvments. But a majority (79%) of Unitil's small business customer respondents are not taking advantage of other water saving measures.
- On-site generation
  - 15% of Unitil Gas's small commercial customer respondents reported having onsite generation (7 emergency back-up generators , 1 onsite electric generator, 1 co-generator & 1 other system). There could be an opportunity to explore this market.

Territory-Specific Insights – Large Commercial

- Program awareness, participation & satisfaction
  - A majority (88%) of Unitil Electric's large business customer respondents are aware of and have participated (93%) in Unitil's energy efficiency programs and are interested in doing so again.
- Past purchase practices
  - 39% of respondents are planning a remodel in the next 12 months.
  - Potential for efficiency projects may exist within Unitil's top 100 largest commercial customers if coupled with these respondents' planned remodeling activities.
- Attitudes
  - Lower bills and receipt of rebates remain major motivators for customer action with Unitil Electric's largest top 100 customers.
  - These attitudes are also impacted by the number of businesses that have moved, sold, gone out of business or otherwise have cut back due to recession.

Territory-Specific Insights – Large Commercial

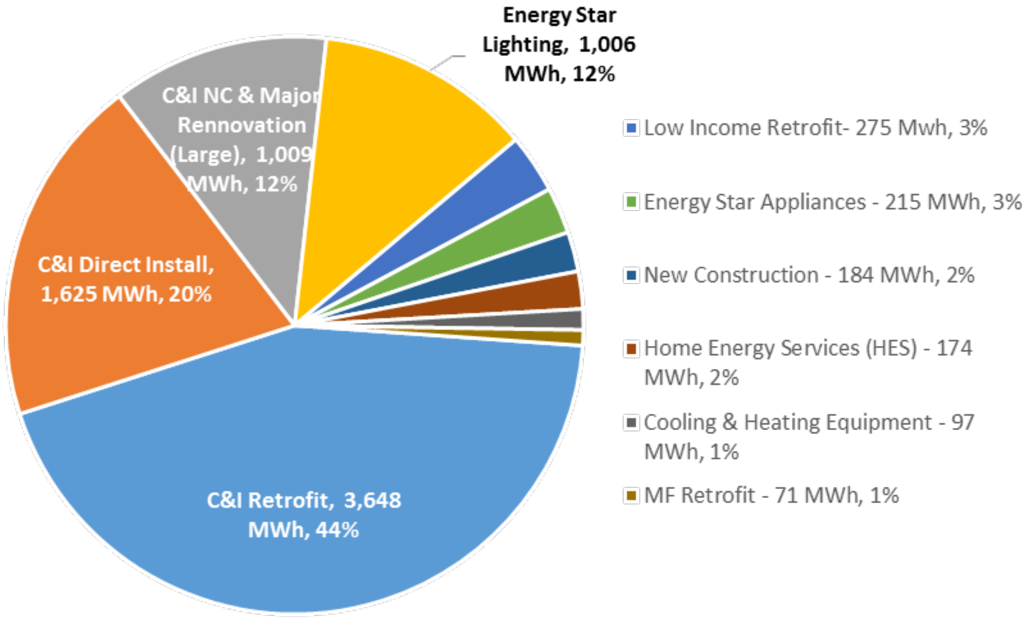
- Building Envelope
  - Opportunities likely exist for building envelope improvements within Unitil Electric's 100 largest customer's buildings.
- Lighting
  - Some of the greatest opportunities for lighting improvement could include replacement of HPS and Metal Halide bulbs, as well as utilization of additional lighting controls.
- Compressed Air & Motors
  - Due to the large number of sites with compressed air systems, implementation of Leak Reduction Maintenance Programs represent a potential opportunity in the Unitil Electric territory.
  - Additional pump maintenance may represent an opportunity for improvement among Unitil Electric's largest customers.
- HVAC
  - Potential remains for replacement of some aging oil-fired steam boilers. Potential may also exist for greater use of boiler controls.
  - Based on site visit findings, a limited potential appears to exist for facility cooling equipment. Maintenance and tune-up services may also represent an opportunity for some businesses.
- Water heating
  - Based on site visit findings, a limited potential appears to exist for oil and electric water heating equipment, with greater opportunities for pre-rinse spray valves, low flow showerheads and faucet aerators.
- Commercial equipment (including kitchens, refrigeration, laundry & electronics)
  - Potential appears to exist for further evaluation of commercial range hoods.
  - Potential also appears to exist for replacement of incandescent bulbs in walk-in/prep areas, as well as scheduling of additional maintenance activities.
- On-site generation
  - There appears to be some potential to explore this market given the lack of on-site generation equipment identified during the site visits.

Three Year Savings Summary Elec.

Program	2011		2012		2013		Three Year Total	
	Participants	MWh	Participants	MWh	Participants	MWh	Participants	MWh
Residential	*24,103*	**936**	*26,564*	**1,366**	*10,164*	**1,747**	*60,831*	***4,049***
New Construction	28	31	3	164	93	184	124	379
Home Energy Services (HES)	221	78	238	78	222	174	681	330
MF Retrofit (Units)	-	-	244	198	88	71	332	269
Cooling & Heating Equipment	27	18	93	37	123	97	243	152
Energy Star Lighting	23,411	685	25,001	599	8,408	1,006	56,820	2,290
Energy Star Appliances	416	124	985	290	1,230	215	2,631	629
Sales (MWh)		145,858		143,608		143,955		433,421
Savings as a % of Sector Sales		***0.64%***		***0.95%***		***1.21%***		***0.93%***
Low Income	*206*	**184**	*250*	**103**	*336*	**275**	792	***562***
Low Income New Construction	-	-	240	93	-	-	240	93
Low Income Retrofit (Units)	206	184	10	10	336	275	552	469
Sales (MWh)		31,000		31,152		33,603		95,755
Savings as a % of Sector Sales		***0.59%***		***0.33%***		***0.82%***		***0.59%***
C&I	*52*	**17,298**	*105*	**4,616**	*204*	**6,282**	*361*	***28,196***
C&I NC & Major Rennovation (Large)	4	621	21	1,209	127	1,009	152	2,839
C&I Retrofit (Large)	7	15,633	19	1,948			31	19,405
C&I Retrofit (Small)	41	1,044	65	1,459	10	3,648	111	4,327.0
C&I Direct Install	-	-	-	-	67	1,625	67	1,625
Sales (MWh)		224,672		220,227		217,509		662,409
Savings as a % of Sector Sales		***7.70%***		***2.10%***		***2.89%***		***4.26%***

2013 Savings Characterization - Elec.

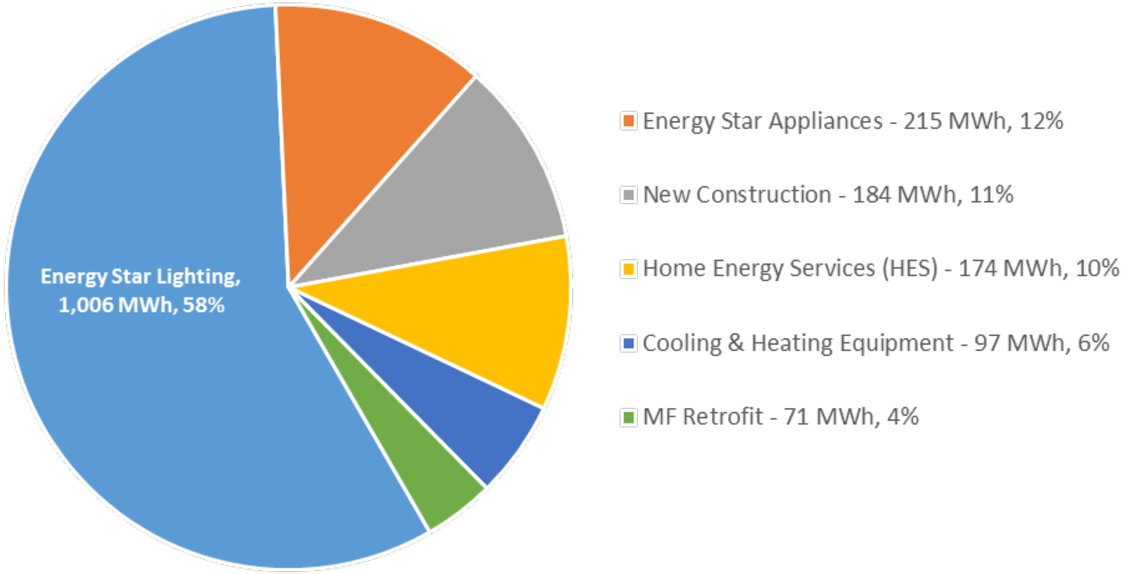
2013 ***Evaluated*** Energy Savings by Initiative, MWh



2013 EE Savings – Residential

2013 *Evaluated* Energy Savings Residential Initiatives, MWh

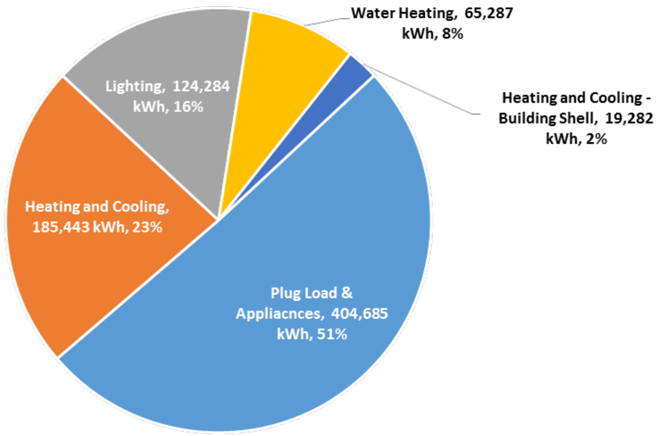
*Please note that savings reported in the remaining slides is derived from program tacking data which is reported as ***Gross*** MWh savings and will not match to this figure or the figure on the previous slide as these are reported as ***Evaluated*** savings.



2013 EE Savings – Residential

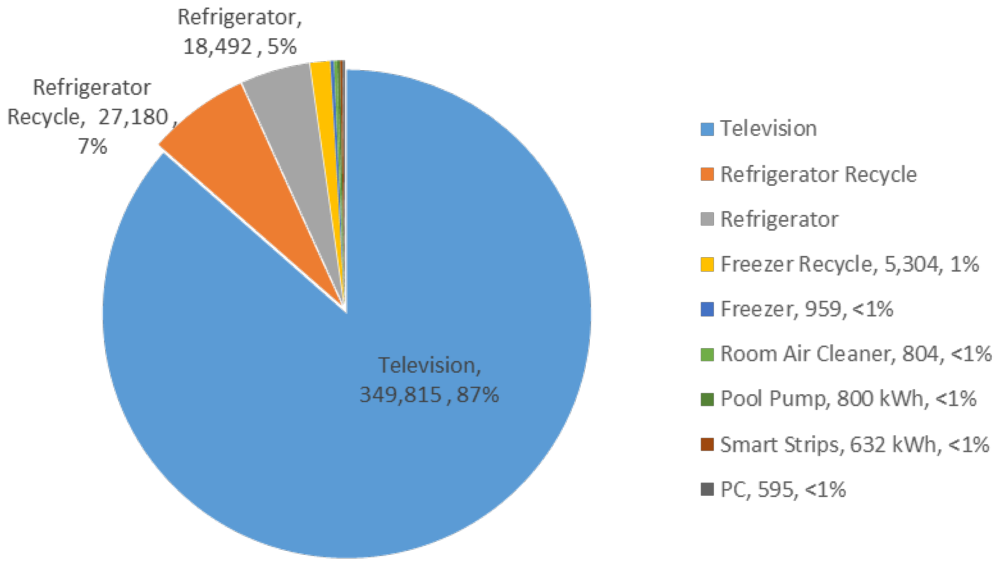
2013 ***Gross*** Energy Savings by End Use, kWh

- Over 50% of Savings is from Plug Load & Appliances
  - About 88% of Appliance Savings if from Televisions
  - Low NTG Factors diminish Gross savings
- Heating and Cooling 23%
- Lighting 16%
  - Lighting savings dominate ***Evaluated*** savings, less predominant in ***Gross*** figures.
- Water Heating 8%
- Building Shell 2%



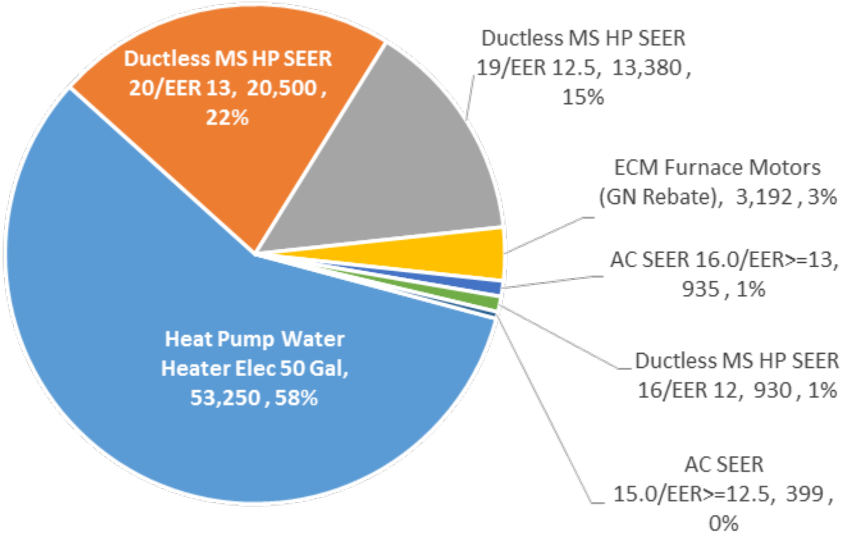
2013 EE Savings-Residential

2013 ***Gross*** Energy Savings Energy Star Appliances, kWh



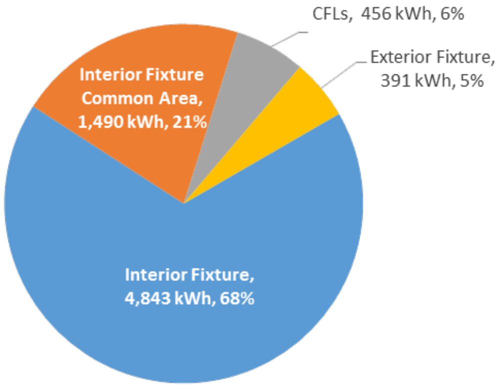
2013 EE Savings-Residential

2013 ***Gross*** Energy Savings Heating & Cooling Equipment, kWh



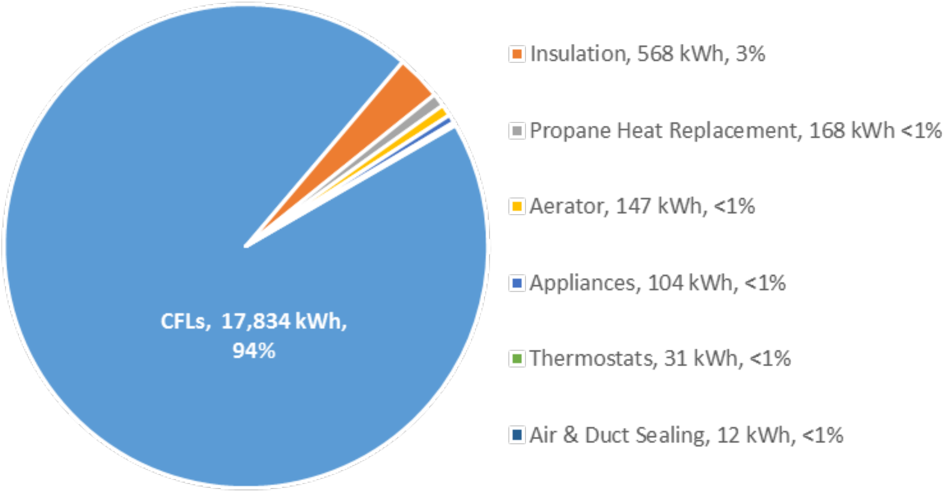
2013 EE Savings-Residential

- Multi-Family Retrofit (5+ Units)
  - 100% of savings comes from lighting
    - 68% (4,843 kWh) interior, in-unit, lighting fixtures
    - 21% (1490 kWh) from common area lighting fixtures
    - 6% (456 kWh) from CFLs
    - 5% (391 kWh) from exterior lighting fixtures



2013 EE Savings - Residential

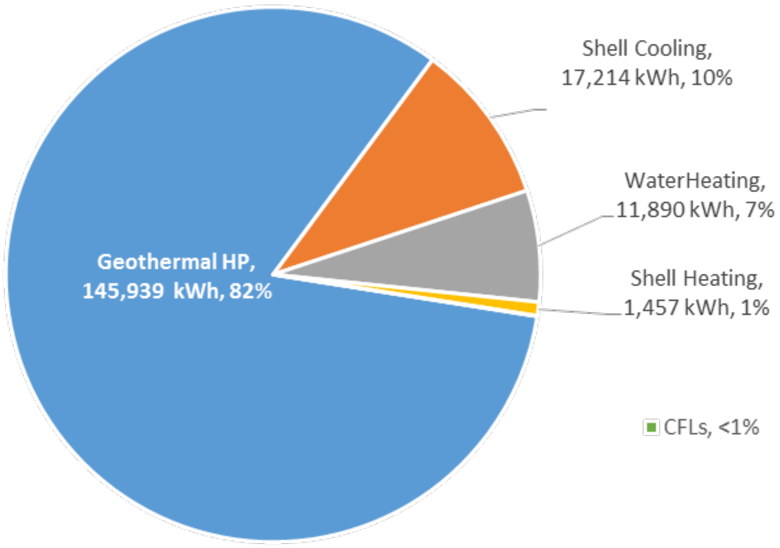
2013 ***Gross*** Energy Savings Home Energy Services (HES), kWh



2013 EE Savings - Residential

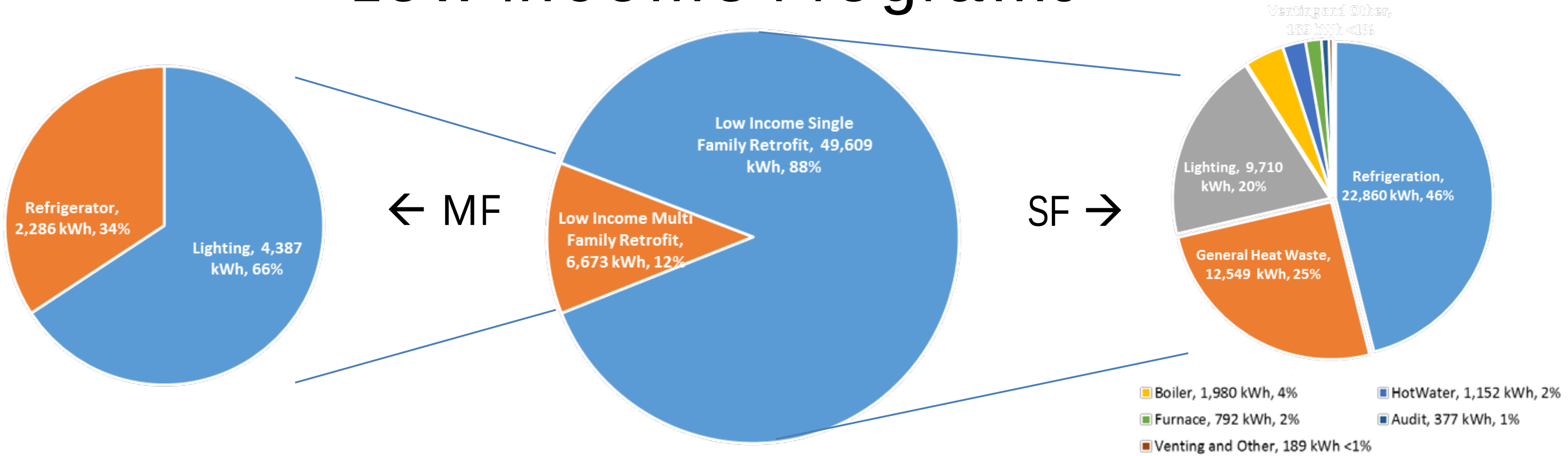
2013 *Gross* Energy Savings ENERGY STAR Homes, kWh

Geothermal Heat Pump installations at multiple program participant homes dominated this program's savings in 2013.



2013 EE Savings – Low Income

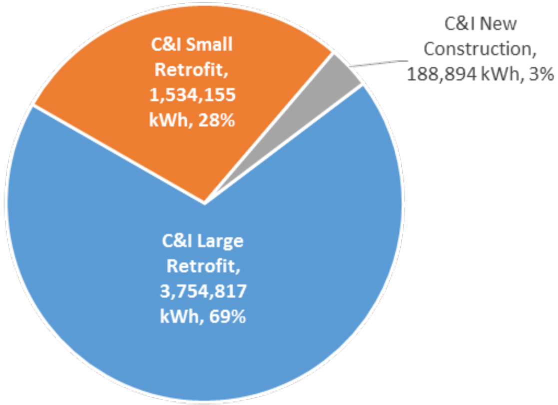
Low Income Programs



Savings for the Low Income program was split between the SF and MF Programs. In the SF program 46% of savings came from refrigerators and 25% from Weatherization (General Heat Waste). Lighting made up 20% of savings and boilers, furnaces, and vending machines also contributed to savings. In the MF program, 66% of savings came from lighting and 34% from refrigerators.

2013 EE Savings – C&I Sector

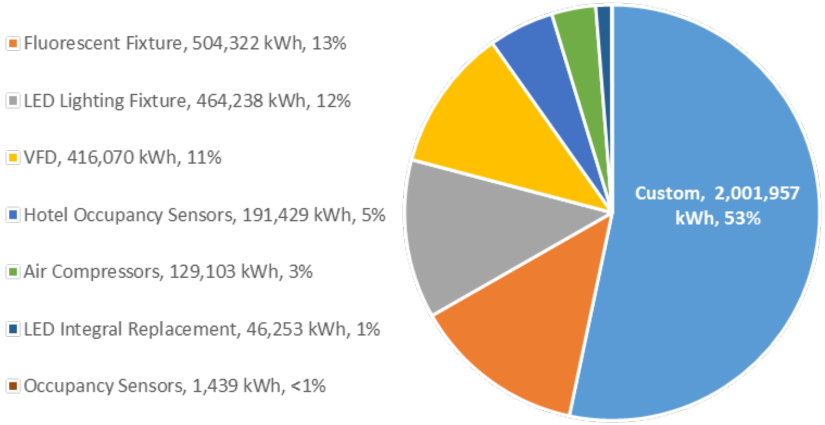
- Of the Total Savings from the C&I sector, 69% came from the Large Retrofit Program, 28% came from the Small Retrofit Program, and the remaining 3% came from the New Construction Program.
  - Large Retrofit – 3,754,817 MWh
  - Small Retrofit – 1,534,155 MWh
  - New Construction – 188,894 MWh



2013 EE Savings – C&I Large Retrofit

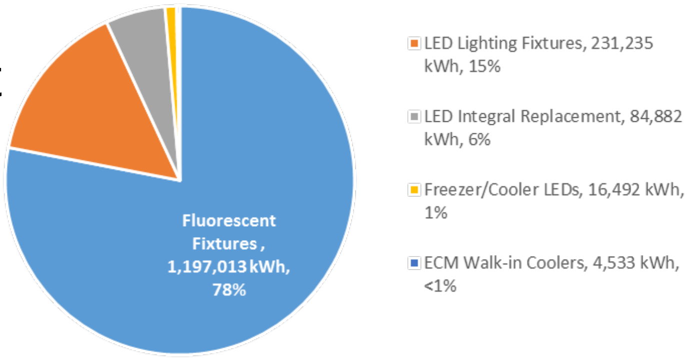
- Over half of the saving of the C&I Large Retrofit program were from custom projects. These custom projects included a compressor retrofit, rooftop replacement and EMS, and VFD and controls for an exhaust fan system.

Other measures included lighting (Fluorescent & LED), VFDs, Air Compressors, and Occupancy sensors (Hotel and Standard).



2013 EE Savings – C&I Small Retrofit

- Of the Total Savings from the C&I Small Retrofit Program, over three-quarters of the savings was from fluorescent light fixtures (over 1 million kWh) the remaining savings came from:
  - LED Lighting/Integral Replacement
  - Freezer/Cooler LEDs
  - ECMs for Walk In Coolers



2013 EE Savings – C&I New Equip.

- Of the Total Savings from the C&I New Equipment program, ninety-four percent was from two custom injection molding projects (177,168 kWh). Other savings came from Lighting and Air Compressors:
  - Lighting, 9,830 kWh 5%
    - All lighting from the Upstream Program
  - Compressors, 1,896 kWh 1%
    - Refrigerated Air Dryer

APPENDICES

- Appendix A – Survey Instruments
- Appendix B – Site Visit Data Collection Forms
- Appendix C – Supplemental Information
- Appendix D – Sector Surveys Raw Data Results

Opinion Dynamics

dunsky ENERGY CONSULTING

Cape Light Compact 2014 Penetration, Potential and Program Opportunity Study:

Volume 1: Methodology and Results

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July 20, 2015

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Executive Summary

This report summarizes the methodology and results of the 2014 Cape Light Compact Penetration, Potential, and Program Opportunity Study, conducted by Opinion Dynamics Corporation and Dunsky Energy Consulting. The goal of this research was to determine the remaining achievable potential from electric measures among residential, low income, and commercial and industrial customers for the six-year period 2016-2021 and to inform CLC's program planning efforts. The outputs of this study satisfy the requirements of the Massachusetts Department of Public Utilities ("DPU") Order dated January 31, 2013 (D.P.U. 12-107) to document the penetration of energy efficiency within the Compact's service territory and develop estimates of remaining savings potential.[1]

The results presented in this report are based on extensive primary and secondary data collection. The primary data collection activities for the residential and low income sectors included a mail survey with 2,785 customers, in-home visits at 169 homes, and a telephone survey with 144 customers. The primary data collection activities for the commercial & industrial sector included a telephone survey with 448 customers and on-site visits at 150 facilities. We also conducted in-depth interviews with a small number of local contractors to inform assumptions for the potential model.

We estimate CLC's total achievable energy efficiency potential for the six-year period 2016-2021 to be 246 annual GWh[2] and 62 MW.[3] Achievable potential represents 51% of economic potential and 36% of technical potential. On average over the six-year period, achievable energy savings represent 1.98% of CLC forecasted annual sales.[4] These electric savings would be expected to cost CLC $220 million (incentive and non-incentive program costs;[5] in 2016 dollars), an average of $37 million per year or $0.895 per annual kWh.[6] It should be noted that per kWh projected costs are relatively high for CLC as compared to the statewide average due to a number of territory-specific reasons, including the small base of large C&I customers and the seasonal nature of many homes and businesses. The total cost (including the participants' net cost) amounts to $246 million for the six-year period. All of the 2016-2021 proposed investments are currently cost-effective, with an expected Total Resource Cost (TRC) ratio of 3.6 and a Program Administrator Cost (PAC) ratio of 2.8.

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[1] MA DPU Order dated January 31, 2013 (D.P.U. 12-107) included the following requirement: "The Program Administrators with an aggregate three-year savings goal of greater than 20 percent below the statewide three-year aggregate goal will conduct a study, either jointly or individually, during the upcoming three-year term to document the penetration of energy efficiency within its service territory and the remaining cost-effective energy efficiency opportunities available."

[2] The gigawatt-hour, or GWh, is a measure of energy, and is equal to 1,000 megawatt-hours (MWh).

[3] These findings reflect the best information and assumptions available as of April 2015. Cape Light Compact and the Opinion Dynamics/Dunsky team plan to refresh these results, prior to the September Three Year Plan draft filing, to incorporate any newly available evaluation findings, as well as updates to non-incentive program costs.

[4] Note that annual sales are forecasted by Eversource.

[5] Non-incentive program costs, dated March 31, 2015, are estimates based on the average actual Cape Light Compact non-incentive costs for plan years 2013 and 2014, and projected non-incentive costs for plan year 2015.

[6] This compares to a projected average cost of $0.794/kWh during the 2013-2015 Three Year Plan Cycle.

Table ES-1 summarizes these results for the six-year period 2016-2021, as well as for each of the next two three-year planning periods.

Table ES-1. Key Potential Results – All Sectors, by Period

	2016-2021		2016-2018		2019-2021	
Potential (Total)	GWh	MW	GWh	MW	GWh	MW
Technical	675	163	343	86	332	77
Economic	481	117	246	63	235	54
Achievable	246	62	121	33	125	29
Potential (Yearly)	GWh	MW	GWh	MW	GWh	MW
Technical	112.5	27.1	114.4	28.7	110.6	25.5
Economic	80.0	19.5	81.9	21.1	78.0	18.0
Achievable	40.9	10.3	40.3	11.1	41.5	9.5
Annual Achievable as % of Sales	1.98%		1.94%		2.02%	
Cost						
Total (millions)	$246		$120		$126	
CLC (millions)	$220		$107		$113	
CLC Cost/kWh	$0.895		$0.882		$0.908	
Cost-Effectiveness						
Total Resource Cost Test	3.6		3.6		3.6	
Program Administrator Cost Test	2.8		2.8		2.9	

Table ES-2 and Table ES-3 detail annual achievable potentials as a percentage of sales, by year and sector, for the first three-year period and the second three-year period, respectively.

Table ES-2. Achievable Potential as a Percentage of Forecasted Energy Sales – 2016 to 2018

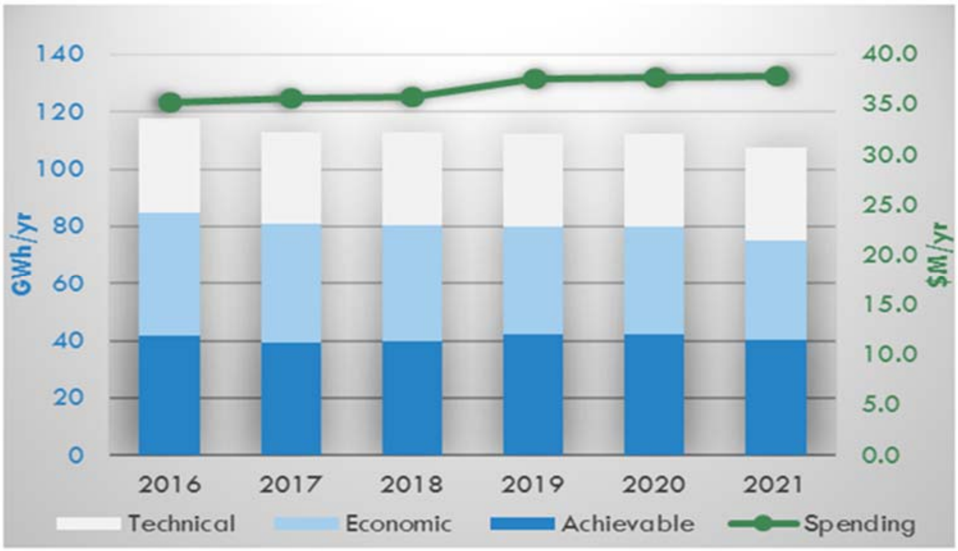
	2016	2017	2018	2016-2018
Residential	2.06%	1.80%	1.79%	1.88%
Low Income	2.39%	2.05%	2.04%	2.16%
Commercial	1.94%	2.00%	2.04%	1.99%
All Sectors	**2.02%**	**1.89%**	**1.90%**	**1.94%**

Table ES-3. Achievable Potential as a Percentage of Forecasted Energy Sales – 2019 to 2021

	2019	2020	2021	2019-2021
Residential	2.00%	2.01%	1.87%	1.96%
Low Income	2.18%	2.19%	2.12%	2.16%
Commercial	2.07%	2.11%	2.07%	2.09%
All Sectors	**2.03%**	**2.06%**	**1.96%**	**2.02%**

Figure ES-1 presents annual savings (GWh) for the three types of potential – technical, economic, and achievable – as well as annual spending required to meet the achievable potential. The increase in spending during the second three-year period (2019–2021) is due to higher LED uptake, which results from an assumption of lower market barriers.[7] While savings from LEDs are higher for that period, they are counterbalanced by somewhat lower savings for other measures.

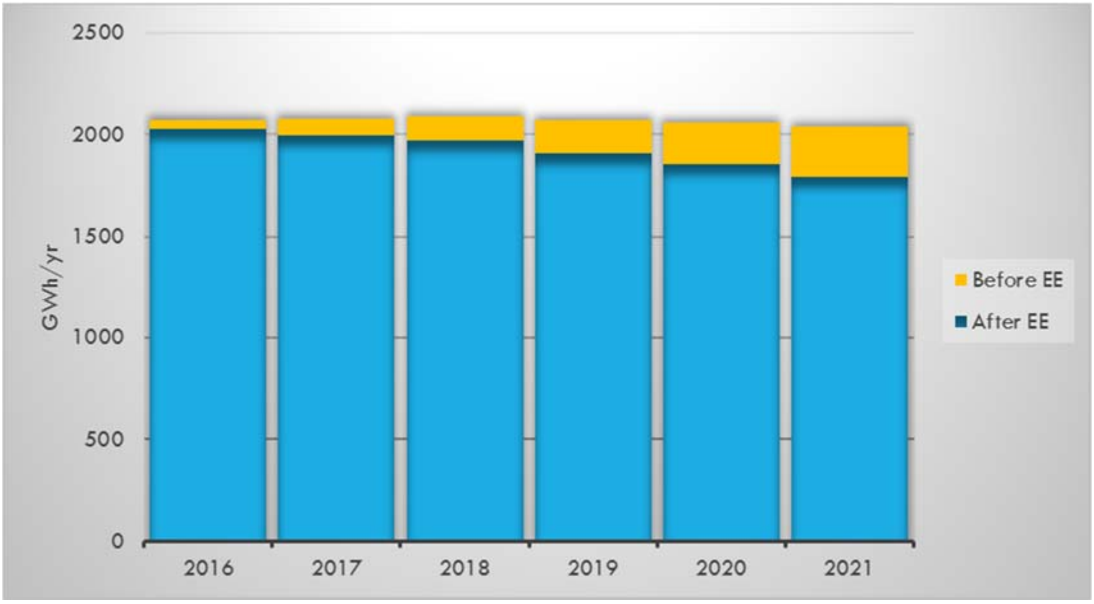
Figure ES-1. Annual Savings and Spending



Energy sales, provided to CLC by Eversource, are forecasted to decline slightly, before energy efficiency (EE) efforts, over the six-year period, with total sales of 2,041 GWh in 2021 compared to 2,071 in 2016. With EE efforts at the level of the achievable potential, energy sales would decline faster, with 2021 sales amounting to 1,795 GWh, a drop of 12% from 2016 sales (Figure ES-2).

[7] The assumptions for measure uptake are based on the best information available at this time and could change in the future.

Figure ES-2. Impact of Achievable Potential on Annual Sales



Achievable potential estimated in this study (120.8 GWh total for the three plan years 2016-2018) is lower than the 2016-2018 savings goal in CLC's Three-Year Plan[8] (156.3 GWh total for the three plan years 2016 - 2018). When comparing CLC's published goal to results from the potential model, it is important to remember that the potential study is not meant to be a direct forecast of claimable savings, because some of the assumptions and inputs used to estimate potential are different from those used for setting goals and claiming savings. In particular, a key objective of this potential study was to reflect the unique circumstances of CLC's service territory and customer base, including the effects on achievable savings of having a large share of seasonal customers. To this end, we collected a wealth of primary data which is reflected in the potential study results. In contrast, the Massachusetts goal setting and savings claiming process requires consistency with Technical Resource Manual (TRM) assumptions.

A key programmatic area where different potential model and TRM assumptions lead to a difference in savings is C&I upstream lighting: The Three-Year Plan estimates savings of 40.9 GWh from C&I upstream lighting whereas the potential model only estimates 8.7 GWh. The main drivers of this difference are assumptions about (1) the mix of baseline (replaced) bulbs (i.e., incandescent vs CFL units); (2) the size (wattage) of the baseline (replaced) bulbs; and (3) hours of use. Aligning potential model assumptions with TRM assumptions for these (and a few other) parameters would increase the achievable potential of the C&I upstream lighting offering to 35.1 GWh and total CLC achievable potential to 147.3 GWh. This change of assumptions would yield an annual achievable potential as a percentage of sales of 2.36% overall in 2016-2018, as compared to 1.94% in the base case (as shown in Table ES-1 above).[9]

[8] References to the Three Year Plan in this document denote the April 30, 2015 draft of this document.

[9] It should be noted, however, that even with these adjustments to C&I upstream lighting, Plan goals are not perfectly comparable to the achievable potential estimated in this study. The potential model also uses CLC-specific assumptions in the other sectors (residential and low income), which we did not vary for this analysis.

1. Introduction

Cape Light Compact contracted with the Opinion Dynamics team to complete a Penetration, Potential, and Program Opportunities Study of its residential, low income, and commercial & industrial sectors. The goal of this research was to determine the remaining achievable potential from electric measures for the six-year period 2016 – 2021 and to inform program planning efforts. The outputs of this study satisfy the requirements of the Massachusetts Department of Public Utilities ("DPU") Order dated January 31, 2013 (D.P.U. 12-107) to document the penetration of energy efficiency within the Compact's service territory and develop estimates of remaining savings potential.[10]

This document, Volume 1, presents the methodology for this study as well as penetration and saturation results and electric potential estimates. Volume 1 is organized as follows:

- **Section 2: Methodology.** This section presents information about our approaches to primary data collection and potential modeling. It includes details about our survey sampling and weighting methodology, and defines key terms and concepts used throughout this report.
- **Section 3: Summary of Key Penetration and Saturation Results.** This section presents the penetration and saturation data collected in the mail and telephone surveys and adjusted, where necessary, by site visit results.
- **Section 4: Overall Potential Results.** This section shows potential results for CLC's service territory, including estimates of technical, economic, and achievable potential for 2016 – 2018, 2019 – 2021 as well as for the six-year period 2016 – 2021. Results are presented by sector, segment, and end-use. This section also includes a comparison of potential model results to CLC three-year Plan.
- **Section 5: Residential Potential Results.** This section shows potential results for the residential sector.
- **Section 6: Low Income Potential Results.** This section shows potential results for the low income sector.
- **Section 7: Commercial & Industrial Potential Results.** This section shows potential results for the commercial and industrial sector.

In addition to this report, separate volumes present additional technical details of the potential modeling, the primary data collection instruments, as well as detailed results from the residential/low income mail survey (adjusted by site visit information) and from the C&I Telephone Survey (also adjusted by site visit information).

However, the different assumptions for C&I upstream lighting can explain a significant portion of the difference between Plan goals and our estimated achievable potential.

[10] MA DPU Order dated January 31, 2013 (D.P.U. 12-107) included the following requirement: "The Program Administrators with an aggregate three-year savings goal of greater than 20 percent below the statewide three-year aggregate goal will conduct a study, either jointly or individually, during the upcoming three-year term to document the penetration of energy efficiency within its service territory and the remaining cost-effective energy efficiency opportunities available."

2. Methodology

Key activities in support of the Potential and Program Opportunities Study included extensive primary data collection as well as potential modeling. The following sections present details about each of these activities.

2.1 Primary Data Collection – Residential & Low Income Sectors

The primary data collection activities for the residential and low income sectors included a mail survey with 2,785 customers, in-home visits at 169 homes, and a telephone survey with 144 customers. This section describes the sampling and weighting methodologies associated with these three activities.

2.1.1 Residential/LI Mail Survey

The 2014 Residential Energy Use Survey consisted of a mail/internet survey of CLC residential and low income customers. The mail survey was designed to collect comprehensive penetration and saturation data on energy-using equipment as well as information about the customers and their homes.

The survey was sent to 12,000 homes in June 2014. To enhance recognition and response rates, all written communications with customers were conducted on specially-designed stationery, displaying the CLC logo. The cover letter included a reference to a website and a personal identification number (PIN), and offered customers the option to complete the survey on-line instead of by mail. The cover letter also announced a drawing of ten $100 gift cards as well as a grand prize of $1,000 in new energy efficient appliances among respondents who returned the completed survey by the specified deadline.

About two and four weeks later, respectively, two reminder mailings – one postcard and one mailing containing another copy of the survey booklet – were sent to customers who had not yet returned a completed survey.

Sample Design

As of February 2014, there were 165,203 residential and 8,530 low income accounts in CLC's service territory.[11] After consultation with CLC, we moved a total of 2,692 accounts classified as residential and low income (including Condo Associations, Realities, Trusts, and Housing Authorities) into the commercial sample frame. We also moved 2,567 accounts classified as "commercial residential" from the commercial sample frame into the residential sample frame, typically because they were single family homes on a commercial rate because of their ownership status as a rental or new construction property in the name of a commercial entity. In either instance, we reclassified these accounts to better capture their energy usage with our primary data collection instruments for their respective sector. Table 2-1 summarizes these account relocations.

[11] It should be noted that the number of CLC customers fluctuates throughout the year.

Table 2-1. Mail Survey Sample Frame Account Relocations

	Residential	Low Income	Total
Number of Accounts in Customer Files	165,203	8,530	173,733
Accounts Moved to Commercial	- 2,688	- 4	- 2,692
Accounts Added from Commercial Residential	+ 2,567	+ 0	+ 2,567
Final Number of Accounts	165,082	8,526	173,608

We then aggregated accounts with the same name and service address to the premise level, resulting in 160,444 residential and 8,507 low income premises. Of these, we dropped records that had no valid usage data (i.e., usage for all 12 months was missing or zero). We also dropped records that had less than 2 kWh average daily usage and an on-Cape mailing address (indicating homes that are likely vacant, rather than seasonal).

The final sample frame for the mail survey consisted of 156,747 residential and 8,338 low income premises (see Table 2-2).

Table 2-2. Mail Survey Sample Frame Premise Drops

	Residential	Low Income	Total
Initial Number of Premises	160,444	8,507	168,951
Dropped Because of Missing or Zero Usage	1,987	136	2,123
Dropped Because of Low Usage (Average Daily Usage < 2 kWh and On-Cape Mailing Address)	1,710	33	1,743
Final Number of Premises (Sample Frame)	156,747	8,338	165,085

The residential premises in the sample frame were classified into non-seasonal and seasonal, based on their 2013 electricity usage pattern. We considered premises seasonal if their usage in June through September exceeded their usage during the rest of the year.

The target number of completed surveys was 1,750. To achieve this number we sent out 12,000 survey booklets, assuming a response rate of approximately 15%. The sampling approach was a random sample within each of the three analysis segments (residential non-seasonal, residential seasonal, and low income).

The following table presents, for the three segments, the number of premises in the population as well as the sample for the outgoing surveys and the expected number of completed surveys.

Table 2-3. Mail Survey Sample Frame and Targets

Sector/Segment	Population	Sample	Expected Completes
Residential Non-Seasonal	107,077	3,500	500
Residential Seasonal	49,670	3,500	500
Low Income	8,338	5,000	750
Total	165,085	12,000	1,750

Summary of Survey Statistics

Overall, we received 2,815 responses to the survey, 2,541 by mail and 274 via the Internet. Of these, 29 responses were duplicates and one was completed by a business. Removing these ineligible responses resulted in a total of 2,785 usable responses. Overall, 1% of mailed surveys were undeliverable. The resulting response rate, calculated as the number of completed surveys divided by the number of deliverable surveys, was 24%. The percentage of undeliverables and the response rates were almost identical for the three segments.

Given this higher than expected response rate, we greatly exceeded the target number of completes in all three segments. Table 2-4 summarizes these survey statistics.

Table 2-4. Summary of Mail/Internet Survey Responses

	TOTAL	Residential Non-Seasonal[a]	Residential Seasonal[a]	Low Income
Total Mailed	12,000	3,500	3,500	5,000
Completed Survey – Mail	2,514	721	699	1,094
Completed Survey – Internet	271	103	86	82
Completed Survey – Total	2,785	824	785	1,176
Undeliverable – Number	154	33	50	71
Undeliverable – Percent	1%	1%	1%	1%
Response Rate	24%	24%	23%	24%

[a] Note that we reclassified the segments for a few respondents, based on their occupancy patters reported in the mail survey.

Weighting

To ensure that mail survey results are representative of CLC's populations of residential and low income customers, respectively, we developed and applied weights. We developed these weights in a two-step process, as described below.

Sample Weights

We first developed sample weights for the residential sector to correct for the fact that we over-sampled seasonal homes and under-sampled non-seasonal homes.[12] For each segment, we estimated the weight by dividing the segment's share of the overall residential population by its share of responses. For example, the seasonal segment represents 32.1% of the residential population but 49.3% of the residential mail survey responses. The weight for this segment is calculated as 32.1% divided by 49.3%, or approximately 0.65. This means that the survey responses of seasonal customers are weighted down, i.e., each response only counts about two-thirds, compared to a weight of 1. Conversely, the weight for non-seasonal customers is 1.34, meaning that each response from a non-seasonal customer is weighted up.

[12] For analysis purposes, both residential segments had the same target number of completes even though the non-seasonal segment is much larger than the seasonal segment.

Table 2-5. Mail Survey Residential Sample Weights

Segment	Population[a]		Responses		Sample Weight
	Count	%	Count	%	
Residential Non-Seasonal	106,399	67.9%	816	50.7%	1.3385
Residential Seasonal	50,348	32.1%	793	49.3%	0.6517
Total Residential	156,747	100%	1,609	100%	

[a] Population counts for the two segments are based on 2013 usage, but were adjusted to reflect occupancy patters reported in the mail survey.

We did not develop sample weights for the low income sector since we did not stratify that sample. Rather, the low income sample was drawn as a simple random sample from the population of low income customers.

Post-Stratification Weights

Post-stratification can be used as a basis for adjusting samples that are not representative of the population for important variables. In other words, it is used when (1) survey respondents are not representative of the population from which they were selected, i.e., some subgroups of interest are over-represented and some are under-represented; and (2) over-represented subgroups are different from under-represented subgroups on important variables. In order to conduct post-stratification, information is required on both the percentage of the population and the percentage of the respondents that fall into the subgroups of interest (or strata). It is important that the strata available for the population are the same as the strata available for survey respondents.

We determined the need for post-stratification by comparing survey responses with known statistics about the population. We compared the survey data across core demographic and household characteristics with 2007-2011 American Community Survey data for CLC's service territory. This comparison found that homes with older heads-of-household are over-represented in our survey responses relative to the population.[13] Since customers of different ages likely vary in their ownership and use of certain electricity-using equipment, we developed an age-based post-stratification weight. This weight is calculated the same way as the sample weight, by dividing the stratum's share of the population by the stratum's share of the sample. It should be noted that to determine the stratum's share of the sample, we first apply the sample weights.

Since the distribution of the age of the head-of-household is different for residential and low income populations, we created separate weights for each. The residential post-stratification weights are shown in Table 2-6; the low income post-stratification weights are shown in Table 2-7.

[13] We also compared the housing type (i.e., single-family attached, single-family detached, apartment/condominium, and mobile home) of respondents to the population in CLC's service territory. Since the distribution of housing types among respondents was almost identical to that in the population, we did not develop post-stratification weights for this statistic.

Table 2-6. Mail Survey Residential Post-Stratification Weights

Age	Population		Responses		Weight
	Count	%	Count	%	
Under 44 years	20,843	22.3%	108	6.9%	3.2448
45 to 64 years	39,866	42.6%	566	36.0%	1.1822
65 years and over	32,950	35.2%	899	57.1%	0.6157
Missing Response			36		1.0000
TOTAL	93,659		1,609		

Table 2-7. Mail Survey Low Income Post-Stratification Weights

Age	Population		Responses		Weight
	Count	%	Count	%	
Under 44 years	2,866	33.0%	161	14.1%	2.3451
45 to 64 years	3,262	37.6%	454	39.7%	0.9465
65 years and over	2,556	29.4%	529	46.2%	0.6365
Missing Response			32		1.0000
TOTAL	8,684		1,176		

Rebalancing Weights

When we applied post-stratification weights for residential customers, the distribution of the sample between seasonal and non-seasonal homes slightly changed from its original proportions. To preserve the proper proportion of the two segments, we developed rebalancing weights. These weights are 1.052 for seasonal homes and 0.977 for non-seasonal homes.

Note that this step was not necessary for the low income sector since it consists of a single segment.

Final Mail Survey Weights

The final weight for each mail survey respondent is the product of the respondent's sample weight, their post-stratification weight (based on their reported age of head-of-household), and their rebalancing weight.[14] These final weights have to be applied whenever mail survey responses are aggregated across multiple respondents. The exception is mail survey variables that have been adjusted with site visit data. For those variables, variable-specific adjustment factors are applied to the final weights (see discussion in the next section).

Adjustment of Mail Survey Data

We used some of the information from the in-home visits, discussed in more detail below, to adjust certain mail survey responses. In general, we considered for adjustment items that are technical in nature and often difficult for customers to report correctly, e.g., questions about

[14] Note that for all low income customers, the sample weight is equal to 1.0 since we did not stratify the sample and the rebalancing weight is equal to 1.0 since the sector consists of a single segment. As a result, the final weight for low income customers is equal to their post-stratification weight.

equipment age or ENERGY STAR rating or questions about the customer's type of windows. We did not consider for adjustment items that cannot be observed during in-home visits (such as questions about home occupancy). We also did not adjust questions with very low incidence in the in-home sample.

We first conducted a Pearson's chi-squared test for questions considered for adjustment. For each question tested, we compared the on-site observations and the mail survey responses for the same set of households (i.e., the comparison only included mail survey responses for homes that received an on-site visit). Only if the test showed that mail survey responses are significantly different from on-site observations, did we include the question for adjustment.

Table 2-8 below presents the survey questions we adjusted, by report section. The number in parentheses indicates the question number in the mail survey (see Appendix 2 for the final mail survey instrument).

Table 2-8. Mail Survey Questions Adjusted with Site Visit Data

B. Central Air Conditioning/Cooling o ENERGY STAR rating of CAC (B4) **C. Window Air Conditioning** o ENERGY STAR rating of window unit (C4a) **D. Insulation and Ventilation** o Inches of attic insulation (D2) o Exterior walls are insulated (D3) o Basement walls are insulated (D4) o Basement ceiling insulated (D5) o Type of windows (D6) **F. Water Heating** o Presence of low-flow showerheads (F5) o Presence of faucet aerators (F6)	**G. Appliances** o ENERGY STAR rating of clothes washer (G2) o ENERGY STAR rating of refrigerators (G8c) o ENERGY STAR rating of dishwasher (G15) **H. Entertainment and Technology** o Count of various TV types (H2a, H2b, H2c, H2f, H2h, H2k) **J. Lighting** o Number of bulbs inside the home (J1) o Percentage of indoor bulbs that are CFLs (J2) o Percentage of indoor bulbs that are LEDs (J3) o Number of bulbs outside the home (J4) o Percentage of outdoor bulbs that are CFLs (J5) o Percentage of outdoor bulbs that are LEDs (J6)

Adjustment Methodology

We used a ratio adjustment approach to adjust the mail survey responses for the questions listed above. The values to be adjusted can be either a mean or a proportion. The ratio adjustment method first develops an adjustment factor, based on the unweighted value of the 169 in-home visits and the unweighted value of the survey responses for the same 169 households:

$$Adjustment\ Factor = \frac{Y_{\text{In-Home Visits}}}{Y_{\text{Survey Responses}}}$$

Where:

$Y_{\text{In-Home Visits}}$	=	unweighted mean or proportion from the 169 in-home visits
$Y_{\text{Survey Responses}}$	=	unweighted mean or proportion from the survey responses for the 169 households with in-home visits

The adjustment factor is then multiplied by the weighted number of survey responses for all households (by sector), to develop an adjusted distribution of responses across response categories. This new distribution is then used to calculate new means or proportions for the adjusted question.

Consider the following example:

If a home reported having a clothes washer, we collected information on whether or not the washer is ENERGY STAR rated (at the time of purchase). The in-home visits found that 56.4% of clothes washers are ENERGY STAR rated. By contrast, the mail survey responses provided by the same 169 households reported that 83.8% are ENERGY STAR rated.[15] Using these values, we developed an adjustment factor for each response category of this question, as follows:

Clothes washer is ENERGY STAR rated: $Adjustment\ \ Factor = \frac{56.4\%}{83.8\%} = 0.673$

Clothes washer is not ENERGY STAR rated: $Adjustment\ \ Factor = \frac{43.6\%}{16.2\%} = 2.691$

We then apply these adjustment factors to weighted mail survey results by response category. Of all residential mail survey respondents with a clothes washer, 916 reported that their washer is ENERGY STAR rated and 212 reported that it is not (valid n=1,128). Multiplying these responses by the adjustment factor yields:

Clothes washer is ENERGY STAR rated: *Adjusted "n" = 916 * 0.673 = 617*

Clothes washer is not ENERGY STAR rated: *Adjusted "n" = 212 * 2.691 = 571*

When adjusting proportions, an additional step is necessary. Because each response category is adjusted separately, the total number of responses no longer sums to the correct valid "n". In the example above, the correct "n" is 1,128 but the adjusted "n"s sum to 1,188 (617+571). To correct for this, we developed an additional balancing factor, which is the ratio of the correct "n" and the adjusted "n". This ratio is multiplied by the adjustment factor for each response category to derive the final adjustment factors for the question.

The final adjustment factor is then multiplied by the post-stratification weight, by response category, to develop adjusted weights. These adjusted weights are specific to each adjusted question. They are used when developing the results used in this analysis.

[15] Percentages are based on unweighted responses.

Precision of Results

Overall, the estimated precision of mail survey results is approximately 2.4% for residential customers and 2.6% for low income customers (at a 95% confidence level). This estimate is based on a two-tailed test, corrected for a finite population, uses an assumed coefficient of variation of 0.5, and includes the total number of responses received (i.e., 1,609 for residential customers and 1,176 for low income customers).

For equipment with low incidence in the population (e.g., central air conditioning), the precision value is higher (i.e., results are less precise) for follow-up questions about equipment characteristics. Similarly, the precision level is higher for questions with many incomplete or invalid responses. For example, a typical rate of incomplete or invalid responses to the mail survey is about 5%. This translates into slightly less precise results, with precision levels of 2.5% for residential customers and 2.7% for low income customers (at a 95% confidence level and holding all other assumptions constant). However, in both examples here, the precision is very good.

2.1.2 Residential/LI In-Home Visits

We conducted a total of 169 in-home visits with Cape Light Compact residential and low income customers. The in-home visits were designed to collect data to verify mail survey responses and to collect additional, more technical data (such as equipment capacity or efficiency ratings) that we did not include in the mail survey as customers generally find it difficult to report.

The site visits took place between August and September 2014 and typically took 60 to 90 minutes per survey. To compensate customers for their efforts, we offered an incentive of $75 for site visits.

Sample Design

The target number of in-home visits was 175. This included 50 residential non-seasonal, 50 residential seasonal, and 75 low income visits. The sampling approach was a random sample within each of these three segments.

The in-home visits were designed as a nested sample, i.e., we drew the sample of homes from the population of mail survey respondents. Therefore, we have a completed mail survey for every in-home visit we conducted.

Overall, we conducted 169 in-home visits. We conducted 61 visits with residential non-seasonal customers, 36 with residential seasonal customers, and 72 with low income customers. The final distribution of site visits by segment was different from the quota since we reassigned the segment for some residential customers based on their self-reported occupancy patterns.

Table 2-9. In-home Visit Quotas by Segment

Segment	Quota	Completed Visits
Residential Non-Seasonal	50	61
Residential Seasonal	50	36
Low Income	75	72
Total	175	169

Weighting

To ensure that in-home results are representative of CLC's population of residential and low income customers, we developed and applied weights. We used the same two-step weighting process that was used for the mail survey.

Sample Weights

We first developed sample weights for the residential sector to correct for the fact that we oversampled seasonal households and under-sampled non-seasonal households. For each segment, we estimated the weight by dividing the segment's share of the overall residential population by its share of responses.[16]

Table 2-10. Site Visit Residential Sample Weights

Segment	Population		Responses		Sample Weight
	Count	%	Count	%	
Residential Non-Seasonal	106,399	67.9%	61	62.9%	1.0794
Residential Seasonal	50,348	32.1%	36	37.1%	0.8655
Total Residential	156,747	100%	97	100%	

We did not develop sample weights for the low income sector since we did not stratify that sample.

Post-Stratification Weights

As with the mail survey, we compared demographics of in-home visit participants with those of the population and found that homes with older heads-of-household are over-represented in our visits. To correct for this, we developed an age-based post-stratification weight. This weight is calculated the same way as the sample weight, by dividing the stratum's share of the population by the stratum's share of the sample. It should be noted that to determine the stratum's share of the sample, we first apply the sample weights.

Since the distribution of the age of the head-of-household is different for residential and low income populations, we created separate weights for each. The residential post-stratification weights are shown in Table 2-11; the low income post-stratification weights are shown in Table 2-12.

[16] As with the mail survey, residential segments had the same target number of completes for analysis purposes even though the non-seasonal segment is much larger than the seasonal segment.

Table 2-11. Site Visit Residential Post-Stratification Weights

Age	Population		Responses		Weight
	Count	%	Count	%	
Under 44 years	20,843	22.3%	7	7.2%	3.0874
45 to 64 years	39,866	42.6%	26	27.5%	1.5487
65 years and over	32,950	35.2%	63	65.3%	0.5387
Missing Response			1		1.0000
TOTAL	93,659		97		

Table 2-12. Site Visit Low Income Post-Stratification Weights

Age	Population		Responses		Weight
	Count	%	Count	%	
Under 44 years	2,866	33.0%	8	11.4%	2.8878
45 to 64 years	3,262	37.6%	29	41.4%	0.9067
65 years and over	2,556	29.4%	33	47.1%	0.6243
Missing Response			2		
TOTAL	8,684		72		

Rebalancing Weights

When we applied post-stratification weights for residential customers, the distribution of the sample between seasonal and non-seasonal homes slightly changed from its original proportions. To preserve the proper proportion of the two segments, we developed rebalancing weights. These weights are 1.058 for seasonal homes and 0.896 for non-seasonal homes.

Note that this step was not necessary for the low income sector since it consists of a single segment.

Final In-Home Visit Weights

The final weight for each in-home visit participant is the product of the participant's sample weight, their post-stratification weight (based on their reported age of head-of-household), and their rebalancing weight.[17] These final weights have to be applied whenever in-home data are aggregated across multiple participants.

2.1.3 Residential/LI Barriers Telephone Survey

The residential/low income telephone survey was aimed at persons in the household who make decisions about purchasing new energy-using equipment for the home. It collected information on barriers to energy efficiency and participation in CLC programs, the role of incentives in adopting energy efficient technologies, as well as program awareness and past program participation. Questions about barriers and incentives were asked separately for

[17] Note that for all low income customers, the sample weight is equal to 1.0 since we did not stratify the sample and the rebalancing weight is equal to 1.0 since the sector consists of a single segment. As a result, the final weight for low income customers is equal to their post-stratification weight.

three major end-use categories: heating and cooling systems, major appliances, and lighting. Survey responses were a key input into the adoption curves developed for the potential model.

The survey was fielded between October 10th and November 10th, 2014 and resulted in 144 completed interviews. On average, the survey took just under 15 minutes to complete. Our response rate was 5.5% with a cooperation rate of 18.0%.

The telephone survey instrument is included in Appendix 2.

Sample Design

Our sampling unit was the residential or low income household. Similar to the mail survey, the population included 107,077 residential non-seasonal households; 49,670 residential seasonal households; and 8,338 low income households. We removed customers who had already received the mail survey and drew a random sample of 2,000 households for each segment. We further removed customers with duplicate or invalid phone numbers. The resulting sample frame included 1,961 residential non-seasonal households; 1,924 residential seasonal households; and 1,965 low income households.

Summary of Telephone Survey Statistics

Table 2-13 presents the final dispositions for the telephone survey. The response rate[18] was 5.5% and the cooperation rate 18.0%, computed using the equations following the table.

[18] Using AAPOR Rate3 (RR3).

Table 2-13. Residential/LI Barrier Survey Disposition

Disposition	Number
Completed Interviews (I)	144
Eligible Non-Interviews	1,995
Refusals (R)	*590*
Mid-Interview terminate (R)	*56*
Partial Interview (P)	*12*
Respondent never available (NC)	*272*
Answering Machine (NC)	*1,053*
Language Problem (NC)	*12*
Not Eligible (E)	582
Fax/Data Line	*26*
Duplicate Number	*4*
Non-Working Number	*461*
Wrong Number	*49*
Business, government office, other organization	*41*
No eligible respondent	*1*
Unknown Eligibility Non-Interview (U)	654
No Answer	*585*
Busy	*54*
Call Blocking	*15*
Total Contacts in Sample	3,375
Response Rate	*5.5%*
Cooperation Rate	*18.0%*

Equation 1

$$\text{Response Rate} = \frac{I}{I+R+NC+(e*U)}$$

$$\text{Where: } e = \frac{I+R+P+NC}{I+R+P+NC+E}$$

Equation 2

$$\text{Cooperation Rate} = \frac{I}{(I+R)}$$

2.2 Primary Data Collection – Commercial & Industrial Sector

The primary data collection activities for this effort included a telephone survey with 448 C&I customers and on-site audits at 150 businesses. This subsection describes the sampling and weighting, data collection, and adjustment methodologies associated with these activities.

The telephone survey primarily gathered high level penetration information on electricity-using equipment and information on barriers to energy efficiency and participation in CLC programs. We conducted site visits with a subset of customers who completed the telephone survey. The site visits collected more detailed information about electricity-using equipment, including penetration, saturation, efficiency, and end-use specific information such as wattage, cooling capacity, and horsepower. We used the combined data from these two sources to characterize penetration and saturation of energy efficiency equipment in the C&I sector and estimate potential.

The primary objective of the sample design was to have a large enough pool of completed phone interviews to recruit site visit participants and to have a distribution of business segments and sizes to enable us to aggregate findings to the sector level. Because the site visit recruits came from the respondents who completed the telephone survey, the basic sample development steps outlined for the telephone survey also form the foundation of the site visit sample.

2.2.1 Telephone Survey

The telephone survey collected high level penetration information on electricity-using equipment and building characteristics, as well as information about customers' decision-making and barriers to purchasing energy-using equipment, and firmographic information, including hours of operation. End-uses for equipment penetration included lighting, cooling, electric space heating, refrigeration, motors, office equipment, water heating, compressed air, cooking, and other energy-using equipment. To maintain a reasonable length and to reduce the likelihood of collecting inaccurate information, the survey only asked high level penetration questions that respondents could be expected to be able to answer over the phone.

The survey was aimed at building owners, business managers, and facility managers with knowledge of energy-using equipment at the premise. We also used the telephone survey to recruit a subset of survey respondents for on-site audits. We implemented the survey through our call center between August 25 and November 3, 2014, and completed 448 interviews.[19] On average, the survey took 15 minutes and 10 seconds to complete. Our response rate was 7%. The telephone survey instrument is presented in Appendix 2.

[19] Nine of the 448 interviews with CLC's top 20 highest usage customers, were completed by more trained Opinion Dynamics analysts in an effort that was managed separately outside of our call center.

Table 2-14. Types of Information Collected in Commercial Telephone Surveys

Business and Occupancy	Penetration of major end-uses	Energy Decision-Making and Barriers
▪ Business segment verification ▪ Own/rent space ▪ Seasonal occupancy ▪ Building structure type ▪ Square footage ▪ Number of employees	▪ Lighting ▪ Cooling ▪ Ventilation ▪ Refrigeration ▪ Electric space heating ▪ Electric water heating ▪ Motors, fans and pumps ▪ Compressed air ▪ Office equipment ▪ Electric food service equipment	▪ Decision-making structure ▪ Equipment investment criteria ▪ Benefits of energy efficiency ▪ Barriers to energy efficiency ▪ Role of incentives on energy efficiency

Sample Design

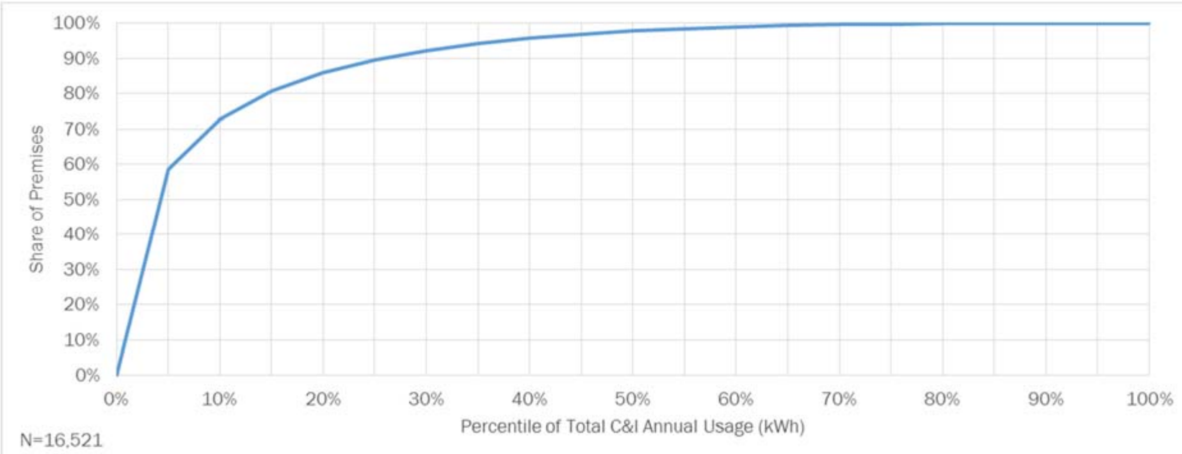
Our sampling unit was the business premise. We developed the population of premises in CLC's territory using two steps. First, we identified accounts with the same name and address and consolidated them. Next, we identified accounts with similar names and addresses, using fuzzy text match, and reviewed these names manually to identify which accounts should be combined to the business premise level. Using an extract of customer data provided by CLC in March 2014, we identified 25,111 customer accounts in CLC's territory, which we consolidated to 18,635 premises. A portion of these premises (2,114, or 11%) were out of scope for this study (e.g., communication towers and street lighting) or had only zero or missing usage data. These records were excluded from the sample frame, resulting in a final frame of 16,521 C&I premises.

Businesses on Cape Cod and Martha's Vineyard are predominantly low users of electricity. As illustrated in Figure 2-1, 9,701 (59%) of 16,521 premises[20] in the sample frame have annual usage that falls within the bottom 5% of total usage.[21]

[20] These premises were not cross-checked with CLC premises as defined by Eversource. As mentioned, low users are defined as low users of electricity and do not reflect fuel use (oil, propane, natural gas).

[21] The threshold for bottom 5% of usage is 11,730 kWh per year.

Figure 2-1. Breakout of C&I Premises by Percentile of Total Annual Usage



To optimize our primary research budget, we used different research approaches for the top 95% of C&I usage and the bottom 5%. We targeted customers in the top 95% usage category with both the telephone survey and site visits while customers in the lowest usage category only completed the telephone survey. The sampling approaches for both groups are described below.[22]

Top 95% Usage Group

The primary objective of the sample design was to have a large enough pool of completed phone interviews to recruit site visit participants and to have a distribution of business segments and sizes to enable us to report findings at the segment level. As such, we developed the target number of site visits needed to meet our research objectives and then determined the number of completed phone interviews required to recruit and complete the site visits based on an average target conversion rate of approximately 33%. We thus targeted 455 completed phone interviews from the Top 95% Usage Group to meet our target of 148 site visits.

Our sample design employed a stratified random sampling approach, with strata based on customers' annual electricity usage. For the stratification, we used the Dalenius-Hodges method to determine strata boundaries and the Neyman allocation to determine the optimal allocation of the available projects to the strata. Table 2-15 shows the number of premises in the sample frame by stratum and the targeted number of phone interviews and site visits.

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[22] While we did not specifically sample for Martha's Vineyard businesses, we attempted to survey a representative proportion. Martha's Vineyard customers make up 7% of the total sample and 10% of completed interviews.

Table 2-15. Sample Frame and Expected Completes by Usage Category of Top 95% Usage Group

Stratum	Usage Range	Number of Premises in Sample Frame	Targeted Number of Phone Interviews	Targeted Number of Site Visits
3	≥ 1000 MWh/year	84	34	16
2	125-1000 MWh/year	936	121	41
1	<125 MWh/year and still in top 95% of usage	5,800	300	91
Total		6,820	455	148

After defining the sample frame and strata, we assigned a phone number to each premise.[23] We identified 5,573 premises in the top 95% group with unique phone numbers. These premises represent our CATI sample.[24]

Bottom 5% Usage Group

We targeted 70 completed interviews from the Bottom 5% Usage Group.[25] We drew a stratified random sample of 2,200 from the Bottom 5% Usage Group, ensuring that the proportion of business segments was representative of the population of businesses on Cape Cod and Martha's Vineyard.

C&I Segment Classification

We established 10 business segments based on discussions with CLC and our review of the customer data. CLC provided segment classifications for all CLC C&I premises.[26] Although we did not use these segments to develop the sample for the Top 95% Usage Group, we sought to complete surveys with a representative share of businesses in each business segment (to ensure that the overall results matched the mix of business segments on Cape Cod and Martha's Vineyard). We therefore set quotas for each business segment in each usage stratum. However, given the low number of premises in some of the segments, we were unable to meet the quotas for all segments. In order to maximize the total number of responses, we conducted a census attempt of all businesses in the Top 95% Usage Group. We then weighted the results of the completed surveys and site visits back to the population (as described below).

Table 2-16 shows the segment groupings, based on CLC's assignments and the customer usage data.

[23] We assigned phone numbers based on account information, program implementer contact data, and results from a matching service used to identify phone numbers for premises with non-unique or missing phone numbers.

[24] After assigning the best phone number to each premise, we also removed four premises from the sample because they participated in Project 21.

[25] The sample frame from which we drew the sample was developed using the same sample cleaning and phone number assignment processes as the top 95% group.

[26] We verified these segment assignments as part of our phone survey.

Table 2-16. C&I Segment Definitions

Study Segment	SIC Category Code	SIC Segment	Number of Premises		
			Top 95%	Bottom 5%	Total
Small Retail	C3	Retail - Small	915	1,135	2,050
	C14	Health Club/Spa	113	175	288
	C94	Gallery/Museum	52	130	182
Office	C71	Office - Large	10	0	10
	C7	Office - Small	758	1,383	2,141
	C100	Charitable/Non-Profit	70	74	144
Restaurant	C31	Restaurant - Full Service	441	159	600
	C1	Restaurant - Fast Food	324	107	431
Government or Education	G4	Government	494	611	1,105
	C98	Schools K-12	81	20	101
	C101	Laboratory/Research Facility	38	14	52
	C18	Library	23	5	28
	C25	Community College/University	2	0	2
Lodging/ Hospitality	C15	Lodging - Hotel/Motel	258	66	324
	C11	Lodging - B&B/Inn/Rooming House	175	126	301
Multifamily or Rental Housing[A]	C96	Multifamily Commercial	562	2,337	2,899
Health Services	C6	Healthcare - Clinic	347	320	667
	C27	Healthcare - Hospital/Nursing Home	51	9	60
Grocery, Convenience or Large Retail	C2	Grocery - Small/ Convenience/Liquor	197	62	259
	C28	Grocery - Supermarket	35	9	44
	C32	Retail - Large	53	4	57
	C91	Big Box	5	1	6
	C99	Warehouse - Refrigerated	8	9	17
Automotive, Warehouse/ Distribution or Industrial	C9	Automotive	253	255	508
	C92	Water and Waste Water Treatment	112	34	146
	C93	Industrial - Light	279	507	786
	C95	Industrial - Heavy	3	3	6
	C30	Transportation	49	110	159
	C26	Warehouse	232	752	984
Other Commercial	C104	Mixed Use Commercial	322	573	895
	C22	Recreational - Other	242	240	482
	C23	Religious/Houses of Worship	132	146	278
	C8	Other	69	152	221
	C29	Agriculture	44	93	137
	C10	Assembly Hall	44	53	97
	C17	Laundry/dry cleaning	23	13	36
	C97	Recreational - Ice Arena	3	1	4
	M2	Unknown	1	13	14
TOTAL			6,820	9,701	16,521

[A]To leverage the C&I sector's telephone survey contact strategy, 1,476 centrally managed residential rental premises were included in the multifamily/rental housing segment.

Summary of Telephone Survey Statistics

Opinion Dynamics fielded the telephone survey between August 25 and November 3, 2014.[27] Table 2-17 presents the final dispositions for the CATI telephone survey, including both the Top 95% and Bottom 5% Usage Groups. The response rate[28] was 7.0% and the cooperation rate was 12.3%, computed using the same equations described for the residential/LI barriers telephone survey in Section 2.1.3. Please note that this includes only full completes for the CATI telephone survey. An additional two respondents completed nearly all of the phone survey, for a total of 439 usable responses. Opinion Dynamics analysts also completed 9 interviews of CLC's top 20 accounts, an effort that was managed separately, resulting in the total number of completes of 448 we present elsewhere in this report.

Table 2-17. C&I Customer Survey Disposition

Disposition	Number
Completed Interviews (I)	437*
Eligible Non-Interviews	5,224
Refusals (R)	*2,945*
Mid-interview terminate (R)	*161*
Respondent never available (NC)	*1,469*
Answering machine confirming contact (NC)	*636*
Language problem (NC)	*13*
Not Eligible (e)	1,520
Fax/data line	*122*
Duplicate number	*46*
Non-Working	*766*
Wrong Number	*366*
Business, government office, other organization	*199*
No eligible respondent	*18*
Quota filled	*3*
Unknown Eligibility Non-Interview (U)	537
Not dialed/worked	*2*
No answer	*495*
Busy	*21*
Call Blocking	*19*
Total Contacts in Sample	7,748
Response Rate	7.0%
Cooperation Rate	12.3%

*Includes only full completes for the CATI C&I telephone survey. Does not include an additional 2 respondents who completed nearly all of the survey or the 9 interviews of CLC's top 20 accounts completed by Opinion Dynamics analysts.

[27] In addition, Opinion Dynamics analysts completed two of nine interviews with top 20 accounts in January 2015.

[28] Using AAPOR Rate3 (RR3).

2.2.2 Telephone Survey Data Weighting and Adjustments

The telephone survey data presented in this report were weighted to be representative of the population and adjusted using the data collected during the site visits. We also adjusted several key survey questions using other sources when respondents could not accurately provide answers. We describe the weighting and data adjustments in the sections below.

Telephone Survey Weighting

We developed and applied weights to ensure that the telephone survey results are representative of the population of premises in CLC's commercial and industrial sector. The penetration and saturation findings presented in this report are weighted to account for the following factors:

1) Differences in the distribution of customer counts by usage group within our sample compared with the population (i.e., customer base), since we oversampled premises with high usage to collect information on electricity-using equipment typically only found in large facilities. For example, chillers are typically only found in large facilities and to collect enough information on this type of equipment, we needed to oversample large facilities (i.e., those with usage over 1,000 MWh/year).
2) Differences in the distribution of customer counts by segment, to account for variations in survey response rates by segment.

We developed the weights using a multiple step process. First, we created a segment weight by dividing the segment's share of the overall commercial population by its share of respondents. For example, the small retail segment represents 18% of survey responses but only 15% of the C&I population. We therefore weighted down the survey responses from this segment so that, when aggregated to the total, the responses are representative of the overall population. The segment weight for small retail is 15% divided by 18%, or 0.8436. Next, we calculated a usage weight by dividing the usage category's share of the overall population by its share of respondents. For example, the Less than 125 MWh/Year stratum accounts for 70% of survey completes but only 35% of the all premises in that stratum, resulting in a weight of 0.5009. The initial sample weight is the product of the segment weight and the usage weight. In this example, the initial sample weight for small retail respondents in the Less than 125 MWh/Year stratum is 0.4226 (0.8436 multiplied by 0.5009).

We then evaluated the initial sample weights for undesirable unequal weighting effects and determined that one weight (7.04 for lodging/hospitality in the Bottom 5% stratum) was higher than desirable.[29] To correct this, we reweighted the data, trimming the weighting factor at 4.70 and equally redistributing the differential across the other categories.[30] The weights applied to the C&I telephone survey results presented in this report are shown in the Final Sample Weight column in Table 2-18.

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[29] A weighting scheme with a high standard deviation of weights relative to the mean weight can yield undesirable results by allowing some customer responses too much influence on the direction of results of their segment.

[30] We trimmed the weight for this segment to three standard deviations from the mean, which is the cutoff recommended by Levy and Lemeshow. (Paul S. Levy and Stanley Lemeshow. Sampling of Populations. 2008. p. 513.)

Table 2-18. C&I Telephone Survey Sample Weights

Usage Stratum	Segment	Premise Count	Responses	Initial Sample Weight	Final Sample Weight
Bottom 5%	Small Retail	1,440	13	3.1704	3.2415
Bottom 5%	Office	1,457	16	3.5981	3.6788
Bottom 5%	Restaurant	266	3	2.2840	2.3353
Bottom 5%	Government or Education	650	1	3.2814	3.3550
Bottom 5%	Lodging/Hospitality	2,529	4	7.0415	4.7051
Bottom 5%	Health Services	329	3	3.5279	3.6070
Bottom 5%	Grocery, Convenience or Large Retail	85	0	--	--
Bottom 5%	Automotive, Warehouse/ Distribution or Industrial	1,661	20	3.3825	3.4584
Bottom 5%	Other Commercial	1,284	10	4.4105	4.5094
<125 MWh/Year	Small Retail	996	66	0.4226	0.4320
<125 MWh/Year	Office	791	48	0.4796	0.4903
<125 MWh/Year	Restaurant	601	33	0.3044	0.3113
<125 MWh/Year	Government or Education	444	24	0.4374	0.4472
<125 MWh/Year	Lodging/Hospitality	843	36	0.9385	0.9596
<125 MWh/Year	Health Services	334	12	0.4702	0.4808
<125 MWh/Year	Grocery, Convenience or Large Retail	171	9	0.3251	0.3324
<125 MWh/Year	Automotive, Warehouse/ Distribution or Industrial	844	51	0.4508	0.4609
<125 MWh/Year	Other Commercial	776	35	0.5879	0.6010
125 - 1000 MWh/Year	Small Retail	84	2	0.4283	0.4379
125 - 1000 MWh/Year	Office	45	1	0.4860	0.4969
125 - 1000 MWh/Year	Restaurant	163	10	0.3085	0.3154
125 - 1000 MWh/Year	Government or Education	163	9	0.4432	0.4532
125 - 1000 MWh/Year	Lodging/Hospitality	141	9	0.9512	0.9725
125 - 1000 MWh/Year	Health Services	54	2	0.4765	0.4872
125 - 1000 MWh/Year	Grocery, Convenience or Large Retail	98	5	0.3295	0.3369
125 - 1000 MWh/Year	Automotive, Warehouse/ Distribution or Industrial	84	7	0.4569	0.4672
125 - 1000 MWh/Year	Other Commercial	104	5	0.5958	0.6091
>1000 MWh/Year	Small Retail	0	0	--	--
>1000 MWh/Year	Office	2	0	--	--
>1000 MWh/Year	Restaurant	1	0	--	--
>1000 MWh/Year	Government or Education	31	6	0.1421	0.1453

Usage Stratum	Segment	Premise Count	Responses	Initial Sample Weight	Final Sample Weight
>1000 MWh/Year	Lodging/Hospitality	11	2	0.3049	0.3117
>1000 MWh/Year	Health Services	10	4	0.1527	0.1562
>1000 MWh/Year	Grocery, Convenience or Large Retail	29	2	0.1056	0.1080
>1000 MWh/Year	Automotive, Warehouse/ Distribution or Industrial	0	0	--	--
>1000 MWh/Year	Other Commercial	0	0	--	--
Total		16,521	448		

Adjustment of Telephone Survey Data

We used information from the site visits to adjust for self-report error in certain phone survey responses. In general, we considered for adjustment any items that customers would be likely to misreport (e.g., penetration of relatively minor equipment and systems), as well as specific equipment types within an overall category (e.g., types of air conditioning systems when a customer had already reported they had air conditioning).

We first conducted a Pearson's chi-squared test for questions considered for adjustment. Only if the test showed that phone survey responses are significantly different from on-site observations, did we include the question for adjustment. We did not adjust questions with low incidence in the site visit sample.

Below are the phone survey questions we adjusted.

- Central Air Conditioning/Cooling
  - Presence of packaged air conditioners (M8)
  - Presence of split air conditioning systems (M8)
  - Presence of heat pumps[31] (M8)
- Water Heating
  - Presence of water heating equipment (M17)
- Refrigeration
  - Presence of ice machines (M27)
- Compressed Air
  - Presence of compressed air equipment (M30)
- Energy Management Systems
  - Presence of EMS (M34)

[31] This study categorizes split air conditioning systems and heat pumps separately. While a heat pump can also be a split system – i.e., have a separate evaporator unit and condenser and compressor unit – a split air conditioning system only provides cooling and cannot provide heating like a heat pump.

Adjustment Methodology

We used the ratio adjustment method to adjust the phone survey responses for the items listed above.[32] This method first develops an adjustment factor, based on the unweighted values of the completed phone survey responses for those sites that later received an on-site visit and the value from the unweighted site visit measurements analogous to the phone survey question being adjusted. The adjustment factor is then multiplied by the value from the survey responses for all sites. The values to be adjusted can be either a mean or a proportion. In the case of this study, we adjusted only penetration, or "presence of" information.

The equation below shows this two-step ratio adjustment method.

$$\text{Adjustment Factor} = \frac{Y_{\text{Site Visits}}}{Y_{\text{Survey Responses}}}$$

Where:

$Y_{\text{Site Visits}}$	=	unweighted proportion from the 150 site visits
$Y_{\text{Survey Responses}}$	=	unweighted proportion from the survey responses for the 150 premises with site visits

The adjustment factor is then multiplied by the weighted number of survey responses for all premises to develop an adjusted distribution of responses across response categories. This new distribution is then used to calculate new proportions for the adjusted question.

Consider the following example:

The on-site visits found that 26% of premises (unweighted) have ice machines. By contrast, the unweighted phone survey responses provided by the same 150 premises reported that 40% have ice machines. Using these values, we first developed the adjustment factor for ice machines, as follows:

Have ice machine: $Adjustment \quad Factor = \frac{26.0\%}{40.3\%} = 0.645$

Do not have ice machine: $Adjustment \quad Factor = \frac{74.0\%}{59.7\%} = 1.239$

We then apply these adjustment factors to unweighted phone survey results by response category. Of all phone survey respondents, 120 reported that that they have an ice machine and 324 reported that they do not (valid n=444). Multiplying these responses by the adjustment factor yields:

Have ice machine: *Adjusted Value = 120 * 0.645 = 77*

[32] Judith T. Lessler and William D. Kalsbeek. Nonsampling Error in Surveys. 1992. p. 269.

Do not have ice machine: *Adjusted Value = 324*1.239 = 401*

When adjusting proportions, an additional adjustment step is necessary. When the data is categorical (including yes/no or present/not present), each category is adjusted separately. As a result, as is the case in the example above, the total number of responses no longer sums to the correct valid "n". To correct for this, we also adjust the base of our results to match the original "n".

Finally, we apply sample weights to these results to produce the final results presented in Volume 3 of this report.

2.2.3 Site Visits

The 150 on-site audits were designed to collect data to verify the telephone survey responses and to collect more detailed and technical data that customers are generally unable to report on during a telephone survey. We also collected energy use and behavioral information from these facilities. The objective of this data collection was primarily to gather information about the saturation and penetration of different types of equipment.

Our team of qualified technicians conducted the site audits between September and November 2014. They entered facility data using tablet computers and a comprehensive Excel-based data collection instrument. The data collection instrument covered the topics listed in Table 2-19.

Table 2-19.Types of Information Collected in C&I Site Visits

Business and Occupancy	Penetration and Saturation of Major End-Uses	Equipment Characteristics	Operations/Behaviors
▪ Seasonal occupancy ▪ Building age ▪ Square footage (facility and occupied) ▪ Conditioned space	▪ Lighting ▪ Cooling ▪ Ventilation ▪ Refrigeration ▪ Electric space heating ▪ Water heating (and fuel type) ▪ Motors, fans and pumps ▪ Compressed air ▪ Office equipment ▪ Electric food service equipment ▪ Wastewater treatment equipment	▪ Equipment type ▪ Nameplate information (make, model, age, size/capacity) ▪ Lighting wattage ▪ Efficiency rating (e.g., EER/SEER, AFUE, insulation levels) ▪ ENERGY STAR status ▪ Efficient and inefficient components (e.g., VFDs, demand-controlled ventilation, tank insulation)	▪ Monthly, weekly, and daily operation ▪ Lighting hours-of-use ▪ Equipment hours-of-use ▪ Control strategy (lighting: manual, EMS, occ. sensors, dimmers, daylighting, etc.; HVAC: thermostat, EMS, etc.)

Appendix 2 presents the final on-site audit data collection instrument.

Site Audit Weighting

To account for differences in segments and usage strata between the premises receiving site visits and the sample frame, we developed a two-step weighting scheme similar to the weighting scheme described above for the C&I telephone survey.

Similar to the C&I telephone survey, we developed and applied weights to ensure that the telephone survey results are representative of the population of premises in CLC's commercial and industrial sector. The site visit findings in this report are weighted to account for the following factors:

1) Differences in the distribution of customer counts by usage group within our sample compared with the sample frame (i.e., customer base), since we oversampled premises with high usage to collect information on electricity-using equipment typically only found in large facilities. For example, chillers are typically only found in large facilities and to collect enough information on this type of equipment, we needed to oversample large facilities (i.e., those with usage over 1,000 MWh/year).
2) Differences in the distribution of customer counts by segment, to account for variations in survey response rates by segment.

As with the C&I telephone survey, the sample weight is a product of the segment weight and the usage weight. After developing the site visit weights, we evaluated the weights for undesirable unequal weighting effects and found none. The weights applied to the C&I telephone survey results presented in this report are shown in the Sample Weight column in Table 2-20.

Table 2-20. C&I Site Visit Sample Weights

Usage Stratum	Segment	Population Count[a]	Responses	Sample Weight
<125 MWh/Year	Small Retail	2,436	20	1.3691
<125 MWh/Year	Office	2,248	16	1.5402
<125 MWh/Year	Restaurant	867	10	0.7842
<125 MWh/Year	Government or Education	1,094	12	0.7347
<125 MWh/Year	Lodging/Hospitality	3,372	15	1.9146
<125 MWh/Year	Health Services	663	5	0.9216
<125 MWh/Year	Grocery, Convenience or Large Retail	256	4	0.4370
<125 MWh/Year	Automotive, Warehouse/ Distribution or Industrial	2,505	21	1.1815
<125 MWh/Year	Other Commercial	2,060	9	2.0574
125 - 1000 MWh/Year	Small Retail	84	1	0.3429
125 - 1000 MWh/Year	Office	45	1	0.3858
125 - 1000 MWh/Year	Restaurant	163	5	0.1964
125 - 1000 MWh/Year	Government or Education	163	2	0.1840
125 - 1000 MWh/Year	Lodging/Hospitality	141	5	0.4796
125 - 1000 MWh/Year	Health Services	54	2	0.2308
125 - 1000 MWh/Year	Grocery, Convenience or Large Retail	98	4	0.1095

Usage Stratum	Segment	Population Count[a]	Responses	Sample Weight
125 - 1000 MWh/Year	Automotive, Warehouse/ Distribution or Industrial	84	4	0.2959
125 - 1000 MWh/Year	Other Commercial	104	3	0.5153
>1000 MWh/Year	Small Retail	0	0	--
>1000 MWh/Year	Office	2	0	--
>1000 MWh/Year	Restaurant	1	0	--
>1000 MWh/Year	Government or Education	31	6	0.0405
>1000 MWh/Year	Lodging/Hospitality	11	1	0.1056
>1000 MWh/Year	Health Services	10	2	0.0508
>1000 MWh/Year	Grocery, Convenience or Large Retail	29	2	0.0241
>1000 MWh/Year	Automotive, Warehouse/ Distribution or Industrial	0	0	--
>1000 MWh/Year	Other Commercial	0	0	--
Total		16,521	150	

[a] The population count for the <125 MWh/year usage stratum includes the Bottom 5% usage stratum

2.2.4 Manual Adjustments

In addition to adjusting phone survey results with information from the site visits, we also made some manual adjustments to the final data.

Square Footage

Square footage is a key input into the potential model. We asked each phone survey respondent about the size of their business in square feet and also collected this information during our on-site visits. Although telephone survey interviewers prompted respondents to give their best estimate, 37% of customers were still unable to estimate the square footage of their business. In these cases, we used the site visit estimate if available. Additionally, our initial review of the phone survey responses found that many of the estimates were not accurate. The telephone survey adjustment methodology used for many questions did not work in this case because the square footage estimates from the site visits may also have been incorrect, either from auditor error or from being provided by the same contact at the site who supplied the erroneous first estimate. Instead we used an alternate adjustment method consisting of randomly selecting a sample of 50 sites and researching the exact square footage of each site to develop an error correction factor of 93% to apply to the population. To find the square footage of these properties, we used public property records,[33] as well as aerial and satellite photographs along with a web-based application designed to obtain the square footage of a building from these photos.

Equipment Information

Whenever possible and reasonable, the site visit auditors collected detailed information (e.g., efficiency level of central air conditioning systems (SEER) and horsepower of motors) for the equipment found onsite. In cases where it was impossible to determine this information

[33] We used tax records found on the Massachusetts Office of Geographic Information (MassGIS) online mapping tool. (http://maps.massgis.state.ma.us/map_ol/oliver.php)

onsite, we used to the model number, collected during the site visit, to research this information following the site visit.[34]

2.3 Potential Modeling

2.3.1 General Methodology

Description of Model

We developed a CLC-specific potential model that estimates the electric energy and capacity saving potential in CLC's service territory. The model embeds CLC-specific inputs with respect to measure characteristics, equipment penetration and saturation, and measure adoption assumptions. We developed a flexible potential model structure that can produce the outputs and level of disaggregation specified by CLC – at the sector level (C&I, residential, and low income), for key market segments, etc. – and that allows for future modification of key model parameters by CLC staff to test different scenarios during the program planning process.

The scope of the study included development of three levels of potential: technical potential, economic potential, and achievable potential. They are defined as follows:

- Technical Potential: For each market,[35] the measure procuring the most energy savings per unit is selected. The technical potential is defined as the electricity savings from these measures multiplied by the theoretical maximum number of units per year.
- Economic Potential: For each market, the cost-effective measure procuring the most energy savings per unit is selected. The economic potential is defined as the electricity savings from these measures multiplied by the theoretical maximum number of units per year.
- Achievable Potential: The achievable potential is defined as the electricity savings from cost-effective measures adjusted by several factors to represent the potential that could be achieved through ambitious and comprehensive programs/initiatives.

Key concepts used in the estimation of potential are briefly described below.

- Inputs: The model requires several inputs at the measure level (e.g., energy and capacity savings, costs, effective useful life, net-to-gross factors, load profile, etc.), as

[34] In some cases, to minimize the time on-site and disruption to customers, auditors only collected the model numbers of equipment knowing that other nameplate information could be researched later. Auditors collected efficiency and capacity information for approximately 85% of systems onsite and looked up the other 15% after the visit.

[35] We use the words "market" or "market size" to describe the number of baseline equipment or buildings in a given segment that capture the opportunity for specific energy-efficient measures. For example, the number of sockets with incandescent bulbs in the non-seasonal residential sector would be an example of a "market" for CFLs or LEDs.

well as other inputs such as avoided costs, rates, electricity forecasts, markets, and initiatives.[36]

- Units per Year (theoretical maximum): Using inputs and calculations such as market size and growth, measure type, and natural replacement rates of existing equipment, the maximum number of units that could be replaced or installed per year is calculated.
- Cost-Effectiveness: The model calculates two types of cost-effectiveness ratios. Both tests can be calculated at the measure, initiative, segment, sector, and portfolio level.
  - The **Total Resource Cost test (TRC)** is used to screen measures for the economic and achievable potentials. A positive TRC result (net present value higher than zero or cost-benefit ratio higher than one) indicates that the energy efficiency measure (or initiative) will produce reductions in energy costs, as well as non-energy benefits, that are greater than the costs of implementing that measure (or initiative).
  - The **Participant Cost Test (PCT)** is an input for measure adoption rates. A positive PCT result means that the participant of an energy efficiency initiative will receive benefits – including energy bill savings and non-energy benefits – that are higher than net costs (i.e., the cost of the measure minus incentives received by the participant).
- Base Adoption Rate: The base adoption rate for determining the achievable potential is calculated using the cost-effectiveness of measures from the participants' point of view and levels of market barriers.
- Competing Measures: At the achievable potential level, multiple cost-effective measures can compete with each other for the same market. In that case, each measure is attributed a share of the overall market, based on its base adoption rate compared to other measures. An example would be CFL and LED bulbs competing for the same sockets where incandescent lighting is currently used. If both are cost-effective, both will be included in the achievable potential.
- Cumulative Annual Savings: Cumulative savings are calculated for each potential type and each year, using incremental savings potentials. Savings from individual measures are removed from the cumulative savings at the end of their effective useful life (EUL). For instance, a measure installed in Year 1 and with a EUL of two years would be removed from the cumulative potential starting in Year 3.
- Aggregate Results and Reporting: Measure-level energy and capacity savings, costs, and benefits are aggregated and can be displayed by sector, segment, end-use, measure-type, or initiative. Costs are reported from both the program administrator's and the service territory's perspectives. The program administrator's costs do not

[36] Initiatives are sub-components of programs that target specific opportunities. For instance, the Residential New Construction, Residential Multi-Family Retrofit, and Residential Behavior/Feedback initiatives are all part of the Residential Whole House Program.

include the participants' share of costs (i.e., costs that are not covered by incentives), nor do they include any adjustments for early retirement measures.

The following sections present more detailed descriptions of the modeling methodology. It should be noted that the rest of the methodology discussion focuses on achievable potential as it is the study's primary focus.

Sectors and Segments

The model reflects three different sectors and 13 segments, as detailed in Table 2-21 below. Measure inputs are differentiated by segment (e.g., lighting savings vary by commercial segment according to reported hours of use and seasonality adjustments). Results are reported at both the sector and segment levels.

Table 2-21. Sector and Segment Definition for Potential Model

Sector	Segment
Residential	Non-seasonal
	Seasonal
Low Income	Low Income
C&I	Small Retail
	Office
	Restaurant
	Government or Education
	Lodging/Hospitality
	Health Services
	Multifamily or Rental Housing
	Grocery, Convenience or Large Retail
	Other Commercial
	Automotive, Warehouse/Distribution or Industrial

End-Uses

The model includes 12 different end-uses, listed in Table 2-22 below (with examples of associated measures).

Table 2-22. End-Uses Included in Potential Model

End-Use	Examples of Measures
Lighting	LED light bulbs, lighting controls, efficient linear lighting
HVAC (Heating, Ventilation, Air Conditioning)	Thermostats, heat pumps, air conditioning units
Motors	Furnace fan motors, pool pumps, C&I ventilation & process motors
Refrigeration	Refrigerators, freezers, vending machine misers
Food Services	Ovens, dishwashers, fryers

Hot Water	Heat pump water heaters, low flow showerheads, spray rinse valves
Appliances	Clothes dryers
Products	Smart strips, TVs, Dehumidifiers
Behavior	Feedback, opt-In behavioral, basic educational measures
Envelope	Insulation, air sealing
CHP (Combined Heat and Power)	Combined heat and power
Other	Retro-commissioning, advanced energy analytics, cable boxes

Measures

We used the 2012 Massachusetts Technical Reference Manual (TRM) (Program Years 2013-2015) as a starting point for the list of measures to be included in this study. Amongst other factors, the expected relative importance of measures in CLC's potential was used to make decisions on aggregating TRM measures or breaking them out into sub-measures. As an example, lighting measures in the TRM are much more detailed than weatherization measures. We bundled measures mainly across initiatives that offer the same measure, using either assumptions for the most prevalent initiative or weighted averages for measure inputs.

The following measure categories were excluded from the scope of this study:

- Demand Response
- Fuel Switching
- Renewables
- Gas-saving measures that are covered by other PA's natural gas initiatives, which may also have an electric impact.

In addition to TRM measures, CLC expressed interest in investigating and screening new measures that are not currently offered in Massachusetts (as reflected by the TRM). We followed the process described below to identify new measures:

1. We reviewed a total of 13 Technical Reference Manuals to identify measures that are not already included in the Massachusetts TRM and are not currently offered by CLC programs.
2. We reviewed the program tracking database of an Emerging Technology program in California (which had close to 200 projects) to identify up-and-coming measures that currently have low market adoption rates but may evolve as a result of product development growth and market awareness for future implementation.
3. We reviewed a list of measures provided by the Massachusetts Technical Advisory Committee (MTAC).

After systematically considering new measures, we found that CLC already has a nearly complete suite of measures available within their portfolio. Many "missing" measures where in fact already included in CLC's initiatives as "custom measures" and were added to our list. We selected new electric measures for inclusion in this study based on the likelihood that they may represent a significant potential during the study period.

Table 2-23 lists new measures included in the study.

Table 2-23. New Measures Included in Potential Model

Residential / Low Income
Whole-House Fan
Residential Behavioral Opt-in[A]
Room Air Conditioning Recycling[B]
C&I
Linear LEDs without Ballast Change
Ultra High Efficiency Roof Top Units
Advanced Controller for Roof Top Units
Smart Thermostat (Cooling)
Advanced Refrigeration for Supermarkets – Glass Door Retrofits
Advanced Refrigeration for Supermarkets – Floating Head Pressure Control
Strip Curtains
Retro-commissioning and Advanced Energy Analytics
Advanced Lighting Controls
Early Replacement of Cable Boxes
Combined Heat and Power

A The Cape Light Compact has previously received information that might question the viability of this type of program, given the size of the population and its ability to participate in an initiative like this one.

B The Compact has previously offered room air conditioning recycling; however, because it is not currently being offered, it is referenced as a new measure here.

Calculation of Achievable Potential

As defined above, the achievable potential is defined as the electricity savings from cost-effective measures multiplied by the theoretical maximum number of units per year, the base adoption rates, the market share adjustments for competing measures, and other adjustments such as market applicability factors[37] and uptake factors.

We used adoption curves, based on the Department of Energy (DOE) adoption model, to determine the base adoption rate for each measure, by segment.[38] These curves provide a formula for relating customer cost-effectiveness to adoption rates, given different levels of market barriers. The DOE model is grounded in a qualitative assessment of market barriers and the calculation of a cost-benefit ratio to estimate the maximum achievable market penetration for energy efficient products. Based on this approach, measure cost-effectiveness and perceived barriers are the two primary factors affecting adoption rates. In our model, both

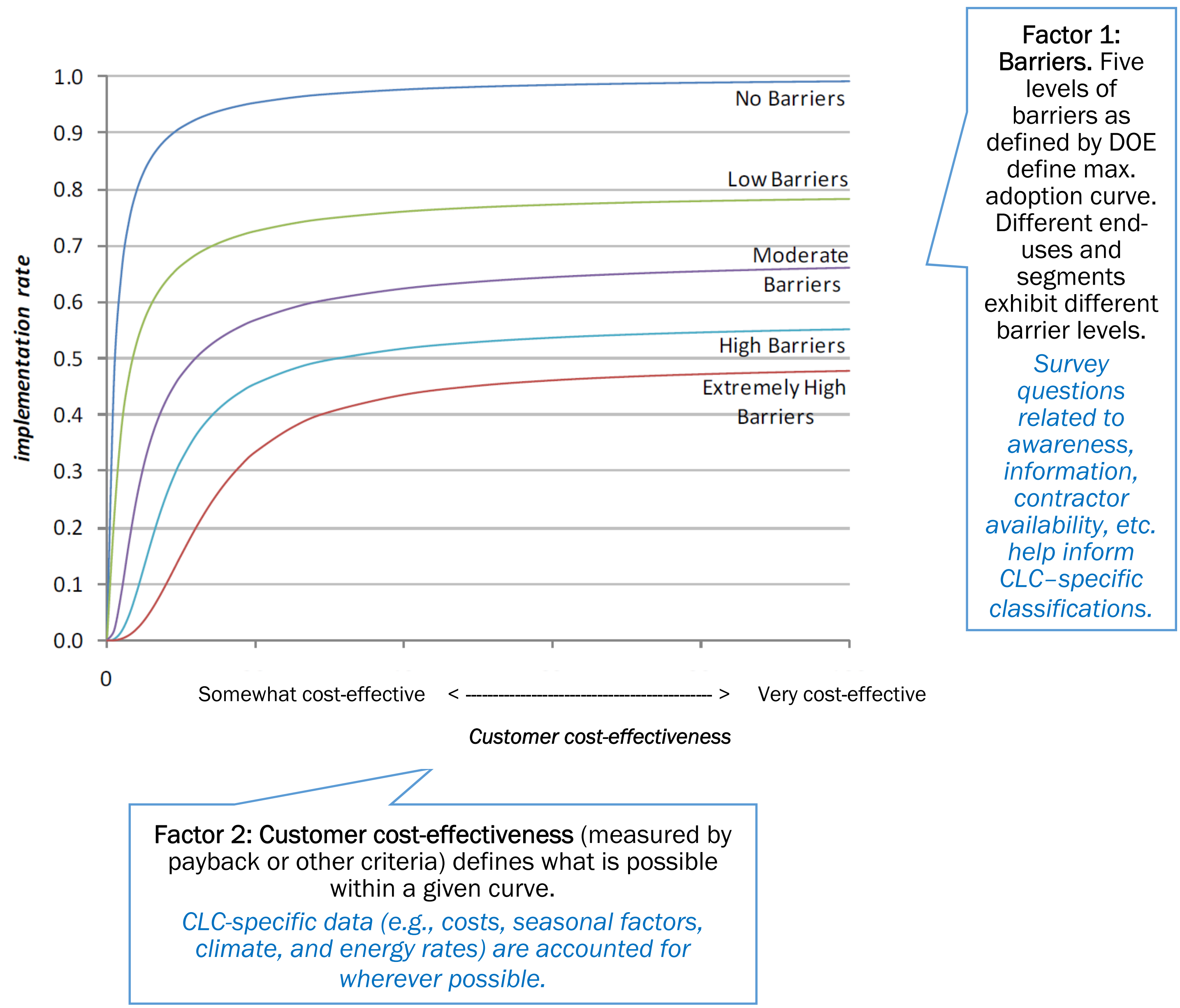
[37] Market applicability factors adjust the potential of some measures to account for specific technical barriers that prevent the application of that measure in a share of the potential market.

[38] DOE uses this model in several regulatory impact analyses. An example can be found in http://www.regulations.gov/contentStreamer?objectId=090000648106c003&disposition=attachment&contentType=pdf, section 17-A.4.

market barriers and the cost-effectiveness ratios encompass several CLC-specific inputs (see also Table 2-24, later in this section).

Figure 2-2 presents a schematic view of adoption curves.

Figure 2-2. US DOE Adoption Curves



The main steps for determining the adoption rate for each measure/segment are:

1. Selection of a curve, based on barriers level and benefit-cost criteria. Both barrier levels and the benefit-cost criteria (net present value vs simple payback period) were determined using survey inputs.

2. Calculation of customer cost-effectiveness, using the model's inputs, including measure characteristics (costs, savings, EUL, etc.), energy rates, and the incentive levels offered by modeled initiatives.
3. Calculation of the adoption rate, based on the selected curve and the cost-effectiveness value.

While our approach to determining the adoption rate is based on the US DOE model, we investigated the need for a few refinements: the choice of the cost-benefit criteria and short-term and long term adjustments. These refinements are described below.

Cost-Benefit Criteria

The DOE model assumes that participants make their decisions based on a benefit-cost ratio calculated using discounted values. While this may be true for more sophisticated customers (large institutional and C&I customers), many customers use much simpler decision criteria, including the payback period. This has implications on the choice of measures by the model, since the payback period ignores the value of money over time as well as any impacts after the break-even point has been reached. Thus, using the payback period, short-term benefits are favored over long-term benefits, creating a bias in favor of measures with a short effective useful life.[39]

To determine which cost-benefit criteria should be used for this study, the surveys gathered information on the criteria actually used by customers. Based on survey responses, we used the PCT ratio for the C&I sector (we did not observe clear differences by C&I segment) and the Simple Payback Period (SPP) for the Residential and Low Income sectors.

As a result, for the residential and low income sectors, we converted the DOE adoption curves to equivalent curves reflecting payback periods, based on discounted values. We assumed an average effective useful life of 15 years and used CLC's discount rate.

Short-term Adjustment

The DOE model determines the percentage of the informed market that will accept an energy efficiency measure based on the barrier level and the cost-effectiveness ratio – this is the "adoption rate" discussed above. The informed market is defined as the portion of the market that is aware and informed about the energy efficiency measure. Low awareness limits implementation of measures.

Furthermore, some programs may be limited in their ability to quickly increase participation after available rebates are increased because of delivery limitations. A good example would be a home retrofit program that requires skilled auditors and contractors: increasing capacity necessitates the enrollment and training of additional program vendors, which could take some time.

[39] Let's suppose a 3-year simple payback criteria is used by a customer. This means that a measure has to pay for itself within this 3-year period, regardless of its useful life. A measure with a payback of 4 years and a useful life of 20 years would be very cost-effective using a PCT ratio (with a cost-effectiveness ratio of approximately 3.5), but would be rejected using a simple payback criteria. On the other hand, a measure that is barely cost-effective (PCT ratio of 1) but has a very short useful life would be included.

These two factors, measure awareness and program delivery structure, can limit program participation, especially during the first few years, and result in lower participation than the maximum achievable implementation rates as calculated using the DOE model.

For this study, we made short-term adjustments to measure adoption on a case-by-case basis, using professional judgment. We adjusted few measures given that overall model results are within reasonable reach of the actual 2013-15 Plan.

Long-term Adjustment

The DOE model is based on the assessment of market barriers at a given point in time. These barriers are then assumed to remain static. In reality, barriers can be lowered in the long run, especially if programs use enabling strategies. Examples of enabling strategies include financing, labeling, and workforce training. For programs, measures, or market segments where specific barriers are prevalent, targeted strategies could, and likely would, be put in place.[40]

However, because the barrier levels, estimated using survey results, are already low (ranging from "low" to "moderate" for most of them), we only made long-term adjustment for LEDs in the residential sector to reflect anticipated evolving technology and better consumers' knowledge.

Chained Measures

Chained measures are measures that are installed in combination with one another. Chained measures require an adjustment in savings because the total savings of these measures is less than the sum of the savings of each individual measure. For example, if a customer installs a heat pump water heater as well as low flow showerheads and faucet aerators, the savings from the low flow showerheads and faucet aerators are smaller than if they were installed in a home with a less efficient water heater (less energy is lost for the same amount of wasted water). The adjustment to the chained measures' savings are calculated based on the different measures in the chain and entered for each individual measure.

CLC-Specific Adjustments

A key aspect of this study was to incorporate CLC-specific factors that differentiate CLC from the rest of Massachusetts.

The most important adjustment to measure inputs in this study was to account for seasonality. A large share of residential customers (31.7%), as well as many C&I customers (especially in the Restaurant and Lodging/Hospitality segments), show reduced occupancy or hours of operation, especially during the winter. Some customers even shut down completely during that period. Reduced activity is also observed during the spring and autumn seasons. For this study, we adjusted energy savings, peak savings, and load shapes to account for seasonality using survey and site visit data. The seasonality adjustment factors were calculated for each major end-use, taking into account the requirement to maintain a minimum temperature in

[40] Higher incentives are already implicitly taken into account in the cost-effectiveness ratio (higher incentives result in lower paybacks and higher Participant Cost Test ratios). To prevent double-counting, no adjustment have been made to market barriers because of higher incentives.

buildings to prevent freezing conditions. Reduced savings due to seasonality impact cost-effectiveness of measures, thus screening out some measures for specific segments and reducing adoption rates of remaining measures for segments with a strong seasonal profile.[41]

We also considered several other CLC-specific characteristics, such as business types and size, building stock, milder climate, and measure cost when developing the model's inputs.

Table 2-24 (next page) summarizes CLC-specific factors that were considered and how they were addressed in the model.

[41] In addition to the savings adjustment, we also increased market barriers for the opt-in behavioral measure in the Residential seasonal segment. Because this measure is more demanding, we expect that customers with secondary homes, presumably on leisure time, would show less interest.

Table 2-24. CLC-Specific Factors Considered in Potential Model

Factors Considered	Model addresses this through...					Notes
	Baseline Equipm. / Usage	Barriers	Costs	Savings	Other	
Residential						
Seasonality A sizable proportion of the population and housing stock is seasonal, which means (a) they may use less energy compared to similarly-sized non-seasonal houses, (b) the savings they could get from a measure may be less, (c) the payback period may be longer, (d) they may have a different set of priorities for home improvements, or (e) CLC may have more limited time period and channels to intervene/promote programs.	✔	✔		✔		Seasonal and non-seasonal are treated as separate segments, with separate annual usage assumptions (based on actual data and survey) and measure characterization (from baseline study). We also adjusted savings for measures affected by seasonality, to reflect factors such as lower HOU. Our survey didn't find significant differences in barrier levels between seasonal and non-seasonal customers, so we did not adjust barriers with the only exception of opt-in behavioral, as this measure requires much more involvement than the other measures.
Age of population The CLC customer base is thought to be older than statewide average. This may result in lower likelihood to invest in EE (ROI calculus is off, fixed income, etc).		✔				Any lower likelihood to adopt EE measures as a result of age was captured in the barrier survey and is therefore reflected in the adoption curves.

Factors Considered	Model addresses this through...					Notes
	Baseline Equipm. / Usage	Barriers	Costs	Savings	Other	
Building stock CLC believes that stock is newer than the rest of the state. That means that pre-weatherization barriers may be low (e.g., knob and tube wiring), and there may be many 1- or 2-story homes that are relatively easy to insulate and work on. Additionally, many 3-season homes are converted to 4 season homes, which presents lots of opportunity. However, this means that the required upgrades are significant, and it's possible that customers would rather renovate the kitchen or bath than spend the incremental dollars for high efficiency.	✔	✔				CLC-specific information on insulation levels and barriers levels were collected and integrated in the potential study.
Commercial						
Seasonal business cycles Cash flow for some business owners is concentrated in a few months of the year. Seasonable businesses have a smaller window of opportunity to actually complete EE retrofits. CLC has a narrow window to approach them to discuss the programs and EE retrofits that are available to them. Seasonality also affects savings - for businesses that are closed during the winter and much of the spring and fall, the payback period may be longer.		✔		✔		The model uses a weighted average of barrier levels by segment (including both seasonal and non-seasonal customers). We also adjusted savings to account for reduced hours of operation and/or shutdowns during the off-peak seasons.

Factors Considered	Model addresses this through...					Notes
	Baseline Equipm. / Usage	Barriers	Costs	Savings	Other	
Business types Lots of retail, hospitality, and government buildings,[42] and relatively few office. Business owners whose income is tied to tourism may be more reluctant to spend on EE in the off season because they have a hard time forecasting how business will be next season.		✔				Since barriers levels are determined for each market segment, and modeling is performed at the segment level, the overall potential model results appropriately represent barriers for CLC's mix of businesses.
For many segments, commercial businesses are generally smaller than businesses in the rest of MA.	✔			✔		Each segment's average and total annual consumption is reflected in the measure characterization, which reflects any difference in equipment penetration/saturation (and equipment size, where relevant) related to small business size.
Building stock Many commercial operations are in structures originally built as residential, creating significant issues with measure applicability. CLC, along with the statewide programs in general, has limited commercial measure offerings for these building types as compared to the average MA commercial customer (though residential measures are offered).	✔				✔	We moved customers who are clearly "residential commercial" (as identified by CLC) into the residential study. Still, there is a fair number of small, house-like structures in other segments. The characteristics of these businesses are reflected in the measure characterisation and baseline equipment.

[42] Note that CLC pays 100% incentives for all projects in government buildings.

Factors Considered	Model addresses this through...					Notes
	Baseline Equipm. / Usage	Barriers	Costs	Savings	Other	
All Sectors						
Climate The climate is milder on the Cape and Vineyard relative to the rest of the state, so weather-dependent measures may have lower savings (and a longer payback)				✔		Savings have been adjusted using Cape Cod weather normals where relevant.

Model Calibration

Model calibration ensures that the overall estimated consumption levels determined by the model are in line with utility electricity forecasts. For this study, because of the amount and quality of primary data, model calibration is not as critical as for other potential studies that must rely on secondary sources to make broad assumptions on equipment saturation and building characteristics. The comprehensive primary data on penetration, saturation, and characteristics of equipment and buildings in each sector and segment greatly reduces the chance of underestimating or overestimating the load forecast because the modeled baseline does not fit the actual baseline and real consumption.

In the residential and low income sectors, we used annual energy consumption levels by equipment type – obtained through regression analyses of actual electric accounts as well as secondary sources – to ensure that our overall estimated consumption matches the electricity forecast for these sectors.

In the C&I sector, this approach would be too onerous due to the complexity and diversity of equipment and buildings. As both the potential markets and the baseline equipment were well defined due to extensive primary research, those elements were not deemed critical. We therefore used indirect approaches, including verification of lighting densities and average floor area, to validate our primary data.

2.3.2 Inputs and Assumptions

Measure Characterization

For existing measures, we reviewed measure assumptions (savings estimates or algorithms, cost, effective useful life, etc.) and assessed if they adequately reflect CLC’s service territory and customer base.

We based savings assumptions on the Massachusetts TRM, where possible. For measures with algorithm-based or custom savings, we used primary data and engineering algorithms, historical program data, or program impact evaluations to derive the required inputs to calculate the savings. We also used evaluation results and participation data to validate measure assumptions.

Savings include other fuels impacts (oil, gas, propane). These other fuels savings or added consumption do not directly affect electric potential results (no “kWh-equivalent” savings/reductions were used) but are considered when calculating measure cost-effectiveness and may positively or negatively impact measure screening and adoption rates.

As discussed above, we made adjustments to savings for residential customers and C&I segments with high seasonality profiles. These adjustments were made for each major end-use, based on survey and site visit occupancy results and operational profiles during unoccupied periods use. For the C&I sector, this was supplemented with a billing analysis, to identify the proportion of businesses within a segment with seasonal consumption patterns. We derived seasonal adjustments from those results for winter peak and off-peak as well as summer peak and off-peak consumption. Overall energy and peak savings were adjusted accordingly.

We used CLC-specific incremental costs wherever those costs were available. For measures where only statewide cost assumptions were available, we considered making an adjustment to account for the difference between statewide and CLC costs. However, we did not find evidence of materially higher CLC costs, based on a comparison of CLC costs with other MA jurisdiction (where available), as well as a comparison of construction cost indexes for CLC's service territory versus the rest of MA. Thus, we made no CLC-specific adjustments.

Non-energy impacts (often referred to as "externalities"), as quantified in the Massachusetts' TRM,[43] are monetized in the potential model. Because they directly affect the cost-benefit ratio results, there is no need to adjust market barriers to account for non-energy impacts.

Types of measure

The model uses four types of measures: replacement on burnout (ROB), early retirement (ER), addition (ADD), and new construction/installation (NEW). Each of these measure types requires a different approach for determining the maximum yearly units available for potential calculations, as detailed in Table 2-25.

Table 2-25. Types of Measures Used in Potential Model

Measure Type	Description	Market Base	Yearly Units Calculation
Replace On Burnout (ROB)	Existing units are replaced by efficient units after they fail *Example: Replacing incandescent bulbs by LEDs*	Existing Units	Market/Effective Useful Life (EUL) *The EUL is set at a minimum of 6 years to spread installations over the potential study period. Alternate EULs can be used to calculate yearly units if baseline units have a different EUL than efficient units.*
Early Replacement (ER)	Existing units are replaced by efficient units before burnout *Example: Early replacement of functional but inefficient refrigerators*	Existing (Old) Units	Market (old units)/6 (study period) *The market is defined as the number of old units, not the total number of units (e.g., old refrigerators that could be retired early, not all existing refrigerators).*
Addition (ADD)	An EE measure is applied to existing equipment or structures	Existing Units	Market/6 (study period)

43 Non-energy impacts are values that are estimated after the measures have been implemented, and as such may not represent exactly what consumers perceive as non-energy impacts at the time of investment decision-making. Our analyses using the potential model indicate, however, that non-energy impacts have a very small effect on results, meaning that this effect would not have a significant impact on potential results.

Measure Type	Description	Market Base	Yearly Units Calculation
	Example: Adding controls to existing lighting systems, adding insulation to existing buildings		
NEW	Measures not related to existing equipment *Example: new construction, installing a new heat pump (not replacing an existing heat pump)*	Custom	Market *Market base is measure-specific and defined as new units per year*

Early Retirement

Early retirement refers to efficiency measures (and program strategies) that seek to replace functional equipment before the end of its useful life. Refrigerator replacement is a common measure that falls into this category, but early retirement can also apply to any other equipment including other appliances, HVAC systems, and lighting.

In addition to the yearly unit calculations explained above, the first cost for early retirements is adjusted to reflect true economic costs. This adjustment is required because early retirements defer the need for new capital investment in the future. Assuming, for example, that there is an initial investment to buy a refrigerator in year 1 and this refrigerator would have been replaced anyway in year 5, the future investment that would have taken place in year 5 is now pushed forward in the future because the new fridge will last 15 years (instead of 5 years for the old fridge). Because the value of money decreases with time, there is an economic benefit in deferring future investments.[44]

We use the following formula to adjust costs for early retirements, which calculates the difference between the discounted values of two streams of investments:

$$PV = (C - incr)\left\{1 + \frac{1}{(1+dr)^{eul} - 1}\right\}\left\{1 - \frac{1}{(1+dr)^{erp}}\right\} + incr$$

Where:

PV = present value of initial cost and deferred future costs

[44] Note that because of this adjustment, the economic cost used by the model might be lower than the incentive in some cases.

C = initial capital cost

incr = Incremental cost (cost of efficient vs baseline unit)

dr = discount rate

eul = effective useful life of new unit

erp = early replacement period (remaining effective useful life of old unit)

During the initial "early retirement" period, the energy consumption of the new, efficient unit is compared to the old, retired unit to calculate savings. After the initial period, the new efficient unit is usually compared to a new "baseline" unit with standard efficiency. This "dual baseline" approach is widely used to calculate savings and cost-effectiveness for early retirement measures. However, in Massachusetts, the "single baseline" approach (constant savings for the full EUL) is still in use. As a result, CLC requested that this study use the single baseline approach to make CLC's potential results comparable to those of other MA program administrators. This single baseline approach for savings has no impact on the method we use for economic costs described above.

Economic Parameters

The potential model incorporates several key economic parameters:

- The **cost-effectiveness** framework used in this study follows the Department's directive in Energy Efficiency Guidelines (D.P.U. 08-50-A), as well as the "BCR Model" used internally by CLC. Before building the potential model, we ensured that our core calculations replicated the results of the BCR Model.
- **Avoided costs** in this study reflect the latest available information from the 2015 study by the Avoided-Energy-Supply-Component (AESC) Study Group.
- **Electricity rates**, used for participant cost-effectiveness calculations, are based on energy and capacity avoided costs for the wholesale portion, and on marginal retail rates for the retail portion. We assumed that the retail portion would grow at the same rate as the energy portion in the long term, reflecting pressures on the grid from renewable energy and aggressive EE targets. For non-electric fuel types (gas, oil, and propane), we used the avoided costs as a proxy of future fuel prices.
- We used a **real discount rate** of 0.44%, based on 2014 10-years Treasury rates.

Baseline Potential Markets

Markets are largely determined by our primary data collection. The surveys and site visits collected existing equipment and building characteristics in CLC's service area. We used this information to quantify baseline equipment and building components to which energy efficient measures can be applied.

For new equipment (e.g., heat pumps that do not replace existing heat pumps), we conducted additional interviews with contractors to estimate the annual market size.

We estimated new construction in the residential sector using the "Annual New Privately-Owned Residential Building Permits (Estimates with Imputation)" from the U.S. Census Bureau. We extrapolated total 2013 building permits for Barnstable and Dukes counties into the future using a 4.6% annual growth rate, based on the observed 2009-2013 growth.

We estimated new construction in the commercial sector using a 2013 market assessment of Cape Cod, prepared by the Chesapeake Group for the Cape Cod Commission.[45] We used the total market growth for retail goods and services (0.12% per year over the next 10 years) as a starting point for evaluating the C&I New Construction market. We set a growth rate three times higher (0.37%) for health services, which the report (qualitatively) identified as a segment with higher growth potential because of the aging population. We then adjusted other segments to 0.09% in order to keep the added square footage per year at the same level (i.e., at an average overall growth rate of 0.12% per year).

We used the new square footage (about 126,000 square feet per year, estimated based on an average annual growth rate of 0.12%) for the advanced lighting design measure, and the annual growth rate (0.09% to 0.37%) for all the other markets except CHP and early retirement measures (i.e., T12 and motors).

[45] The Chesapeake Group (c.2013), "Market Assessment of Cape Cod, Massachusetts".

3. Summary of Key Penetration and Saturation Results

A primary purpose of this portion of the study was to determine the penetration and saturation of key electricity-using equipment in homes and businesses. These two concepts are defined as follows:

- **Penetration:** A percentage representing the proportion of customers that have one or more of a particular piece of equipment. It is calculated by dividing the number of customers with one or more of a piece of equipment by the total number of customers responding to that question. For example, non-seasonal residential customers had an LED penetration rate of 49%, compared to only 21% of seasonal residential customers and 8% of low income customers.
- **Saturation:** A number representing how many of a particular piece of equipment exist, on average, among all customers. It is calculated by dividing the total number of a particular piece of equipment by the total number of customers responding to that question (regardless of whether they reported having the equipment or not). This ratio is at least equal to, but generally higher than the corresponding penetration of the equipment, because some customers will have more than one of the equipment. For example, the saturation rate of LEDs in non-seasonal homes was 5.1 LED bulbs on average across all non-seasonal homes, compared to an average of 1.5 LED bulbs across all seasonal residential customer homes and less than one across all low income homes.

Table 3-1 presents key equipment penetration and saturation data collected in the 2014 Residential Energy Use Survey and adjusted, where necessary, by site visit results. In some cases (footnoted), penetration and saturation data is based directly on site visit data. Penetration and saturation results are presented for the three study segments: residential seasonal (Res-S), non-seasonal (Res-NS), and low income (LI). The full adjusted results of the 2014 Residential Energy Use Survey are presented in Volume 2 of this report.

Table 3-1. 2014 Residential and Low Income Equipment Penetration and Saturation Results

Appliance/Equipment	Penetration			Saturation		
	Res - S	Res - NS	LI	Res - S	Res - NS	LI
Lighting[S]						
Incandescent	100%	100%	96%	27.5	30.0	16.1
CFL	83%	96%	93%	17.0	18.1	14.8
Fluorescent tube lighting	57%	76%	69%	2.9	6.1	3.3
Halogen	35%	44%	19%	1.3	2.4	1.5
LED	21%	49%	8%	1.5	5.1	0.5
Cooling						
Central air conditioning	36%	32%	13%			
Window units	39%	56%	68%	1.36	1.24	0.85
Programmable thermostats[S] *(of those with central AC)*	70%	71%	44%	1.12	1.09	0.67

Appliance/Equipment	Penetration			Saturation		
	Res - S	Res - NS	LI	Res - S	Res - NS	LI
WiFi thermostats[S] *(of those with central AC)*	4%	0%	0%	0.04	0.00	0.00
Space and Water Heating						
Space Heating (Primary)						
Electric	13%	8%	12%			
Natural Gas	51%	59%	48%			
Oil	25%	27%	34%			
Propane	8%	5%	5%			
Space Heating (Secondary)						
Electric	15%	22%	25%			
Wood	3%	9%	7%			
Propane	2%	3%	2%			
Any electric space heating	27%	29%	36%			
Boiler reset controls[S] *(of those with boilers)*	10%	30%	10%			
Water heating						
Electric	30%	19%	28%			
Natural Gas	47%	57%	44%			
Oil	14%	18%	21%			
Propane	9%	6%	7%			
Major Appliances						
Clothes washer *(private use only)*	87%	95%	84%			
Electric clothes dryer *(private use only)*	69%	69%	66%			
Refrigerator	100%	100%	100%	1.31	1.42	1.22
Secondary refrigerator	28%	37%	20%			
Standalone freezer	4%	26%	24%	0.04	0.28	0.25
Electric cooktop	53%	52%	67%			
Electric oven	60%	61%	69%			
Dishwasher	77%	88%	68%			
Electronics and Computing						
Television	96%	98%	99%	2.01	2.47	2.37
CRT TV	45%	44%	52%	0.73	0.73	0.84
Flat screen LCD TV	54%	59%	54%	1.03	1.30	1.15
Flat screen LED TV	19%	26%	23%	0.40	0.57	0.49
Flat screen plasma TV	7%	12%	10%	0.10	0.19	0.15
Projection TV	0%	1%	1%	0.01	0.01	0.01
Cable/satellite box with DVR	40%	57%	45%	0.52	0.79	0.64

Appliance/Equipment	Penetration			Saturation		
	Res - S	Res - NS	LI	Res - S	Res - NS	LI
Stand-alone cable/satellite box	54%	50%	46%	0.76	0.78	0.73
DVR separate from cable/satellite box	8%	9%	5%	0.08	0.11	0.07
Digital TV converter box	36%	34%	34%	0.57	0.57	0.57
TV streaming device	10%	19%	16%	0.11	0.22	0.20
Home theater system	8%	15%	12%	0.08	0.16	0.14
Video game player	8%	27%	37%	0.09	0.37	0.55
DVD or VCR player	63%	69%	70%	0.75	0.94	0.99
Stereo, CD player, iPod, or MP3	47%	58%	55%	0.58	0.94	0.94
Desktop computer	18%	53%	44%	0.20	0.63	0.53
Computer monitor[S]	27%	53%	44%	0.62	0.84	0.55
Laptop	56%	72%	59%	0.75	1.03	0.82
Tablet	39%	50%	40%	0.50	0.66	0.57
Printer, fax, scanner, copier, or multifunction device	37%	79%	61%	0.39	0.93	0.70
DSL/cable modem, WiFi routers, or home network	60%	78%	61%	0.62	0.83	0.66
Other Electric Equipment						
Electronic household air cleaner/humidifier	9%	27%	22%	0.12	0.32	0.26
Dehumidifier	53%	71%	48%	0.60	0.78	0.52
Hot tub/whirlpool	6%	12%	5%	0.06	0.12	0.05
Electric-powered exercise equipment	2%	16%	8%	0.02	0.18	0.09
Aquarium	1%	4%	8%	0.01	0.04	0.08
Water bed	<1%	<1%	1%	<0.01	<0.01	0.01
Well and/or sump pump	20%	18%	14%	0.21	0.19	0.15
Microwave oven	93%	94%	90%	0.96	0.98	0.94
Pools						
Pool	3%	6%	5%			
Pool pump *(of those with pool)*	97%	97%	94%	1.09	0.97	0.94
Pool timer *(of those with pool)*	97%	59%	42%			

Source: 2014 CLC Residential Mail Survey; 2014 Residential Site Visits

[S] Results are based on site visits.

Table 3-2 presents key equipment penetration and saturation data collected in the 2014 commercial and industrial telephone survey and on-site visits. The penetration results are based on data from either the phone survey and or the on-site visits, depending on the measure, while the saturation results for all measures are based on data collected as part of the site visits.[46]

Table 3-2. 2014 Commercial and Industrial Penetration and Saturation Results

End Use/Equipment Type	Penetration	Saturation
Lighting[a]		
All Light Fixtures	100%	113.10
Linear Fluorescent Light Fixtures	89%	39.72
T12 Linear Fluorescent Light Fixtures	54%	8.85
T10 Linear Fluorescent Light Fixtures	8%	1.11
T8 Linear Fluorescent Light Fixtures [b]	65%	28.42
T5 Linear Fluorescent Light Fixtures	4%	1.13
T5HO Linear Fluorescent Light Fixtures	2%	0.21
CFL Fixtures	70%	36.54
Incandescent Bulb Fixtures	72%	19.04
High Pressure Sodium Bulb Fixtures	14%	0.66
Mercury Vapor Bulb Fixtures	5%	0.21
Metal Halide Bulb Fixtures	23%	1.67
Halogen Bulb Fixtures	26%	2.41
LED Light Fixtures	38%	12.19
Neon (Cold Cathode) Light Fixtures	<1%	<0.01
Other Fixtures	3%	0.66
Cooling Equipment		
Packaged Units	19%	0.32
Split Systems	40%	1.10
Window/Wall Units	35%	2.58
Chillers	<1%	0.01
Ventilation		
Ventilation Hoods	8%	0.07
Demand Controlled Ventilation	<1%	
Process Ventilation	2%	
Motors and Compressed Air		
All Motors	20%	0.79
Overall Compressed Air	15%	
Compressors	15%	0.27
Refrigeration		
All Commercial Refrigeration	15%	

[46] We list the source of the results for each measure in Volume 3 of this report, which presents the C&I Penetration and Saturation Results spreadsheet.

End Use/Equipment Type	Penetration	Saturation
Standalone Refrigerator or Freezer	11%	1.86
Refrigerated Display Cases [c]	6%	0.11
Walk-in Coolers	10%	0.15
Walk-in Freezers	7%	0.08
Refrigeration Systems	15%	0.19
Refrigerated Vending Machines	9%	0.10
Ice Machines	9%	0.22
Electronics		
Computers (All Types)	88%	5.85
Desktops	87%	5.05
Laptops	31%	0.80
Large Printers	30%	0.51
Small Printers	80%	2.79
Televisions	53%	6.67
Cash Registers/POS Terminals	42%	0.65
Rack Mounted Servers	6%	
Cooking Equipment		
All Commercial Food Service Equipment	12%	
Electric Ovens	4%	0.26
Electric Griddles	3%	0.15
Electric Commercial Fryers	2%	0.04
Electric Food Holding Cabinets	1%	0.01
Electric Steam Cookers	<1%	<0.01
Dishwashers	8%	0.22
Water Heating		
All Electric Water Heating	47%	
Electric Resistance Water Heaters	41%	0.48
Heat Pump Water Heaters	1%	0.01
Low Flow Showerheads [d]	0%	0.00
Faucet Aerators [d]	37%	1.65

*Denotes fewer than 30 observations
[a] Lighting combines both indoor and outdoor overhead hardwired lighting, unless specified.
[b] T8 linear fluorescent lights include T8 Plus lights.
[c] Saturation refers to linear feet, not units
[d] Includes only showerheads and aerators served by electric water heating

4. Overall Potential Results

We estimate CLC's total achievable energy efficiency potential for the six-year period from 2016-2021 to be 246 annual GWh and 62 MW.[47] Achievable potential represents 51% of economic potential and 36% of technical potential. On average over the six-year period, achievable energy savings represent 1.98% of CLC annual forecasted sales. These savings would cost CLC $220 million (incentive and non-incentive program costs), an average of $37 million per year or $0.895/kWh.[48] The total cost (including the participants' net cost) amounts to $246 million (in 2016 dollars) for the six-year period. All of the 2016-2021 proposed investments are cost-effective, with a Total Resource Cost (TRC) ratio of 3.6 and a Program Administrator Cost (PAC) ratio of 2.8.

Table 4-1 summarizes these results for the six-year period 2016-2021, as well as for each of the next two three-year planning periods. Table 4-2 provides these results by sector.

Table 4-1. Key Potential Results – All Sectors, by Period

	2016-2021		2016-2018		2019-2021	
Potential (Total)	GWh	MW	GWh	MW	GWh	MW
Technical	675	163	343	86	332	77
Economic	480	117	246	63	234	54
Achievable	246	62	121	33	125	29
Potential (Yearly)	GWh	MW	GWh	MW	GWh	MW
Technical	112.5	27.1	114.4	28.7	110.6	25.5
Economic	80.0	19.5	81.9	21.1	78.0	18.0
Achievable	40.9	10.3	40.3	11.1	41.5	9.5
Annual Achievable as % of Sales	1.98%		1.94%		2.02%	
Cost						
Total (millions)	$246		$120		$126	
CLC (millions)	$220		$107		$113	
CLC Cost/kWh	$0.895		$0.882		$0.908	
Cost-Effectiveness						
Total Resource Cost Test	3.6		3.6		3.6	
Program Administrator Cost Test	2.8		2.8		2.9	

[47] These findings reflect the best information and assumptions available as of April 2015. Cape Light Compact and the Opinion Dynamics/Dunsky team plan to refresh these results, prior to the September Three Year Plan draft filing, to incorporate any newly available evaluation findings, as well as updates to non-incentive program costs.

[48] This compares to a projected average cost of $0.794/kWh during the 2013-2015 Three Year Plan Cycle. It should be noted that per kWh projected costs are relatively high for CLC due to a number of territory-specific reasons, including the small base of large C&I customers and the seasonal nature of many homes and businesses.

Table 4-2. Key 2016-2021 Potential Results by Sector

	All Sectors		Residential		Low Income		C&I	
Potential (Total)	GWh	MW	GWh	MW	GWh	MW	GWh	MW
Technical	675	163	420	85	31	12	224	66
Economic	480	117	244	46	22	10	214	61
Achievable	246	62	131	29	9	3	106	29
Potential (Yearly)	GWh	MW	GWh	MW	GWh	MW	GWh	MW
Technical	112.5	27.1	70.0	14.1	5.1	2.0	37.4	11.0
Economic	80.0	19.5	40.7	7.6	3.6	1.7	35.7	10.2
Achievable	40.9	10.3	21.8	4.8	1.5	0.6	17.6	4.9
Annual Achievable as % of Sales	1.98%		1.92%		2.16%		2.04%	
Cost								
Total (millions)	$246		$159		$11		$76	
CLC (millions)	$220		$135		$10		$75	
CLC Cost/kWh	$0.895		$1.029		$1.134		$0.710	
Cost-Effectiveness								
Total Resource Cost Test	3.6		3.0		4.2		4.8	
Program Administrator Cost Test	2.8		2.5		2.9		3.4	

Table 4-3 and Table 4-4 detail annual achievable potentials as a percentage of sales, by year and sector, for the first three-year period and the second three-year period, respectively.

Table 4-3. Achievable Potential as a Percentage of Forecasted Energy Sales – 2016 to 2018

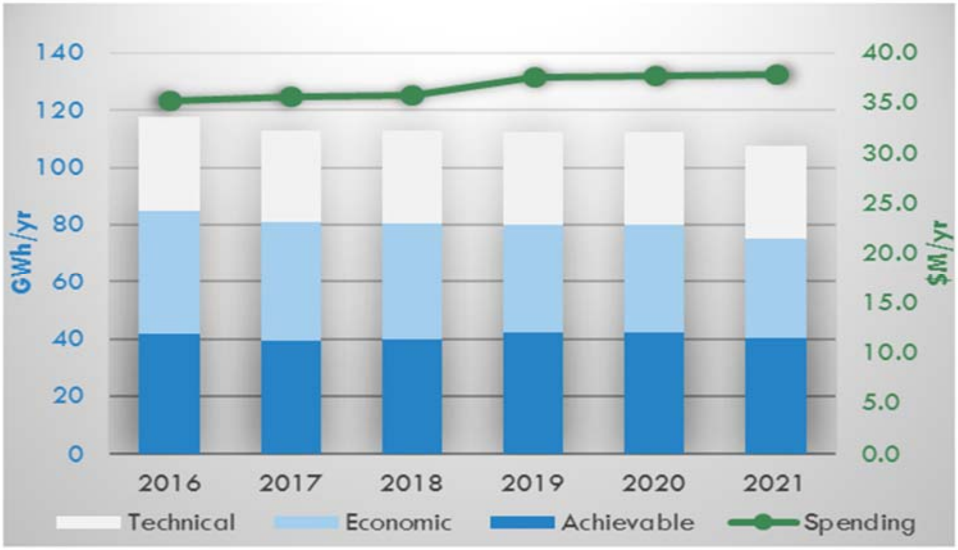
	2016	2017	2018	2016-2018
Residential	2.06%	1.80%	1.79%	1.88%
Low Income	2.39%	2.05%	2.04%	2.16%
Commercial	1.94%	2.00%	2.04%	1.99%
All Sectors	**2.02%**	**1.89%**	**1.90%**	**1.94%**

Table 4-4. Achievable Potential as a Percentage of Forecasted Energy Sales – 2019 to 2021

	2019	2020	2021	2019-2021
Residential	2.00%	2.01%	1.87%	1.96%
Low Income	2.18%	2.19%	2.12%	2.16%
Commercial	2.07%	2.11%	2.07%	2.09%
All Sectors	**2.03%**	**2.06%**	**1.96%**	**2.02%**

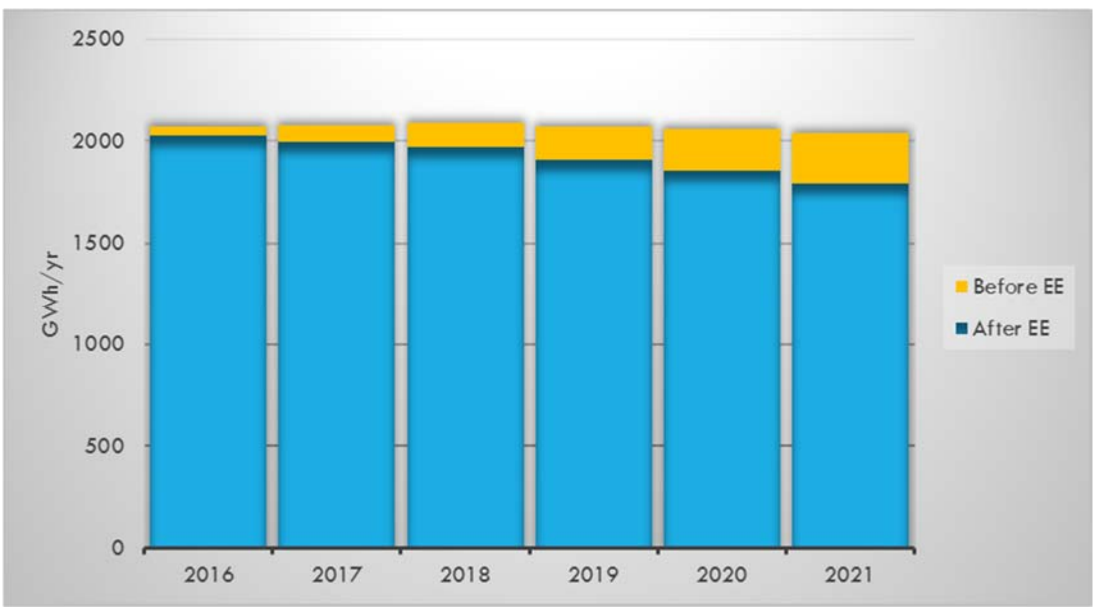
Figure 4-1 presents annual GWh savings for the three types of potential, as well as annual spending required to meet the achievable potential. The increase in spending during the second three-year period (2019–2021) is due to higher LED uptake, which results from an assumption of decreasing market barriers. While savings from LEDs are higher for that period, they are counterbalanced by somewhat lower savings for other measures.

Figure 4-1. Annual Savings and Spending



Eversource forecasts slightly declining energy sales, before energy efficiency (EE) efforts, over the six-year period, with total sales of 2,041 GWh in 2021 compared to 2,071 in 2016. With EE efforts at the level of the achievable potential, energy sales would decline faster, with 2021 sales amounting to 1,796 GWh, a drop of nearly 12% from 2016 sales (Figure 4-2).

Figure 4-2. Impact of Achievable Potential on Annual Sales

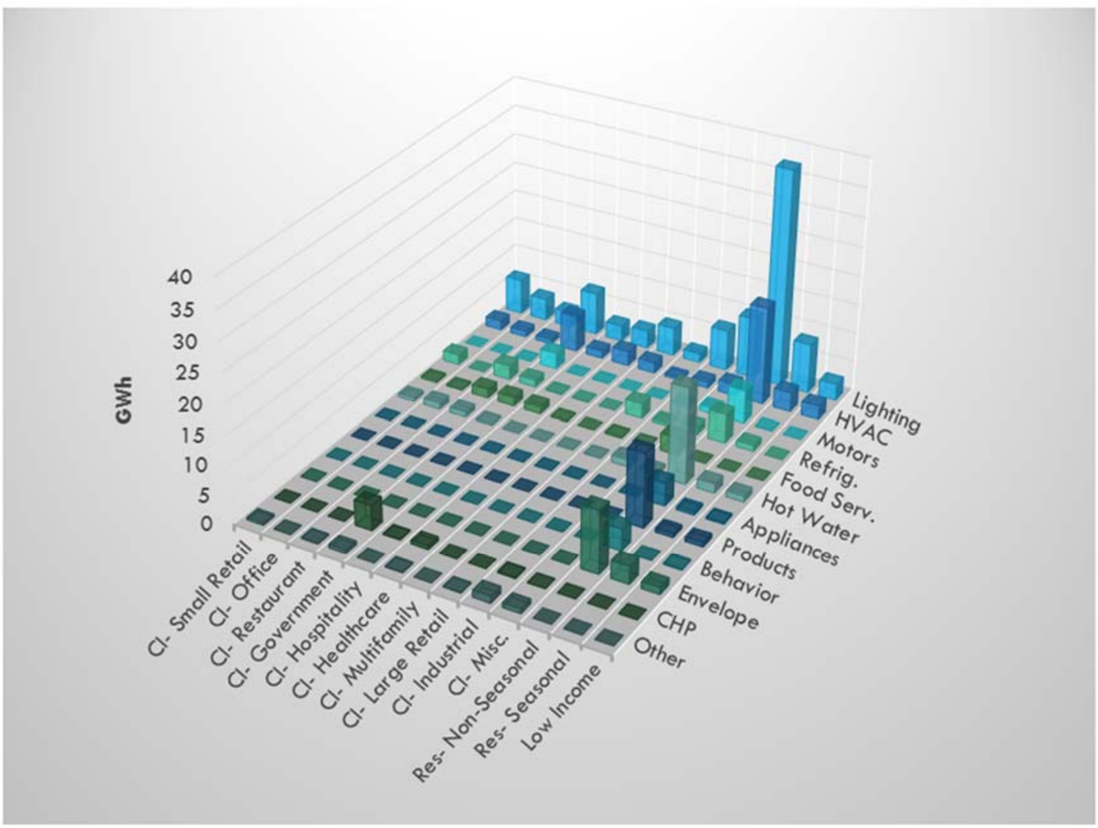


4.1 Results by Sector and End-Use

Over half of the achievable potential comes from the Residential Sector (54%). The Commercial & Industrial (C&I) Sector accounts for 42% of potential and the Low Income Sector for only 4%. The dominance of the Residential Sector, compared to C&I, reflects the economic structure of CLC's service territory, in which residential kWh sales comprise a higher proportion of CLC's total annual kWh sales (56%) than the statewide average (37%). The small contribution of the Low Income Sector is in line with the sector's number of accounts and annual energy sales (3%). (See Figure 4-3.)

Achievable potential associated with seasonal residential customers is rather low, even though they account for almost one-third (32%) of residential homes on Cape Cod and Martha's Vineyard and 23% of residential sector usage. This is mainly due to seasonal occupancy and its effect on annual savings (i.e., lower hours of use resulting in lower savings for the same measure). Some measures also do not pass the TRC test for seasonal customers because of reduced savings. Likewise, seasonality also has an effect on the commercial potential result, especially for segments such as hospitality and restaurants. Serving seasonal customers yields lower than average savings and higher cost per kWh because of lower hours of use.

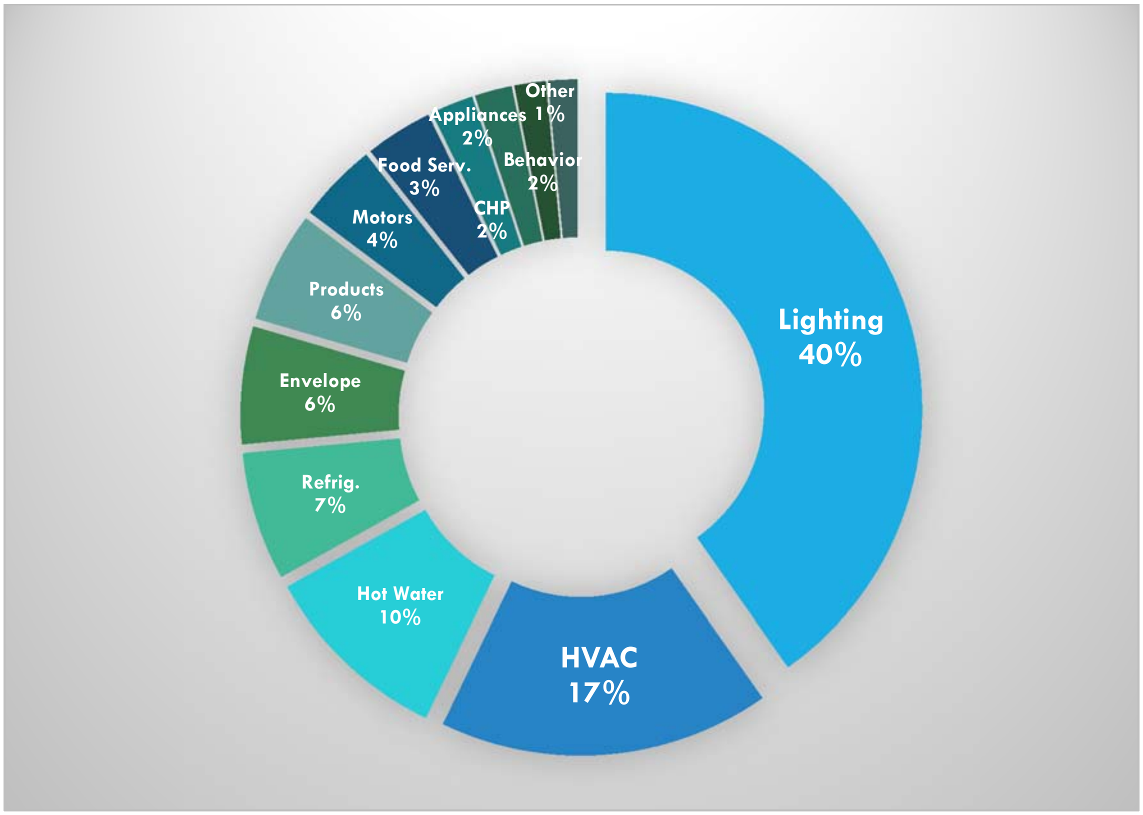
Figure 4-3. Six-Year Cumulative Achievable Potential (GWh)



The main end-use contributing to achievable potential is lighting (40%). Other significant end-uses are HVAC (17%), hot water (10%), refrigeration (7%), building envelope (6%), and products[49] (6%). (See Figure 4-4.)

[49] Including electronics, smart strips, and dehumidifiers.

Figure 4-4. Achievable Potential by End-Use



4.2 Top Five Measures

Three of the top five measure categories (across all sectors combined) are lighting measures, reflecting the large share of lighting savings in the overall achievable potential. LED bulbs are by far the highest energy-saving measure category, contributing 52.9 GWh of savings (22% of total achievable potential) over the six-year period. Linear lighting savings also include some savings from LED technology. Some potential for CFL savings remains, assuming that CLC continues to promote CFLs through its programs. CFLs and LEDs currently compete with each other for several types of baseline sockets/fixtures.

Hot water and building envelope measures also account for a substantial share of overall potential.

Table 4-5 summarizes the potential contribution by the top five measure categories, by sector.

Table 4-5. 2016-2021 Savings for Top Five Measure Categories by Sector

Rank	All Sectors		Residential		Low Income		C&I	
	Measure	GWh	Measure	GWh	Measure	GWh	Measure	GWh
1	LED Bulbs	52.9	LED Bulbs	28.6	Air Conditioning	2.0	LED Bulbs	22.4
2	Hot Water	18.4	CFL Bulbs	17.4	LED Bulbs	1.9	Linear Lighting	14.0
3	CFL Bulbs	18.3	Building Envelope	13.6	Building Envelope	1.2	Lighting Control	12.7
4	Building Envelope	14.8	Hot Water	13.5	CFL Bulbs	0.9	Refrigeration	10.0
5	Linear Lighting	14.0	Heat Pumps	11.6	Hot Water	0.8	Food service	9.1

4.3 Combined Heat & Power

Table 4-6 presents the annual potential results with and without Combined Heat & Power (CHP) in the C&I sector. C&I CHP has a relatively small impact on the overall achievable potential results, contributing only 5.4 GWh, or 2%, over the six-year period. A large part of the technical potential is not cost-effective with current inputs and assumptions, and high barriers result in a low adoption rate. When removing C&I CHP, the annual achievable potential drops from 1.98% to 1.93% of sales.

Table 4-6. Comparison of 2016-2021 Cumulative Achievable Potential: With and without C&I Combined Heat & Power

Potential	With C&I CHP		Without C&I CHP	
	GWh	MW	GWh	MW
Technical	675	163	494	126
Economic	480	117	447	114
Achievable	246	62	240	61

4.4 Comparison to Three Year Plan

In its April 30th 2015 draft of the Three-Year Plan for 2016-2018, CLC established a portfolio-wide savings goal of 156.3 GWh. This goal is 29% higher than our estimated achievable potential of 120.8 GWh for the same period.

When comparing CLC's published goal to our potential estimate, it is important to remember that the potential study is not meant to be a direct forecast of claimable savings, because some of the assumptions and inputs used to estimate potential are different from those used for setting goals and claiming savings. In particular, a key objective of our potential study was to reflect the unique circumstances of CLC's service territory and customer base, including the effects on achievable savings of having a large share of seasonal customers. To this end, we collected a wealth of primary data which is reflected in the potential study results. In contrast, the Massachusetts goal setting and savings claiming process requires consistency with TRM assumptions. As a result, the potential study results reflect certain CLC-specific information that is not mirrored in CLC's goals.

Further analysis of potential study results and Plan goals identified C&I upstream lighting as a key programmatic area where results are different: The April 30th Three-Year Plan estimates savings of 40.9 GWh from C&I upstream lighting whereas the potential model only estimates 8.7 GWh. The main drivers of this difference are assumptions about (1) the mix of baseline (replaced) bulbs (i.e., incandescent vs CFL units); (2) the size (wattage) of the baseline (replaced) bulbs; and (3) hours of use. The potential study used primary data for all of these factors, which showed:

1. higher penetration of CFL bulbs;[50]
2. lower wattage of baseline (replaced) bulbs; and
3. lower weekly hours of use during normal business operations

These differences lead to significantly lower savings estimates in the potential study compared to those used for planning purposes.

Another, but smaller, difference comes from consideration of seasonality in the potential study. While businesses on the Cape generally have shorter weekly hours of use during normal business weeks, which is reflected in the hours of use adjustment above, a number of businesses also have an additional reduction in their hours of operation during the off-peak season, especially winter.

In addition to differences stemming from the use of primary data, chaining – i.e., reduced savings from cumulative effects – also has an important effect because of high adoption rates for lighting controls in the potential study (resulting from high cost-effectiveness for these measures). When new lighting equipment is installed together with controls, the savings are smaller than the sum of each measure alone. Finally, small differences in net-to-gross and realization rate assumptions result in a negligible effect on savings compared to the Plan.

Table 4-7 below details the key differences in assumptions for C&I upstream lighting, and their impacts on 2016-2018 savings.

Table 4-7. Impact of Assumptions on Upstream Lighting Results

DESCRIPTION	Potential Study 3-Year Model (GWh)[51]	Increase /decrease (GWh)	Increase /decrease (% change)	3-Year Plan (GWh)
Base scenario (Potential Model)	8.7	---	---	40.9
Adjustment for seasonal customers removed	9.2	+0.5	+6%	
Hours of use adjusted to 3,901 per year (statewide assumption)	12.6	+3.4	+37%	
Mix of baseline incandescent/CFL set to 75%/25% for Type A bulbs	19.3	+6.7	+53%	

[50] For the potential study, we determined the mix of CFL versus incandescent bulbs being replaced using site visit and survey information, as well as natural replacement rates. This value is significantly different from the statewide TRM assumption.

[51] This column shows cumulative GWh from each assumption change.

Net-to-gross and realization rate factors set to same values as the 2016-18 CLC Plan	19.2	-0.1	-1%	
Chaining adjustment removed	25.3	+6.2	+32%	
Size of bulbs (watt difference between baseline and efficient bulbs for Type A bulbs) set to same value as CLC Plan	35.1	+9.8	+39%	

Using statewide assumptions and removing CLC-specific adjustments for C&I upstream lighting would increase our estimated C&I achievable potential by 26.5 GWh, from 52.5 GWh to 79.0 GWh. These additional 26.5 GWh would increase our estimated total achievable potential from 120.8 GWh to 147.3 GWh, in turn increasing the achievable potential as a percentage of sales from 1.94% in the base case to 2.36%. It should be noted, however, that even with these adjustments to C&I upstream lighting, Plan goals are not perfectly comparable to the achievable potential estimated in this study. The potential model also uses CLC-specific assumptions in the other sectors (residential and low income), which we did not vary for this analysis. However, the different assumptions for C&I upstream lighting can explain a significant portion of the difference between Plan goals and our estimated achievable potential.

4.5 Sensitivity Analysis

We conducted a sensitivity analysis to assess uncertainty regarding the 6-year GWh savings potential, using the following ranges:

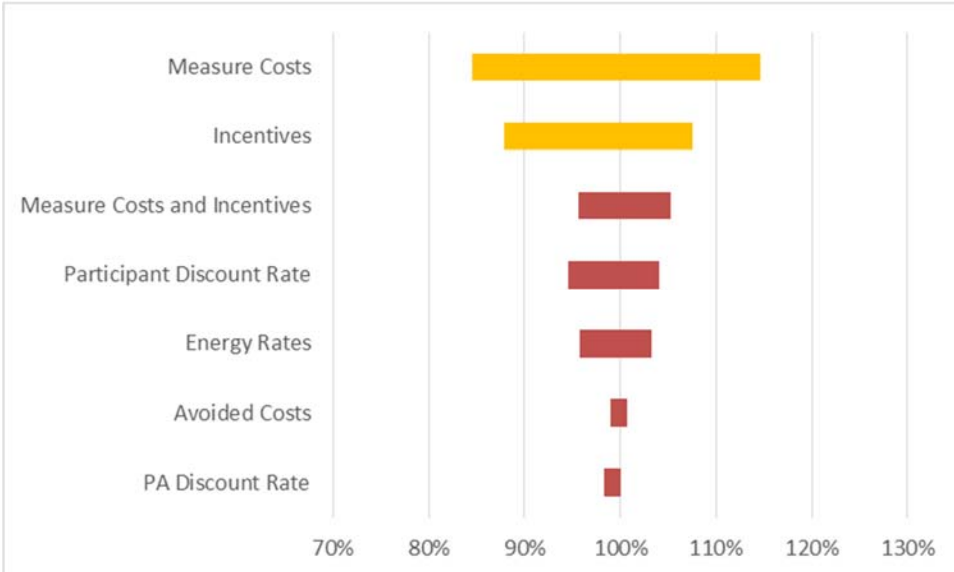
- Program administrator discount rate: 0% to 4%
- Participant discount rate: 0% to 10%
- Measure costs, incentives, energy rates, and avoided costs: -20% to +20%

Figure 4-5 presents the results of these analyses, as the percentage of savings under the lower and upper bounds for each factor, compared to the base scenario.

The potential model appears sensitive to measure costs and to incentives, because moving just one of these two parameters creates a discrepancy between costs and incentives (see orange bars in graph below). In reality, incentives are largely endogenous as they can be adjusted to evolving costs. As the graphic shows, adjusting measure costs and incentives at the same time (red bar) produces far less variability in results.

The potential savings appear robust, as all tested factors produce a variability of less than 20% compared to the base scenario.

Figure 4-5. 6-Year GWh Savings and Variability (Base Scenario = 100%)



4.6 Detailed Results

The following tables present additional detail on the results of the potential study, by type of potential, sector, segment, and end-use.

Table 4-8. Technical, Economic, and Achievable Potential by Year (GWh)

	2016	2017	2018	2019	2020	2021	2016-2018	2019-2021	2016-2021
Cumulative Annual									
Technical	117.5	230.2	343.1	455.2	567.5	675.0	343.1	331.9	675.0
Economic	84.6	165.1	245.6	325.5	405.0	479.8	245.6	234.1	479.8
Achievable	41.8	81.1	120.8	163.0	205.4	245.5	120.8	124.6	245.5
Incremental Annual									
Technical	117.5	112.8	112.9	112.1	112.3	107.5	343.1	331.9	675.0
Economic	84.6	80.6	80.5	79.8	79.5	74.8	245.6	234.1	479.8
Achievable	41.8	39.3	39.8	42.2	42.4	40.1	120.8	124.6	245.5
Incremental as % of Sales									
Technical	5.7%	5.4%	5.4%	5.4%	5.4%	5.3%	5.5%	5.4%	5.4%
Economic	4.1%	3.9%	3.9%	3.9%	3.9%	3.7%	3.9%	3.8%	3.9%
Achievable	2.0%	1.9%	1.9%	2.0%	2.1%	2.0%	1.9%	2.0%	2.0%

Table 4-9. Detailed Results by Sector, Segment, and End-Use (2016-2021 Cumulative Achievable Potential – GWh)

Segment	End-Use												
	Lighting	HVAC	Motors	Refrig.	Food Serv.	Hot Water	Appliances	Products	Behavior	Envelope	CHP	Other	TOTAL
CI- Small Retail	6.0	1.7	0.0	1.7	0.4	0.6	---	---	---	---	0.0	0.3	10.7
CI- Office	3.9	1.0	0.0	0.0	0.2	1.1	---	---	---	---	0.0	0.1	6.3
CI- Restaurant	2.4	0.8	0.1	2.2	1.4	0.9	---	---	---	---	0.0	0.2	8.0
CI- Government	7.9	6.3	3.0	1.4	1.6	0.3	---	---	---	---	4.3	0.7	25.5
CI- Hospitality	2.5	1.3	0.0	0.2	1.1	0.0	---	---	---	---	0.2	0.0	5.4
CI- Healthcare	3.3	2.6	0.2	0.1	0.2	0.1	---	---	---	---	0.6	0.2	7.2
CI- Multifamily	5.2	1.9	0.1	0.0	0.0	0.1	---	---	---	---	0.0	0.0	7.2
CI- Large Retail	1.6	0.4	0.0	2.6	0.3	0.1	---	---	---	---	0.0	0.1	5.1
CI- Industrial	7.4	1.1	0.0	0.5	0.1	1.2	---	---	---	---	0.2	1.2	11.7
CI- Misc.	10.0	2.0	1.0	1.3	3.0	0.6	---	---	---	---	0.0	0.8	18.7
CI- Subtotal	50.2	19.1	4.3	9.9	8.3	4.9	---	---	---	---	5.4	3.5	105.7
Res- Non-Seasonal	37.4	16.8	5.7	4.9	---	16.3	3.9	12.6	3.7	10.6	---	---	112.0
Res- Seasonal	8.6	3.3	0.1	1.1	---	1.6	0.5	0.6	0.0	3.0	---	---	18.8
Res- Subtotal	46.0	20.2	5.8	6.0	---	17.9	4.4	13.2	3.7	13.6	---	---	130.9
Low Income	2.9	2.3	0.1	0.1	---	1.0	0.3	0.7	0.2	1.2	---	---	8.8
Low Income - Subtotal	2.9	2.3	0.1	0.1	---	1.0	0.3	0.7	0.2	1.2	---	---	8.8
TOTAL	99.0	41.6	10.2	16.0	8.3	23.9	4.7	14.0	3.9	14.8	5.4	3.5	245.5

5. Residential Potential Results

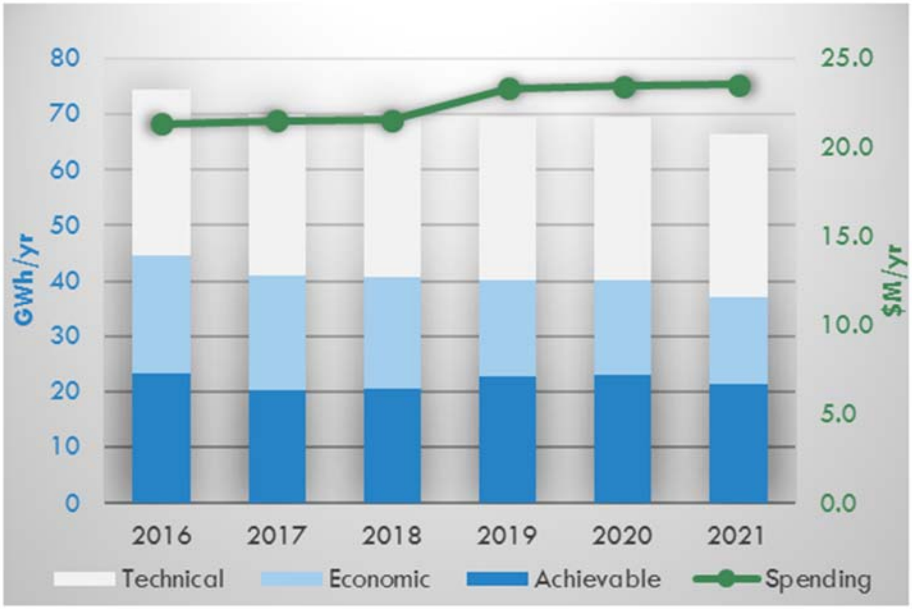
CLC's annual achievable energy efficiency potential for the residential sector is estimated at 131 GWh and 29 MW for the six-year period from 2016 to 2021. Achievable potential represents 54% of economic potential and 31% of technical potential. On average, achievable energy savings amount to 1.92% of CLC annual sales to the sector. These savings would cost CLC $135 million (incentive and non-incentive program costs), an average of $23 million per year. The total cost (including the participants' net cost) amounts to $159 million for the six-year period. These investments are cost-effective, with a Total Resource Cost (TRC) ratio of 3.0 and a Program Administrator Cost (PAC) ratio of 2.5. Table 5-1 summarizes these results.

Table 5-1. Key Potential Results – Residential Sector, by Period

	2016-2021		2016-2018		2019-2021	
Potential (Total)	GWh	MW	GWh	MW	GWh	MW
Technical	420	85	215	47	205	38
Economic	244	46	127	27	118	18
Achievable	131	29	64	17	67	12
Potential (Yearly)	GWh	MW	GWh	MW	GWh	MW
Technical	70.0	14.1	71.6	15.7	68.4	12.6
Economic	40.7	7.6	42.2	9.1	39.2	6.1
Achievable	21.8	4.8	21.3	5.5	22.3	4.1
Annual Achievable as % of Sales	1.92%		1.88%		1.96%	
Cost						
Total (millions)	$159		$77		$83	
CLC (millions)	$135		$64		$70	
CLC Cost/kWh	$1.029		$1.007		$1.050	
Cost-Effectiveness						
Total Resource Cost Test	3.0		2.9		3.0	
Program Administrator Cost Test	2.5		2.4		2.6	

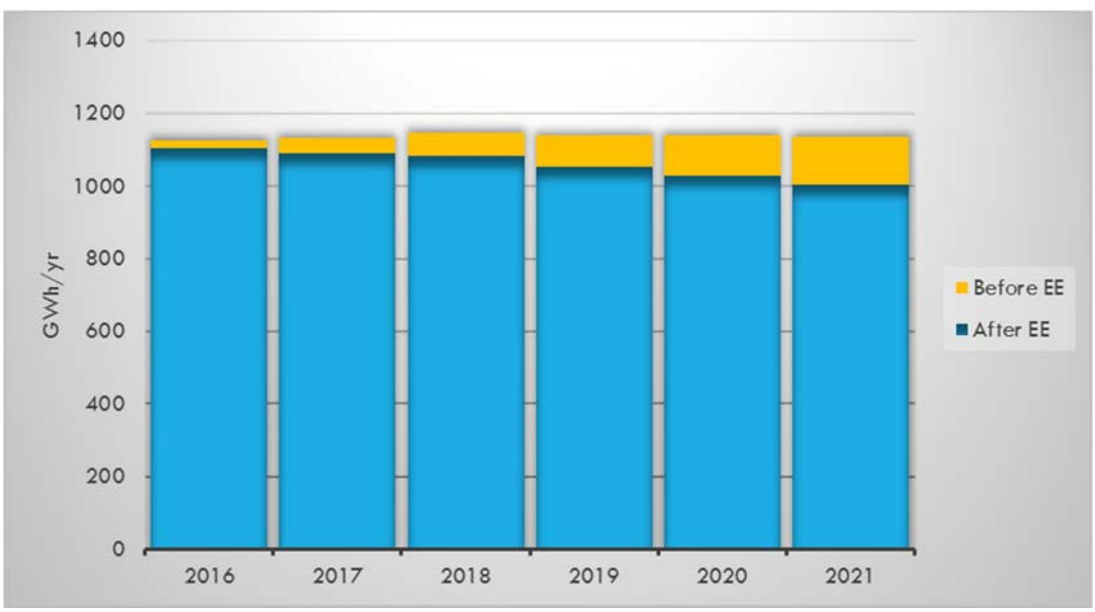
Figure 5-1 presents annual GWh savings for the three types of potential, as well as annual spending required to meet the achievable potential. As noted for the overall potential, the increase in spending during the second three-year period (2019–2021) is due to higher LED uptake, which results from an assumption of decreasing market barriers. While savings from LEDs are higher for that period, they are counterbalanced by somewhat lower savings for other measures.

Figure 5-1. Annual Savings and Spending for Residential Sector



Eversource forecasts slightly increasing energy sales for the residential sector, before energy efficiency (EE) efforts, over the six-year period, with total sales of 1,136 GWh in 2021 compared to 1,125 in 2016. With EE efforts at the level of the achievable potential, energy sales would decline, with 2021 sales amounting to 1,005 GWh, a drop of 11.5% from 2016 sales (Figure 5-2).

Figure 5-2. Impact of Achievable Potential on Annual GWh Residential Sales



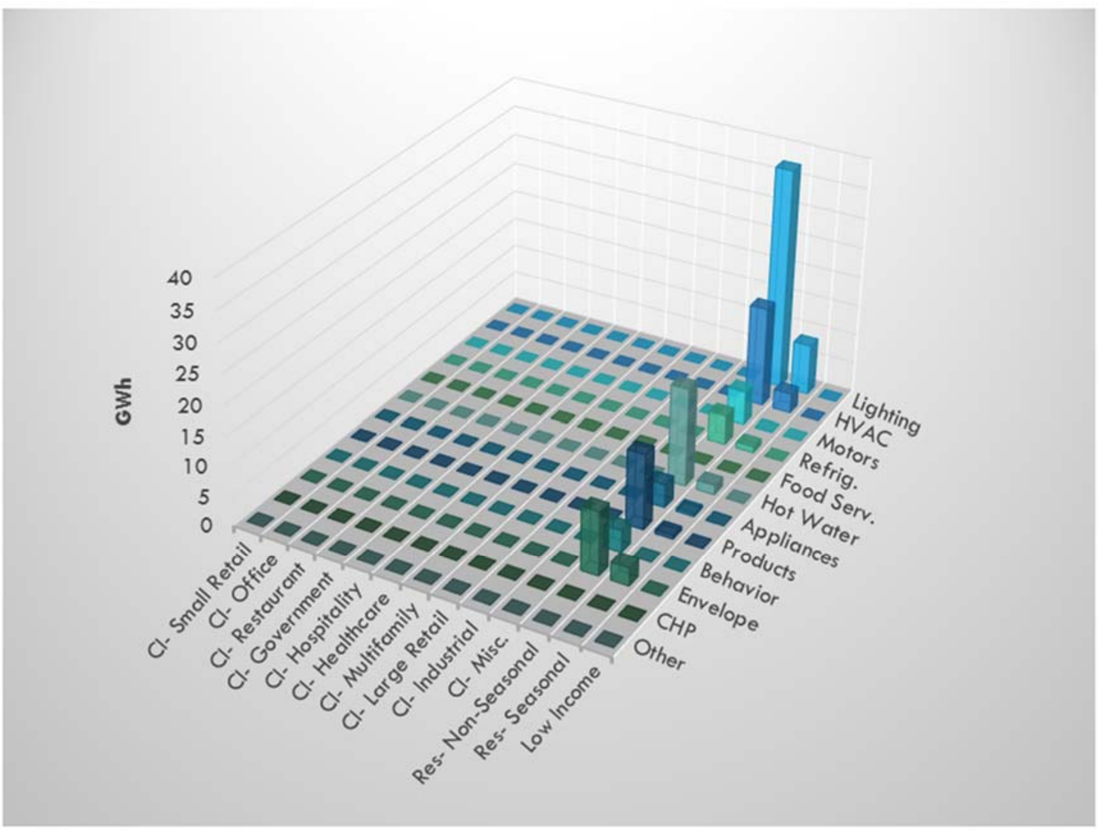
5.1 Results by Segment and End-Use for Residential Sector

Achievable potential associated with seasonal residential customers is rather low compared to non-seasonal residential customers. Over the six-year period, we estimate achievable energy savings of 2.14% of energy sales for non-seasonal customers and 1.19% of energy sales for seasonal customers.

This low potential is mainly due to the effect of seasonal occupancy on annual savings (i.e., lower hours of use resulting in lower savings for the same measure compared to non-seasonal customers). Several measures also do not pass the TRC for seasonal customers because of reduced savings, including important measures such as ENERGY STAR Homes - New Construction, heat pumps with lower efficiency levels, heat pump water heaters, and smaller LED bulbs that replace CFLs. Finally, because energy savings also affects the economics from the customer's point of view, lower Participant Cost Test (PCT) ratios will translate into lower adoption rates.

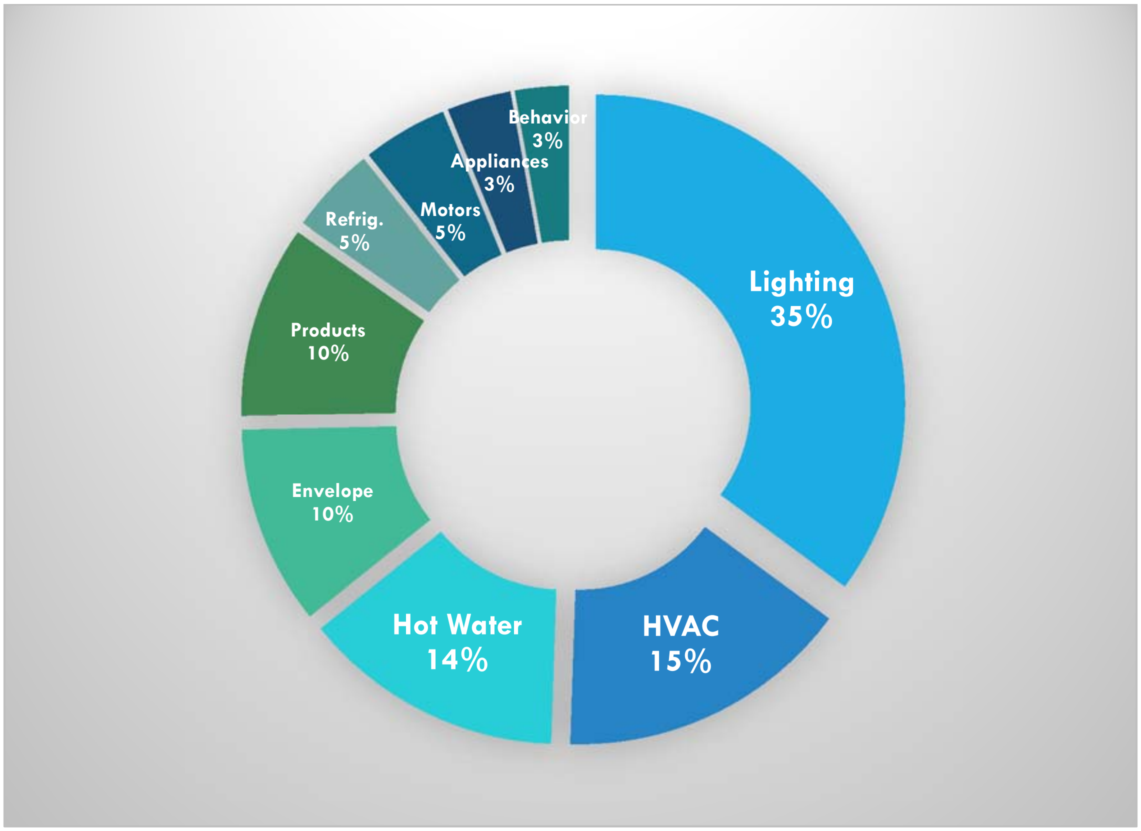
As can be seen on Figure 5-3, there are significant differences in the achievable savings patterns between seasonal and non-seasonal customers due to these factors.

Figure 5-3. 2016-2021 Cumulative Achievable Savings (GWh) for Residential Sector



The main end-uses contributing to achievable potential in the residential sector are lighting (35%), HVAC (15%) and hot water (14%). Other significant end-uses are building envelope (10%) and products (10%) (Figure 5-4).

Figure 5-4. 2016-2021 Achievable Potential by End-Use for Residential Sector



5.2 Top Five Measures for Residential Sector

The two top residential measures categories are lighting measures, reflecting the large share of lighting savings in the overall achievable potential. LED bulbs are the highest energy-saving measure, contributing 28.6 GWh of savings (22% of total achievable potential for the residential sector) over the six-year period, followed by CFL bulbs at 17.4 GWh (13%). CFLs and LEDs are competing with each other for several types of baseline sockets/fixtures.

Building envelope (13.6 GWh) and hot water (13.5 GWh) measures also account for a substantial share of overall potential.

Finally, heat pumps, including both new additions and replacements on burnout, are estimated to contribute 11.6 GWh to the six-year achievable potential.

Table 5-2. 2016-2021 Savings for Top Five Measure Categories in the Residential Sector

Rank	Measure	GWh
1	LED Bulbs	28.6
2	CFL Bulbs	17.4
3	Building Envelope	13.6
4	Hot Water	13.5
5	Heat Pumps	11.6

6. Low Income Potential

CLC's annual achievable energy efficiency potential for the low income sector is estimated at 9 GWh and 3 MW for the six-year period from 2016 to 2021. Achievable potential represents 41% of economic potential and 29% of technical potential. On average, achievable energy savings amount to 2.16% of CLC annual sales to the sector. These savings would cost CLC $10 million (incentive and non-incentive program costs), an average of $2 million per year. The total cost (including the participants' net cost) amounts to $11 million for the six-year period. These investments are cost-effective, with a Total Resource Cost (TRC) ratio of 4.2 and a Program Administrator Cost (PAC) ratio of 2.9. Table ES-1 summarizes these results.[52]

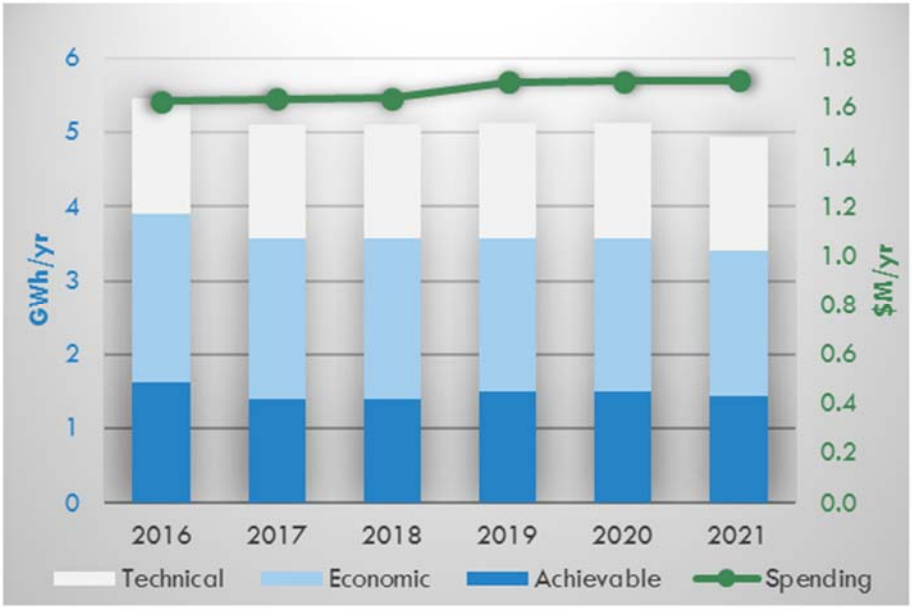
Table 6-1. Key Potential Results – Low Income Sector, by Period

	2016-2021		2016-2018		2019-2021	
Potential (Total)	GWh	MW	GWh	MW	GWh	MW
Technical	31	12	16	6	15	6
Economic	22	10	11	5	11	5
Achievable	9	3	4	2	4	1
Potential (Yearly)	GWh	MW	GWh	MW	GWh	MW
Technical	5.1	2.0	5.2	2.0	5.1	2.0
Economic	3.6	1.7	3.7	1.7	3.5	1.7
Achievable	1.5	0.6	1.5	0.7	1.5	0.5
Achievable as % of Sales	2.16%		2.16%		2.16%	
Cost						
Total (millions)	$11		$5		$5	
CLC (millions)	$10		$5		$5	
CLC Cost/kWh	$1.134		$1.112		$1.156	
Cost-Effectiveness						
Total Resource Cost Test	4.2		4.1		4.2	
Program Administrator Cost Test	2.9		2.9		3.0	

Figure 6-1 presents annual GWh savings for the three types of potential, as well as annual spending required to meet the achievable potential. Similar to the residential sector, the increase in spending during the second three-year period (2019–2021) is due to higher LED uptake over that period.

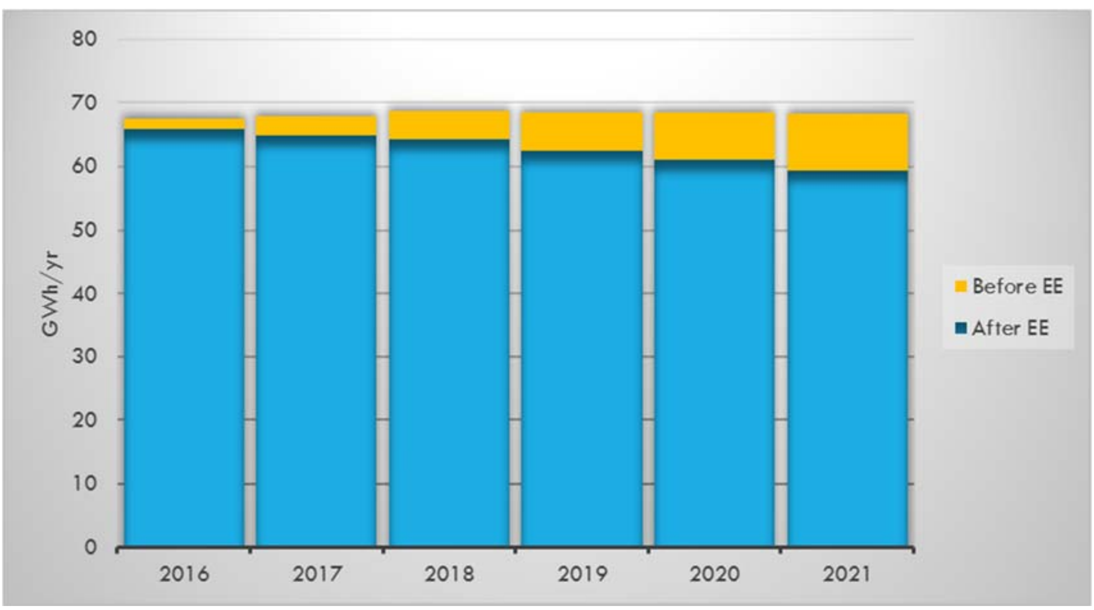
[52] Note that the indicated budget allocation for low income programs in the Potential Model is not 10% of the overall CLC budget, as required by Massachusetts Statute. In order to meet the statutory 10% requirement, CLC may need to expend additional budget without corresponding savings.

Figure 6-1. Annual Savings and Spending for the Low Income Sector



Eversource forecasts slightly increasing energy sales for the low income sector, before energy efficiency (EE) efforts, over the six-year period, with total sales of 68.2 GWh in 2021 compared to 67.6 in 2016. With EE efforts at the level of the achievable potential, energy sales would decline, with 2021 sales amounting to 59.4 GWh, a drop of nearly 9% from 2016 sales (Figure 6-2).

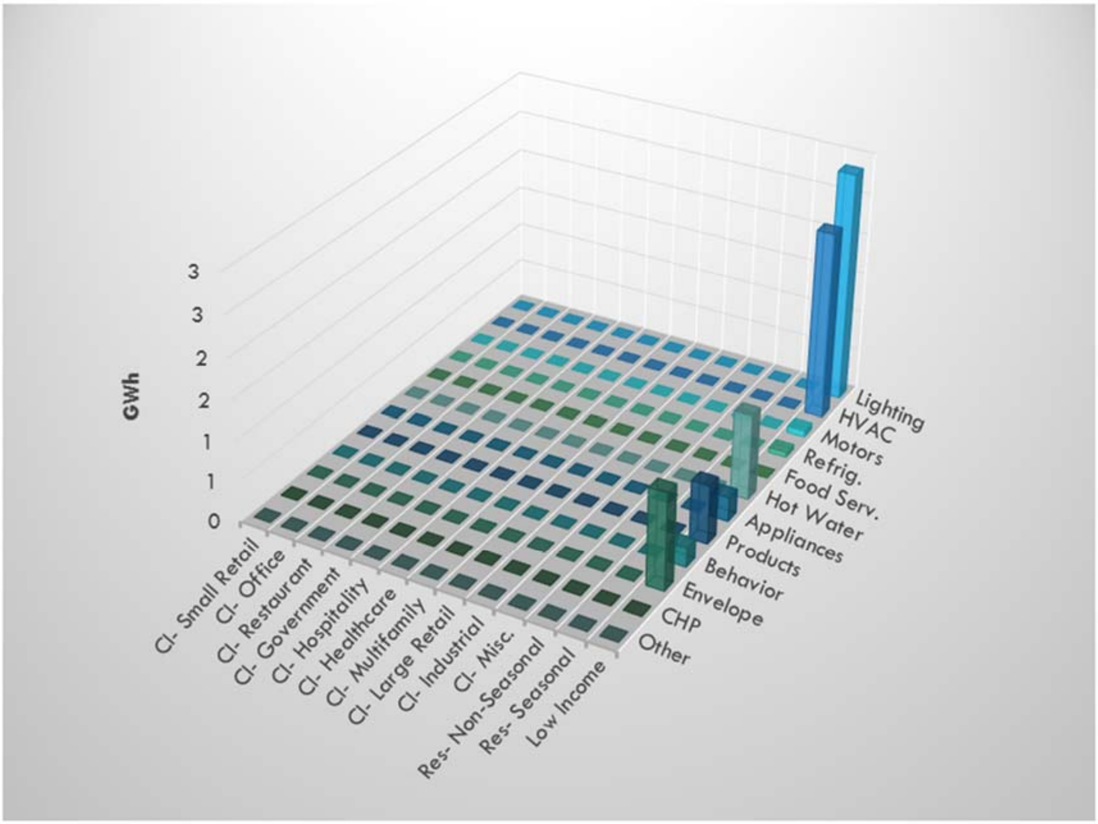
Figure 6-2. Impact of Achievable Potential on Annual Low Income GWh Sales



6.1 Results by End-Use for Low Income Sector

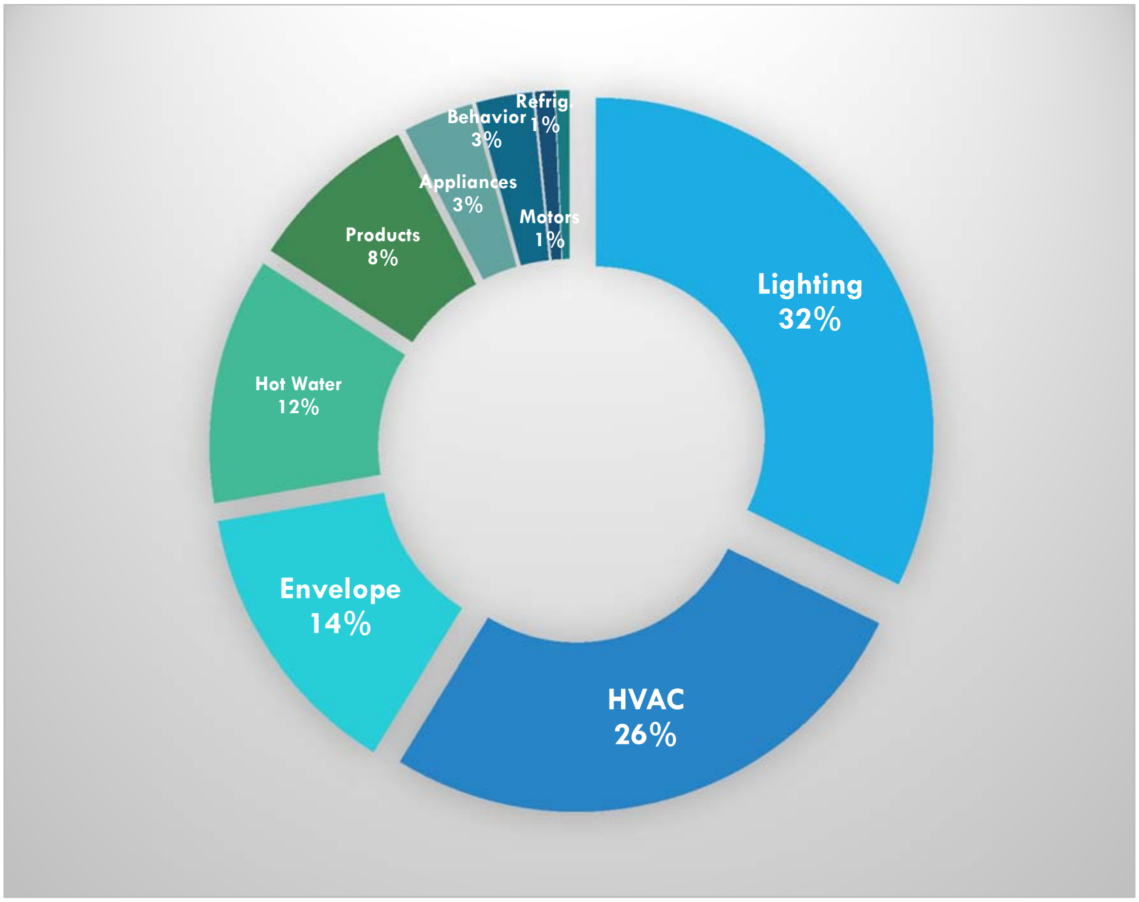
The small contribution of the Low Income Sector to overall achievable potential (4%) is in line with the sector's number of accounts and annual energy sales. This sector is not affected by seasonality, unlike the Residential and C&I sectors.

Figure 6-3. 2016-2021 Cumulative Achievable Savings (GWh) for the Low Income Sector



The main end-uses contributing to achievable potential are lighting (32%) and HVAC (26%). Other significant end-uses are building envelope (14%), and hot water (12%) (Figure 6-4).

Figure 6-4. 2016-2021 Achievable Potential by End-Use for the Low Income Sector



6.2 Top Five Measures for Low Income Sector

Two of the top five measure categories are lighting measures, reflecting the large share of lighting savings in the overall achievable potential. Air conditioning is the highest energy-saving measure, followed closely by LED bulbs. The importance of air conditioning saving potentials for the low income sector can be explained by the higher penetration of room air conditioning units compared to the residential sector, and by the existence of an income dependent initiative for room AC replacements. On the other hand, lighting savings are lower for the low income sector because low income households have fewer lightbulbs on average, and a larger proportion of them have already been replaced by CFLs. There still remains some potential for CFL savings, assuming that CLC continues to promote them through its programs. As noted above, CFLs and LEDs currently compete with each other for several types of baseline sockets/fixtures.

Hot water and building envelope measures also account for a substantial share of overall potential.

Table 6-2. 2016-2021 Savings for Top Five Measures in the Low Income Sector

Rank	Measure	GWh
1	Air Conditioning	2.0
2	LED Bulbs	1.9
3	Building Envelope	1.2
4	CFL Bulbs	0.9
5	Hot Water	0.8

7. Commercial & Industrial Potential Results

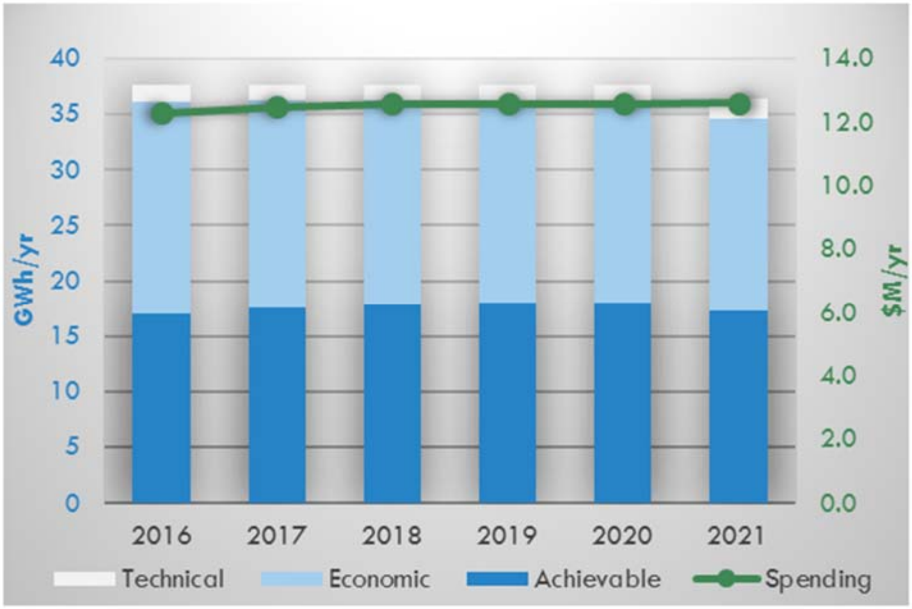
CLC's annual achievable energy efficiency potential for the commercial and industrial (C&I) sector is estimated at 106 GWh and 30 MW for the six-year period 2016 to 2021. Achievable potential represents 49% of economic potential and 47% of technical potential. On average, achievable energy savings amount to 2.04% of CLC annual sales to the sector. These savings would cost CLC $75 million (incentive and non-incentive program costs), an average of $13 million per year. The total cost (including the participants' net cost) amounts to $77 million for the six-year period. These investments are cost-effective, with a Total Resource Cost (TRC) ratio of 4.8 and a Program Administrator Cost (PAC) ratio of 3.4. Table ES-1 summarizes these results.

Table 7-1. Key Potential Results – C&I Sector, by Period

	2016-2021		2016-2018		2019-2021	
Potential (Total)	GWh	MW	GWh	MW	GWh	MW
Technical	224	66	113	33	111	33
Economic	214	61	108	31	106	30
Achievable	106	30	53	15	53	15
Potential (Yearly)	GWh	MW	GWh	MW	GWh	MW
Technical	37.4	11.0	37.6	11.0	37.1	11.0
Economic	35.7	10.2	36.1	10.3	35.3	10.2
Achievable	17.6	4.9	17.5	4.9	17.7	4.9
Achievable as % of Sales	2.04%		1.99%		2.09%	
Cost						
Total (millions)	$76		$38		$39	
CLC (millions)	$75		$37		$38	
CLC Cost/kWh	$0.710		$0.711		$0.710	
Cost-Effectiveness						
Total Resource Cost Test	4.8		4.9		4.8	
Program Administrator Cost Test	3.4		3.4		3.4	

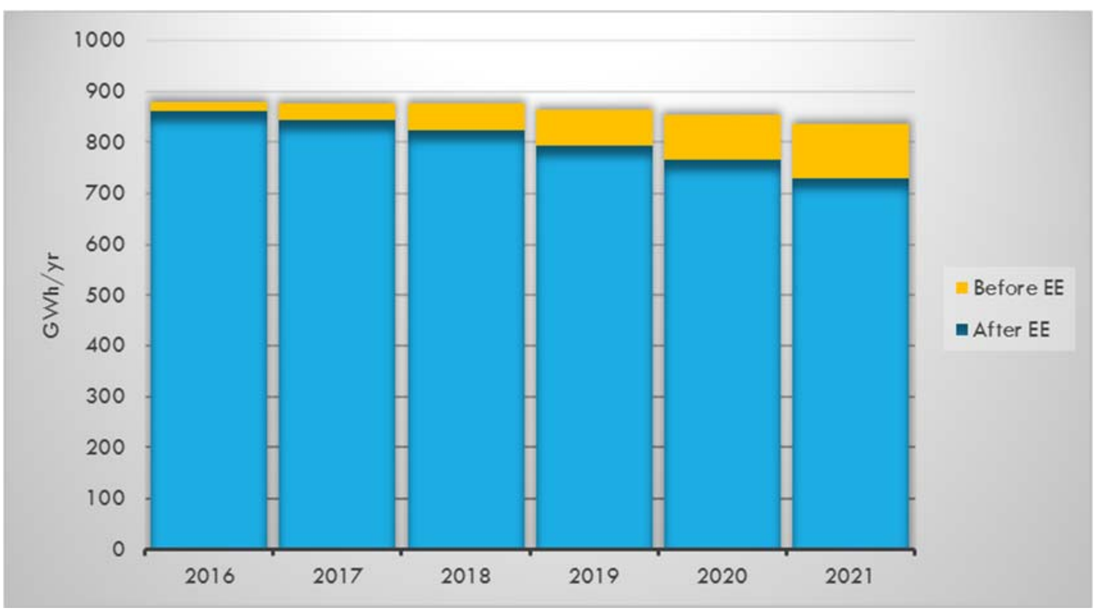
Figure 7-1 presents annual GWh savings for the three types of potential, as well as annual spending required to meet the achievable potential. Both spending and savings are rather flat during the six-year period.

Figure 7-1. Annual Savings and Spending for the C&I Sector



Eversource forecasts declining energy sales for the C&I sector, before energy efficiency (EE) efforts, over the six-year period, with total sales of 837 GWh in 2021 compared to 879 in 2016. With EE efforts at the level of the achievable potential, energy sales would decline faster, with 2021 sales amounting to 731 GWh, a drop of nearly 17% from 2016 sales (Figure 7-2).

Figure 7-2. Impact of Achievable Potential on Annual C&I GWh Sales

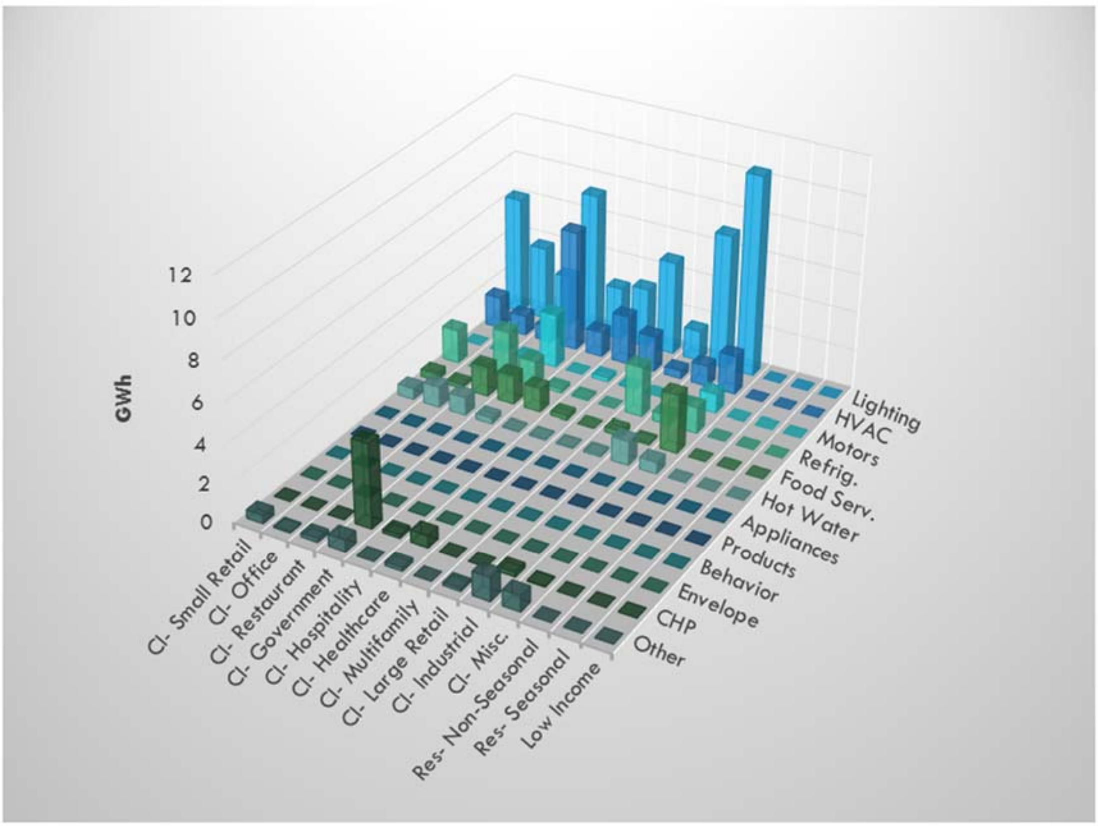


7.1 Results by Segment and End-Use for C&I Sector

The C&I sector accounts for 42% of the overall achievable potential. The relatively small contribution of the C&I sector, which compares to 57% of statewide C&I savings for the 2016-18 period, reflects the economic structure of Cape Cod and Martha's Vineyard. CLC's non-residential customer base is dominated by small businesses, with very few large commercial or industrial customers. This structure results in lower potential from the C&I sector as well as higher cost per kWh saved, as it is more expensive to serve smaller customers.

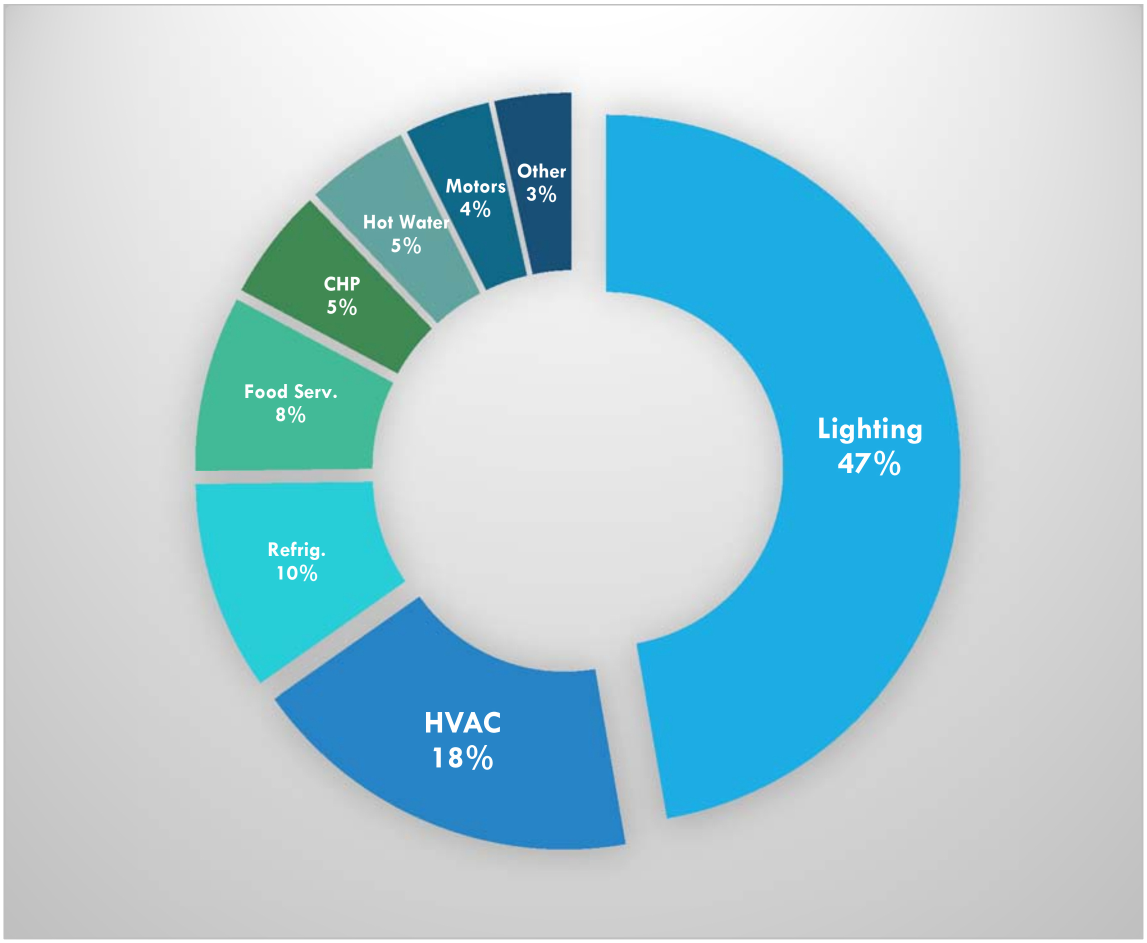
Achievable potential of the C&I sector is affected by seasonality, especially for the Restaurant and Hospitality segments. A large proportion of businesses have reduced hours of operation and/or occupancy during the off-peak season, and some even shut down completely during the winter.

Figure 7-3. 2016-2021 Cumulative Achievable Savings (GWh) for the C&I Sector



The main end-uses contributing to achievable potential are lighting (47%) and HVAC (18%). Other significant end-uses, which are specific to the C&I sector, are refrigeration (10%) and food service equipment (8%) (Figure 7-4).

Figure 7-4. 2016-2021 Achievable Potential by End-Use for C&I



7.2 Top Five Measures for C&I Sector

Three of the top five measure categories are lighting measures, reflecting the large share of lighting savings in the overall achievable potential. LED bulbs are by far the highest energy-saving measure, contributing 22.4 GWh of savings (21% of total achievable potential for the C&I sector) over the six-year period. Linear lighting savings also include some savings from LED technology.

Refrigeration and food service equipment also account for a substantial share of overall potential.

Table 7-2. 2016-2021 Savings for Top Five Measure Categories in the C&I Sector

Rank	Measure	GWh
1	LED Bulbs	22.4
2	Linear Lighting	14.0
3	Lighting Control	12.7
4	Refrigeration	10.0
5	Food service	9.1

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DNV·GL

National Grid Massachusetts Energy Efficiency Potential Study

FINAL

Prepared by KEMA, Inc.

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1. EXECUTIVE SUMMARY

In 2014, National Grid Massachusetts (National Grid) engaged DNV GL to assess the potential for electric and natural gas energy and electric demand savings from company-sponsored commercial and industrial demand side management (DSM) programs. The method used for estimating potential is a "bottom-up" approach, in which energy efficiency costs and savings are assessed at the customer segment and energy efficiency measure level. For cost-effective measures (based on the Total Resource Cost (TRC) test), achievable savings potential is estimated as a function of measure economics, rebate levels, and program marketing and education efforts. The modeling approach was implemented using a National Grid specific Excel model which allows for efficient integration of large quantities of measure, building, and economic data to determine energy efficiency potential.

1.1 Methodology

DNV GL leveraged its proprietary model, DSM ASSYST™, in order to develop a dynamic, transparent, user-friendly, Excel-based model that allows National Grid staff to update certain predetermined fields as new information and/or program parameters arise. Wherever possible, National Grid specific data were used as inputs to the model. The model was populated with data collected from National Grid customers through Wave 1 and a portion of Wave 2 of the Massachusetts Existing Building Market Characterization C&I Customer On-site Assessments (EM&V Project 41),[1] previous state-wide and National Grid specific evaluation efforts, the Massachusetts Technical Reference Manual, National Grid's internal documents and tracking data and other secondary sources.

The analysis has a starting year of 2015 and uses that year as its calibration year, assuming that 2015 costs and savings are similar to available 2014 savings. Results from 2016 onward are presented so as to accurately reflect a start date that is consistent with the 2016 to 2018 planning period. In this document DNV GL shows a three-year forecast for the 2016 to 2018 planning period and a longer term 10-year forecast from 2016 to 2025.

Three basic types of energy efficiency potential were estimated in this study:

- **Technical potential:** The complete penetration of all measures analyzed in applications where they were deemed technically feasible from an engineering perspective. Technical potential is a purely theoretical estimate of potential, as it ignores cost effectiveness, measure turnover and other barriers that might inhibit measure adoption. The size of the technical potential hinges primarily on the list of measures being evaluated: An expansive measure list with many cutting-edge but not currently cost effective technologies would have a much higher technical potential than one with a more restrictive list of measures known to be cost effective in at least some applications.
- **Economic potential:** The technical potential of those energy efficiency measures that are cost-effective when compared to supply-side alternatives. It should be noted that the potential captured in economic potential includes all possible measure installations regardless of the timing of the installation, i.e., all potential savings across all time periods

[1] The Massachusetts Existing Building Market Characterization – C&I Customer On-site Assessments (EM&V Project 41) is a two year study and includes two waves of on-site data collection. Wave 1 data collection was completed in December 2014 and included 350 sites, Wave 2 data collection began in January 2015 and is anticipated to include 450 sites and is slated to be complete in late 2015. A total of 257 National Grid electric sites were included in this study and a total of 207 gas sites were included (the majority of which were National Grid serviced sites with the only exception being industrial sites which included sites from all Massachusetts gas PAs).

modeled are counted in this number. At this stage, the analysis leverages the TRC test to determine which measures have a TRC value above a certain threshold (in the case of National Grid this is 1.0). Any measures with a TRC below this threshold are dropped from the analysis at this point. The modeling effort addresses competing measures at a variety of levels. Retrofit and replace-on-burnout approaches to the same measures are addressed through market segmentation. Beyond that, the research team utilizes a supply curve approach to avoid double counting of savings, in which measures are ranked by cost-effectiveness and assumed to be implemented in that order. For measures in direct competition (that is, one or the other may be installed, but not both), the study applies the most cost effective measure, then evaluates the second measure based on its marginal cost and savings relative to the first.

- **Achievable program potential:** The amount of savings that would occur in response to specific marketing and measure incentive levels. Here, timing of the measure installation becomes a factor for the modeled savings. In this study DNV GL looked at the potential available under three scenarios - a business-as-usual (BAU) scenario where overall incentives levels paid in 2015 are used going forward as well as two additional funding scenarios: 25 percent increase over those BAU levels (25 Percent Plus scenario) and a 75 percent increase (75 Percent Plus scenario).[2] Program energy and peak-demand savings, as well as program cost effectiveness, were assessed under all three funding scenarios. The National Grid study also provides an estimate of naturally occurring savings, i.e., those savings that are projected to result from normal market forces in the absence of any intervention by utility sponsors. These savings are not included in the estimate of achievable program potential.[3] While economic potential is based on a TRC test screening, measure adoption for achievable potential and naturally occurring is based on the measure benefit/cost ratio from the customer perspective.

1.2 Model Assumptions & Limitations

In order to best understand and interpret the results of this analysis, the reader should first have a solid understanding of the assumptions and limitations of the model used for this study. Each of these is presented in Table 1-1 along with an assessment of the effect on the model outputs. Most importantly, it should be noted that the model used in this analysis is primarily intended to give National Grid a realistic picture of savings potential during the 2016 to 2018 time frame under current technology, program and market conditions, this was an intentional choice made by the project team. Therefore, the study takes a more conservative stance when modeling energy efficiency potential.

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[2] The 25 percent plus and 75 percent plus scenarios reflect a percentage increase of the incentives already paid to the customer, capping at 100 percent of incremental measure cost to be paid in customer incentives. Increasingly, customer incentives in National Grid's service territory are paid in cents per kWh.

[3] Naturally occurring are free riders or non-participants that would have installed the measure without program assistance. The calculation for naturally occurring parallels that for program savings. Both look at adoption as a function of the measure benefit cost (B/C) ratio from the customer perspective, but the B/C ratio used to calculate naturally occurring excludes the incentive, while the B/C ratio used to calculate adoption under the program includes it. The difference in savings between the two adoption scenarios represents the estimated net program savings.

Table 1-1: Model Assumptions & Limitations

Assumption/ Limitation	Notes	Effect on Model Results
Conservative Approach to New Technologies	The new technologies that are included in the study are commercially available and most have been included in National Grid's programs, although in relatively small numbers to date and often as Custom measures. This approach is a result of a decision made by the DNV GL and National Grid teams to take a conservative approach when modeling emerging technologies so as to best represent those technologies that will be market-ready during the 2016 to 2018 time frame.	Reduces Savings Estimates
No CHP or Streetlighting Measures	Both CHP and streetlighting measures are not accounted for in the model. National Grid is aware of this limitation and has adjusted estimates of three year savings goals accordingly.	Reduces Savings Estimates
Limited Range of Policy Interventions	The model design allows for a limited range of policy interventions – specifically increased marketing and/or incentive levels.	Limits the ability to model increased (or decreased) program support and new program designs
Assumes static measure efficiency over time	The modeling effort does not address incremental improvements in energy efficiency due to the ongoing evolution and gradual improvement of existing technologies. These improvements will lead to increased energy efficiency potential over time.	Reduces Savings Estimates
Does not address ongoing tightening of equipment and building standards	The modeling effort does not address the ongoing tightening of equipment and building standards (beyond those known to be effective within the study period), which will lead to a decrease in energy efficiency potential over time. The improvements in energy-efficient technologies provide opportunities for additional program savings over a static base-case technology. However, as the market matures, codes and standards are tightened to raise base-case efficiency, and the result is subsequent reduction in program savings opportunities to levels that were available prior to the improvements in technology efficiency.	The effects of gradual technology improvement and ongoing tightening of codes and standards offset each other over the long term.

1.3 Results

1.3.1 Overall Cumulative Energy Efficiency Savings – Electric Energy and Demand Savings

Table 1-2 shows the results of the achievable analysis as compared to base consumption[4], technical potential, and economic potential for the 2016 to 2018 time frame. For this time period, technical potential is estimated at 4,710 GWh per year by 2018. Economic potential is estimated at 4,533 GWh by 2018. BAU achievable potential is 686 GWh, or approximately 15 percent of economic potential. For the 75 Percent Plus scenario, this potential increases to 867 GWh and 19 percent of economic potential. Economic potential for energy savings is estimated to be 36% percent of base 2018 energy use, while achievable potentials range from six percent of base usage in the BAU case to seven percent of base energy use in the 75 Percent Plus case (averaging between 2 and 2.3 percent each year). Keep in mind that these results exclude 2015 program savings and naturally occurring savings.

Table 1-2: Three Year Cumulative Annual Electric Potential (2016-2018) – GWh

Sector	2018 Base Energy Use	Three Year Cumulative Annual Potential - GWh					
		Technical Potential	Economic Potential	BAU Scenario (Net)	25% Plus Scenario (Net)	75% Plus Scenario (Net)	Naturally Occurring
Commercial	9,318	3,881	3,792	546	599	663	25
Savings % of Base		**42%**	**41%**	**6%**	**6%**	**7%**	**0.3%**
Industrial	3,203	828	741	140	162	204	8
Savings % of Base		**26%**	**23%**	**4%**	**5%**	**6%**	**0.3%**
Total	12,521	4,710	4,533	686	761	867	34
Savings % of Base		**38%**	**36%**	**6%**	**6%**	**7%**	**0.3%**
Cumulative Program Costs-Real, $ Million		NA	NA	$216	$270	$356	NA

There are several reasons for the observed drop off between technical and economic potential and achievable potential including slow turnover rates for replace-on-burnout measures, retrofit "procrastination" (where customers wait before implementing a new measure), market barriers (not related to measure costs), hard-to-reach (or change-resistant) customers, the effects of codes and standards, and the fact that economic potential captures savings regardless of timing while achievable savings take into account measure turnover and other factors that affect the timing of measure installation over the modeled time frames.

[4] The model provides independent estimates of base consumption, however for these tables DNV GL presents National Grid's own forecast data so as to create a more direct comparison to the savings estimates presented in the draft 2016-2018 three year energy efficiency program plan.

Table 1-3 shows the same results for the 2016 to 2025 time frame. A similar drop-off between economic potential and achievable potential estimates is observed under this time frame as well. It should be noted, that this is not outside of the range normally observed by DNV GL and in fact is in line with recent potential efforts in states with similar longevity and program support as Massachusetts.[5]

Table 1-3: Ten Year Cumulative Annual Electric Potential (2016-2025) – GWh

Sector	2025 Base Energy Use	Ten Year Cumulative Annual Potential – GWh					
		Technical Potential	Economic Potential	BAU Scenario (Net)	25% Plus Scenario (Net)	75% Plus Scenario (Net)	Naturally Occurring
Commercial	9,554	4,764	4,567	1,275	1,378	1,512	69
Savings % of Base		**50%**	**48%**	**13%**	**14%**	**16%**	**1%**
Industrial	2,910	868	789	322	350	429	28
Savings % of Base		**30%**	**27%**	**11%**	**12%**	**15%**	**1%**
Total	12,465	5,633	5,357	1,597	1,728	1,941	97
Savings % of Base		**45%**	**43%**	**13%**	**14%**	**16%**	**1%**
Cumulative Program Costs- Real, $ Million		NA	NA	$573	$689	$895	NA

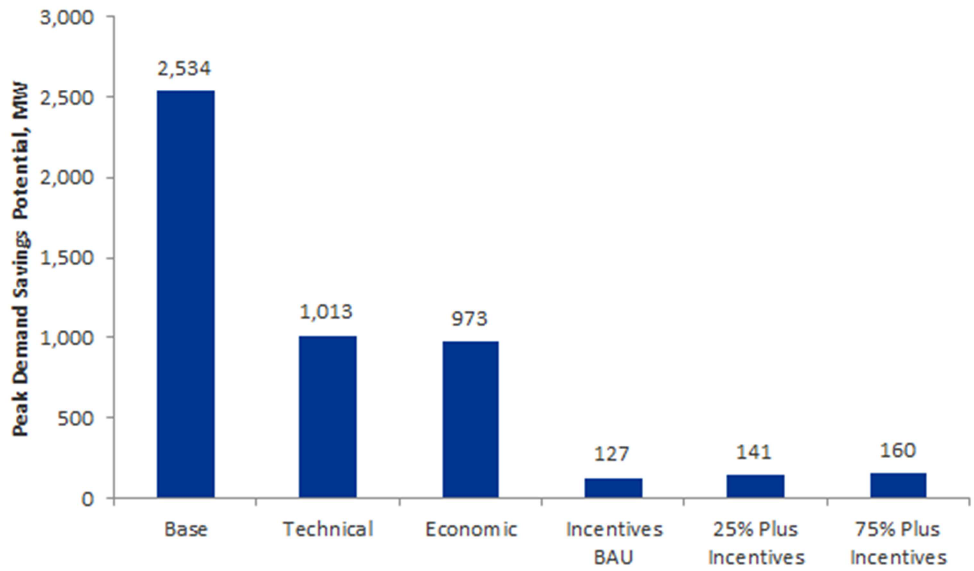
Cumulative peak demand savings potential estimates for both the 3-year and 10-year periods are provided in the figures below.[6]

Technical potential is estimated at 1,013 MW for the 3-year period while economic potential is estimated at 973 MW. Cumulative achievable program potential ranges between 127 MW in the BAU case up to 160 MW in the 75 Percent Plus incentive case. Economic potential for peak demand savings is estimated to be 38 percent of base peak demand and achievable potentials range from five percent of base peak demand in the BAU case up to six percent of base peak demand in the 75 Percent Plus incentive case (averaging between 1.7 and 2 percent each year).

[5] The current California potential study being conducted by Navigant shows a precipitous drop in potential in the commercial sector in 2018 and a gradual decline in industrial potential. Navigant, 2015 California Potential and Goals Study, Draft Results Presentation to DAWG, March 17, 2015. http://www.cpuc.ca.gov/NR/rdonlyres/1D3525C7-7145-4AD5-80A8-55515B066223/0/2015PGStudyMarch17DAWGPublicWorkshop.pdf. Slides 7 and 9.

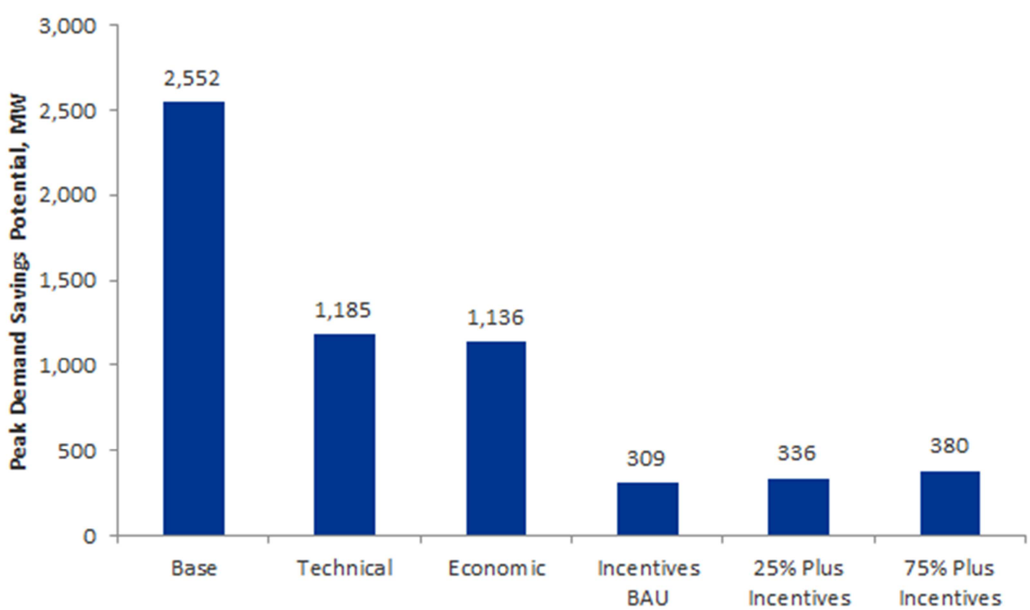
[6] The estimates of peak demand savings are from the installation of energy efficiency measures and do not include demand savings from demand response technologies such as direct load control or dynamic pricing.

Figure 1-1: Estimated Peak Demand Savings Potential, 2016-2018



Technical potential is estimated at 1,185 MW summer coincident peak savings for the 10-year period. Economic potential is estimated at 1,136 MW for the 10-year period. For the 10-year period, cumulative achievable program potential ranges between 380 MW in the 75 Percent Plus incentive case down to 309 MW in the BAU case. Economic potential for peak demand savings is estimated to be 37 percent of base 2025 peak demand; achievable potentials range from 10 percent of base peak demand in the BAU case to 12 percent of base peak demand in the 75 Percent Plus incentive case.

Figure 1-3: Estimated Peak Demand Savings Potential, 2016-2025



1.3.2 Overall Cumulative Energy Efficiency Savings - Natural Gas Savings

Table 1-4 shows the results of the achievable analysis as compared to base consumption, technical potential, and economic potential for the 2016 to 2018 time frame. BAU achievable potential is 12,063 thousand therms, or approximately seven percent of economic potential. For the 75 Percent Plus scenario, this potential increases to 17,606 thousand therms and 10 percent of economic potential. Economic potential for energy savings is estimated to be 30 percent of base 2018 energy use while achievable potentials range from two percent of base usage in the BAU case to three percent of base energy use in the 75 Percent Plus case (averaging between 0.7 and 1 percent each year).

Table 1-4. Three Year Cumulative Annual Gas Potential (2016-2018)

Sector	2018 Base Energy Use	Three Year Cumulative Annual Potential – thousand therms					
		Technical Potential	Economic Potential	BAU Scenario (Net)	25% Plus Scenario (Net)	75% Plus Scenario (Net)	Naturally Occurring
Commercial	512,915	184,472	158,672	10,363	13,038	15,221	949
Savings % of Base		**36%**	**31%**	**2%**	**3%**	**3%**	**0.2%**
Industrial	68,184	20,287	18,021	1,700	2,087	2,384	75
Savings % of Base		**30%**	**26%**	**3%**	**3%**	**4%**	**0.1%**
Total	581,099	204,759	176,693	12,063	15,125	17,606	1,024
Savings % of Base		**35%**	**30%**	**2%**	**3%**	**3%**	**0.2%**
Cumulative Program Costs-Real, $ Million		NA	NA	$45	$52	$65	NA

Table 1-5 shows the same results for the 2016 to 2025 time frame. A similar drop-off between economic potential and achievable potential estimates is observed under this time frame as well. It should be noted, that this is not outside of the range normally observed by DNV GL and in fact is in line with recent potential efforts in states with similar longevity and program support as Massachusetts.

Table 1-5. Ten Year Cumulative Annual Gas Potential (2016-2025)

Sector	2025 Base Energy Use	Ten Year Cumulative Annual Potential – thousand Therms					
		Technical Potential	Economic Potential	BAU Scenario (Net)	25% Plus Scenario (Net)	75% Plus Scenario (Net)	Naturally Occurring
Commercial	551,417	225,886	188,610	26,536	31,950	36,633	3,193
Savings % of Base		**41%**	**34%**	**5%**	**6%**	**7%**	**0.6%**
Industrial	85,585	23,712	21,338	4,782	5,917	6,617	251
Savings % of Base		**28%**	**25%**	**6%**	**7%**	**8%**	**0.3%**
Total	637,003	249,598	209,948	31,318	37,867	43,250	3,445
Savings % of Base		**39%**	**33%**	**5%**	**6%**	**7%**	**0.5%**
Cumulative Program Costs- Real, $ Million		NA	NA	$137	$156	$191	NA

1.4 Interpreting the Results

While the DNV GL team recognizes that the results of this modeling effort are lower than anticipated, based on DNV GL's experience, the numbers are reasonable given the landscape of the Massachusetts energy efficiency programs and the assumptions made in the model. As noted above, DNV GL and National Grid made assumptions regarding the availability of new technologies and program designs that were in line with National Grid's expectations for the 2016 to 2018 time frame which limited the potential for savings from innovative program design or the introduction of new technologies that are further from being market-ready. This decision was made intentionally so that the study would best represent the technology, program and market conditions during the 2016–2018 program period.

In addition to the model assumptions, there are two key factors that are leading to lower estimates of potential savings:

1. The maturity of National Grid's energy efficiency programs causes awareness among the participant population to be already quite high. Put more simply, much of the "low hanging fruit" is gone in National Grid's territory, while simultaneously there is not an anticipated disruptive change (either in new technology or program design) during the 2016 to 2018 time frame.
2. The saturation of retrofit upgrades during earlier years of the model result in a noted decline over time in the annual energy savings. Put another way, as retrofits are completed, there are fewer opportunities going forward.

Additional detail on the DNV GL team's assessment of the results of the model is presented in Section 5.4 of this report.

2. INTRODUCTION

National Grid retained DNV GL to conduct a demand side management (DSM) market potential study which was based on existing and proposed commercial and industrial customer end-use energy efficiency measures and programs. The study provides estimates of potential energy and peak demand savings from energy efficiency measures in National Grid's Massachusetts service territory, including technical, economic, and achievable program potential. This study covers two time periods, years 2016 to 2025 and years 2016 to 2018. The 2016 to 2018 time period covers the forthcoming 3-year planning cycle for Massachusetts and is of particular interest. Analyses of electric and natural gas measures in both the commercial and industrial sectors were performed to arrive at potential estimates.

2.1 Overview

National Grid's primary objective in conducting this potential study is to obtain realistic estimates of achievable commercial and industrial electric and gas energy efficiency potential for years 2016 to 2018 for use during the forthcoming 3-year planning cycle. Secondary objectives include the creation of a dynamic, transparent, user-friendly, Excel-based model that allows National Grid staff to update certain predetermined fields as new information and/or program parameters arise as well as the use of National Grid specific data wherever possible to populate the model.

In support of these goals, DNV GL developed a modified version of its DSM Assyst model built to National Grid's specifications. The model was used to estimate electric energy and demand savings and natural gas savings potentials for National Grid's commercial and industrial (C&I) customers for both a 10-year period beginning with 2016 and for the next 3-year planning period of 2016 to 2018. The model was populated with data collected from National Grid customers through the Massachusetts Existing Building Market Characterization – C&I Customer On-site Assessments (EM&V Project 41) being conducted under the statewide C&I evaluation contract. Additional model inputs came from pervious Massachusetts statewide and National Grid specific evaluation efforts, the Massachusetts Technical Reference Manual, National Grid's internal documents and data, and other secondary sources.

2.2 Study Approach

The energy efficiency potential portion of the study involved identifying and developing baseline end-use and measure data and developing estimates of future energy efficiency impacts under varying levels of program effort.

DNV GL performed a baseline characterization that identified the types and approximate sizes of the various market segments that are the most likely sources of DSM potential in National Grid's service territory. These characteristics then served as inputs to a modeling process that incorporated National Grid's energy-cost parameters and specific energy efficiency measure characteristics (such as costs, savings, and existing penetration estimates) to provide more detailed potential estimates.

This study provides thorough and transparent documentation of model inputs and calculations used for estimating technical, economic, and achievable potential. The research team estimated technical, economic, and achievable program potential for the commercial and industrial sectors, with a focus on energy efficiency impacts through 2018 and 2025.

It should be noted that the primary focus of the modeling effort is to provide National Grid with a realistic picture of the achievable program savings during the 2016 to 2018 time frame. As a result the team made specific assumptions regarding the program, technology and market conditions that would best represent the 2016 to 2018 period, including the exclusion of new technologies that are not likely to be cost-effective and market ready during the 2016 to 2018 time frame; the exclusion of estimates of CHP or streetlighting measures; and a similar program design as seen during the 2013-2015 program cycle.

2.3 Organization of the Report

The remainder of this report is organized as follows:

- Section 3 provides a brief overview of the data collection activities conducted for this study. Full results for EM&V Project 41 data is provided in a separate report that presents the detailed results of on-sites that were conducted to develop inputs used in the market potential models.
- Section 4 discusses the methodology and concepts used to develop the technical, economic, and achievable potential estimates.
- Section 5 provides results of the analysis and a discussion and interpretation of the model results.

3. DATA COLLECTION AND DEVELOPMENT

This section describes the efforts used by DNV GL to develop data inputs for this potential study. The main sources of these data were the Massachusetts Commercial and Industrial Customer On-site Assessment, and information provided by National Grid including: National Grid 2013 non-residential customer billing data, CoreLogic property information, data provided by the National Grid staff, and other secondary data sources.

3.1 Developing the Measure List

The team developed the measure list for the study to include efficiency measures currently commercially available, including measures currently offered through National Grid's current programs as well as measures offered through other utility programs. The measure list was intentionally designed to be conservative, focusing on technologies with well-documented costs and savings that were known to be available in the region. This approach mitigated the uncertainty associated with unproven technologies, but may underestimate potential to the extent that some of those technologies may eventually become mainstream, especially in the later years of ten-year time frame. The research team believes that impact is negligible in the 2016 to 2018 period, as the new technologies are unlikely to gain sufficient foothold in the market to have a significant impact in just three years.

The research team did evaluate a number of emerging technologies for inclusion in the model. These were:

- Advanced Rooftop Controls
- Advanced Lighting Controls
- Comprehensive lighting design
- Ventilation Controls for High Outside Air Use Facilities
- Data Center Optimization
- Cold Weather Heat Pumps
- Rooftop Unit Automated Fault Detection
- Kitchen Exhaust Demand Control Ventilation
- Phase Change Materials

Of these, advanced rooftop controls, advanced lighting controls, and rooftop automated fault detection were explicitly included in the model. The research team believed that the savings from kitchen exhaust demand control ventilation and ventilation controls for high outside air facilities were captured under a more broadly defined demand control ventilation measure. Small data center optimization was initially included, but dropped, along with large data center optimization, at National Grid's direction, because they felt that data center measures were more appropriately captured under the model's custom measures. Cold-weather heat pumps do not have enough of a track record in the marketplace to develop a good estimate of savings or feasibility, and the initial screening of the technology indicated relatively low savings potential. Similarly, phase-change materials have little track record on which to base savings or estimate costs, and the initial review suggested that savings potential was low.

Included in the measure list are a number of custom measures for each sector:

- Commercial electric: Custom lighting, custom cooling, custom building shell, custom ventilation, custom refrigeration, and custom operations and maintenance
- Industrial electric: Custom compressed air, custom drives, custom water/wastewater, custom process heating, custom process cooling, custom other process
- Commercial gas: Custom boiler, custom furnace, custom other heat, custom water heating
- Industrial gas: Custom boiler, custom furnace, custom process heating, custom HVAC

These were intended to represent highly customer-specific measures and uncommon measures not explicitly included in the model. DNV GL believes that these measures are sufficient to represent the early phases of commercialization for technologies that were not explicitly included in the model.

3.2 National Grid-Specific Data Collection Efforts

The Massachusetts Program Administrators engaged DNV GL to collect end-use saturation data from non-residential customers, through the Massachusetts C&I Customer On-site Assessment (EM&V Project 41), to be used to inform the Massachusetts PAs energy efficiency programs. Data collected via this study include building characteristics, occupant characteristics, and the penetration and usage of various measures and end uses throughout the PAs' service territories. Those primary data collected from EM&V Project 41 that were specific to National Grid were combined with other secondary data sources to fully populate the data inputs required for the potential study modeling efforts. Table 3-1 presents the percent of each model input type that comes from the data collected via EM&V Project 41. The number of incomplete factors from this project is low, at 29 percent. This is due to the fact that the incomplete factors are measure specific and therefore the number of questions that would have been required for the on-site survey to address all these data points would have made the surveys unacceptably time consuming and costly.

Table 3-1: Percent of Model Inputs by Type from Project 41

Model Input Type	% of Inputs from P41
Applicability Factor (% of floor space for which the measure is applicable)	88%
Technical Saturations (units* per square foot)	62%**
Incomplete Factor (% of applicable floor space without the efficiency measure already installed)	29%

*"Units," in the context of the tech saturation, are the units in which costs are specified. If costs are in tons, tech saturations are tons per square foot; if costs are per horsepower, tech saturations are HP per square foot.

**An additional 24% of the technology saturations were "by definition." For example, if costs were expressed per square foot of building area, the tech saturation is always one (one building square foot per building square foot). Other costs were expressed per kWh saved, which the research team calculated internally from other model inputs (percent savings and base energy use per square foot). Only 14 percent of technology saturations were from other sources.

The first and second waves of primary data collection resulted in enough National Grid specific data to inform the commercial electric, commercial gas, and industrial electric potential models. There were not enough National Grid specific data to inform the industrial gas potential model. This was a result of the primary data collection being based on a sample of electric accounts, with no specific targeting of gas accounts. After discussion with National Grid, the analysis team decided to include industrial gas data collected in other PA territories as part of the study. Table 3-2 provides a breakdown of the completed sites used in the analysis by commercial building type for customers to whom National Grid is an electric or gas provider. Table 3-3 provides a breakdown of completed Manufacturing/Industrial sites used in the analysis by fuel type and National Grid/non-National Grid, where applicable.

Table 3-2: Breakdown of Utilized EM&V Project 41 Commercial Site Visits

Building Type	Commercial Electric	Commercial Gas
Campuses	9	6
Education	27	17
Food Sales	16	10
Food Service	26	25
Healthcare	14	14
Hospitals	7	4
Lodging	20	12
Office	39	29
Other	16	11
Public Assembly	18	20
Retail	30	17
Warehouse	9	3
Total	*231*	*168*

Table 3-3: Breakdown of Utilized EM&V Project 41 Industrial Site Visits

Program Administrator	Industrial Electric	Industrial Gas
National Grid	26	13
Non-National Grid	N/A	26
Total	*26*	*39*

3.3 Additional Data Sources

In addition to EM&V Project 41, DNV GL used additional data sources to inform certain inputs of the potential study model that could not be ascertained through the aforementioned data collection efforts. This section outlines those sources, and how they were used in the modeling process.

3.3.1 Measure Data

Several secondary data sources provided insight on measure-level energy usage and savings potential, measure costs and lifetimes, and the current penetration of various efficiency measures. DNV GL reviewed a variety of data sources for this information with the aim to find data that was specific to

National Grid's service territory or geographic location as much as possible. The sources listed below provided information for these inputs:

- EIA Commercial Buildings Energy Consumption Survey (CBECS)
- National Grid 2013 and 2014 Program Tracking Data
- Massachusetts Technical Reference Manuals (TRMs) including the 2013-2015 Plan TRM, and 2013 and 2014 Report TRMs.
- Professional judgment of DNV GL analysts and engineers with experience in National Grid's service territory
- National Grid and Massachsetts PA EM&V Results
- Gas Networks studies
- TRMs from other states

3.3.2 Economic Data

Economic inputs from National Grid's service territory were used to provide a more accurate picture of the monetary cost and benefits associated with energy efficiency. National Grid provided data to support the following model requirements:

- Inflation Rate
- Utility Discount Rate
- Avoided Energy and Demand Cost Forecasts from the 2015 Avoided Energy Supply Component Study (2015 AESC).
- Retail Electric and Gas Rate Forecasts

3.3.3 Building Data

National Grid's Customer Analytics group provided a wealth of detailed customer information. They matched customer data to tax record information and data from other sources to identify building types with greater accuracy than that provided by the NAICS codes in the customer billing database. In particular, the tax record data provided building square footage, which allowed the analysis team to develop estimates of energy intensity by building type. As energy use per square foot is a key input to the model, having the information at this level of resolution and accuracy enhanced the overall accuracy of the potential estimates.

The total energy use from the customer analytics data accounted for only about 2/3 of National Grid's total energy sales for both gas and electric, for reasons the analysis team was unable to resolve with customer analytics staff. The team extrapolated the breakdown of energy use across building types from the customer analytics sample to the entire population, and estimated square footage for the missing customers by assuming that the energy intensity was the same (by building type) for the missing customers as for the customer analytics sample. The resulting forecast aligned with National Grid's load forecast.

3.3.4 Program Budgets

As part of the potential modeling process, past and projected program budgets were used to as a starting point for the achievable potential analysis which estimates the market penetration of measures as a function of marketing, incentive levels and other factors.[7] To help calibrate the achievable modeling efforts, past National Grid program budgets were used to gauge the range of program costs in the National Grid's service territory. Specifically, marketing and administrative dollars were two inputs into the model that were derived from National Grid's 2014 Plan Year Report Benefit Cost Model provided to DNV GL. Table 3-4 outlines the data that DNV GL reviewed for this effort.

Table 3-4: National Grid 2014 Plan Year Report Budget Summary Definitions

National Grid Screening Model Budget Summary	DNV GL Funding Designation
A001 - Program Planning & Administration	Admin
A002 - Marketing	Marketing
A003 - Customer Incentive	Incentive dollars
A004 - Sales, Tech Assist & Training	Marketing
A005 - Evaluation & Market Research	Admin

[7] The methodology of calculation measure penetration is described in more detail in Section 4 and Appendix A

4. ENERGY EFFICIENCY METHODS

This section provides a brief overview of the concepts, methods, and scenarios used to conduct this study.

4.1 Characterizing the Energy Efficiency Resource

Energy efficiency has been characterized for some time now as an alternative to energy supply options, such as conventional power plants that produce electricity from fossil or nuclear fuels. In the early 1980s, researchers developed and popularized the use of a conservation supply-curve paradigm to characterize the potential costs and benefits of energy conservation and efficiency. Under this framework, technologies or practices that reduced energy use through efficiency were characterized as making the energy saved available to meet other demands, and could therefore be thought of as a resource and plotted on an energy supply curve. The energy efficiency resource paradigm argued simply that the more energy efficiency or "nega-watts"[8] produced, the fewer new plants would be needed to meet end-users' power demands.

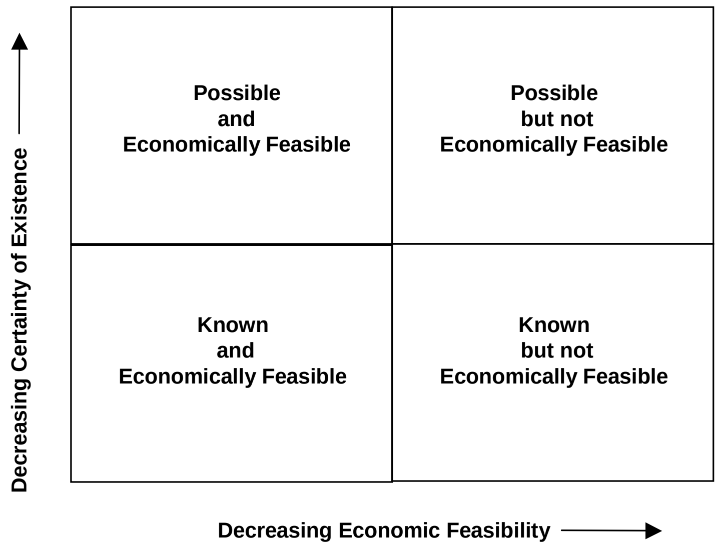
4.2 Defining Energy Efficiency Potential

Energy efficiency potential studies became popular throughout the utility industry from the late 1980s through the mid-1990s. This period coincided with the advent of what was called least-cost or integrated resource planning (IRP). Energy efficiency potential studies became one of the primary means of characterizing the resource availability and value of energy efficiency within the overall resource planning process.

Like any resource, there are a number of ways in which the energy efficiency resource can be estimated and characterized. Definitions of energy efficiency potential are similar to definitions of potential developed for finite fossil fuel resources, like coal, oil, and natural gas. For example, fossil fuel resources are typically characterized along two primary dimensions: the degree of geological certainty with which resources may be found, and the likelihood that extraction of the resource will be economic. This relationship is shown conceptually in Table 4-1.

[8] Term coined by environmental scientist Amory Lovins in 1989.

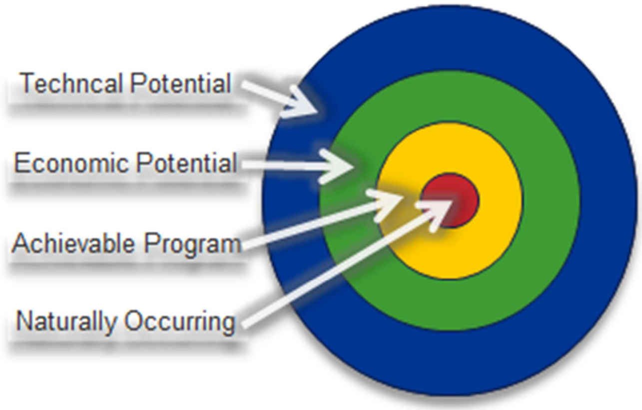
Table 4-1: Conceptual Framework for Estimates of Fossil Fuel Resources



Somewhat analogously, this energy efficiency potential study defines several different *types* of energy efficiency *potential*, namely technical, economic, achievable program, and naturally occurring. These potentials are shown conceptually in Figure 4-1 and described below.

- **Technical potential** is defined in this study as the *complete* penetration of all measures analyzed in applications where they were deemed *technically* feasible from an *engineering* perspective.
- **Economic potential** refers to the *technical potential* of those energy conservation measures that are cost effective when compared to supply-side alternatives.
- **Achievable program potential** refers to the amount of savings that would occur in response to specific program funding and measure incentive levels. Savings associated with program *achievable potential* are savings that are projected beyond those that would occur naturally in the absence of any market intervention.
- **Naturally occurring potential** refers to the amount of savings estimated to occur as a result of normal market forces; that is, in the absence of any utility or governmental intervention.

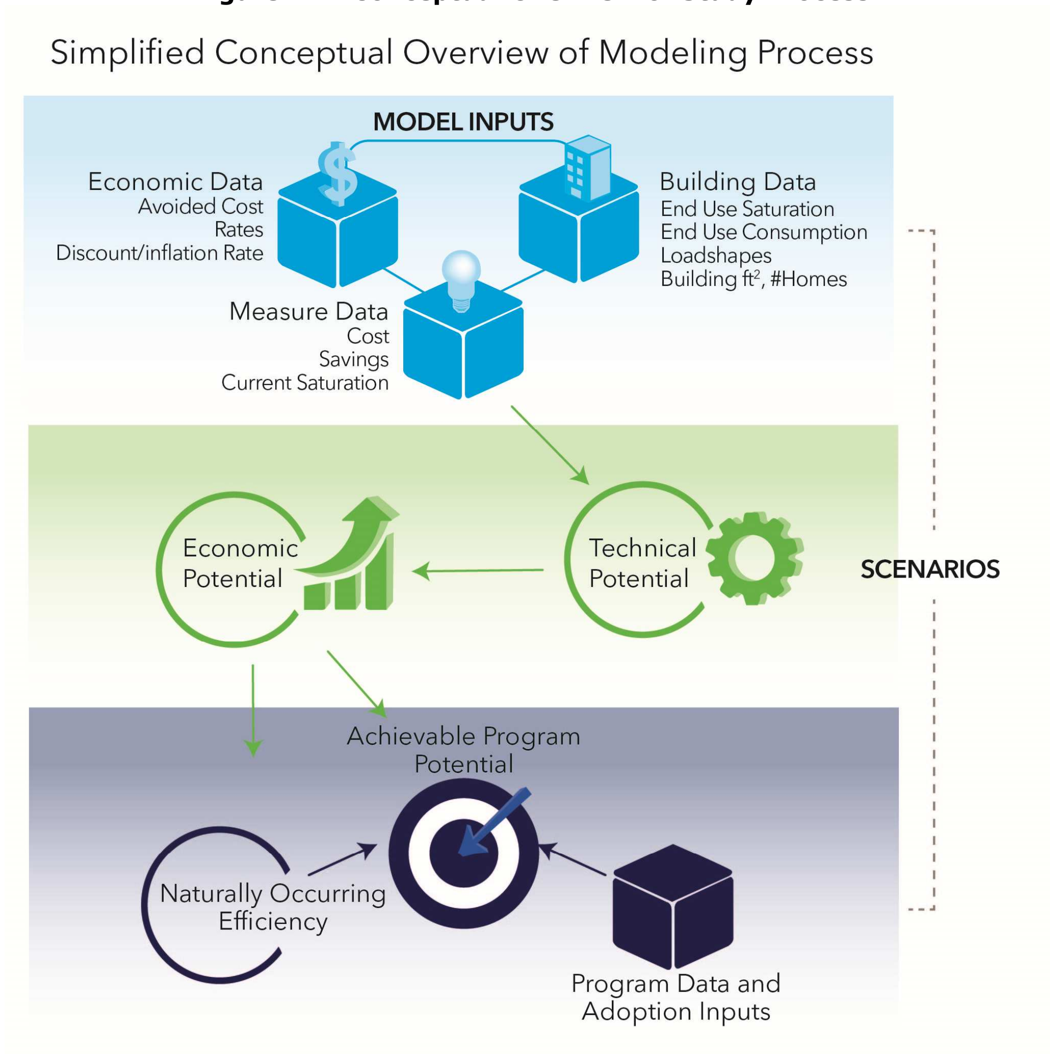
Figure 4-1: Conceptual Relationship among Energy Efficiency Potential Definitions



4.3 Summary of Analytical Steps Used for the Energy Efficiency Potential

The crux of this study involves carrying out a number of basic analytical steps to produce estimates of the energy efficiency potentials introduced above. The basic analytical steps for this study are shown in relation to one another in Figure 4-2. The bulk of the analytical process for this study was carried out in a model developed by DNV GL for conducting energy efficiency potential studies. Details on the steps employed and analyses conducted are described in Appendix A. The study integrates technology-specific engineering and customer behavior data with utility market saturation data, load shapes, rate projections, and marginal costs into an easily updated data management system.

Figure 4-2: Conceptual Overview of Study Process



The key steps implemented in this study are:

Step 1: Develop Initial Input Data

- Develop a list of energy efficiency measure opportunities to include in scope. In this step, an initial draft measure list was developed and provided to National Grid. The final measure list was developed after incorporating comments.
- Gather and develop technical data (costs and savings) on efficient measure opportunities. Data on measures were gathered from a variety of sources. Measure inputs are provided in Appendix E.
- Gather, analyze, and develop information on building characteristics, including total square footage, energy consumption and intensity by end use, end-use consumption load patterns by time of day and year (i.e., load shapes), market shares of key electric consuming equipment, and market shares of energy efficiency technologies and practices. Section 5 of this report describes the baseline data developed for this study.
- Collect data on economic parameters: avoided costs, electricity rates, discount rates, and inflation rate. These inputs are provided in Appendix C of this report.

Step 2: Estimate Technical Potential and Develop Supply Curves

- Match and integrate data on efficient measures to data on existing building characteristics to produce estimates of technical potential and energy efficiency supply curves.

Step 3: Estimate Economic Potential

- Match and integrate measure and building data with economic assumptions to produce indicators of costs from different viewpoints (e.g., societal and consumer).
- Account for interaction and competition between measures. Measures are assumed to be implemented in order of cost-effectiveness, with the most cost-effective measures implemented first. If subsequent measures are mutually exclusive with previous measures (for example, CFL and LED lamps competing for the same socket), the subsequent measure is evaluated on its marginal costs and marginal savings compared to the more cost-effective measure.
- Estimate total economic potential. Note that at this stage of the analysis, program-related costs are not factored into the cost-effectiveness screening. Thus, the results reflect the theoretical estimate of the measure impacts, while disregarding the mode of delivery. In addition, this step does not take into account natural measure turnover and instead assumes that all available measure installations occur immediately in year one.

Step 4: Estimate Achievable Program and Naturally Occurring Potentials

- Screen initial measures for inclusion in the program analysis. This screening may take into account factors such as natural measure turnover, cost effectiveness, potential market size, non-energy benefits, market barriers, and potentially adverse effects associated with a measure. For this study, measures were screened using the total-resource-cost test, with the exclusion of program marketing and administrative costs.
- Gather and develop estimates of program costs (e.g., for administration and marketing) and historic program savings.
- Develop estimates of customer adoption of energy efficiency measures as a function of the economic attractiveness of the measures, barriers to their adoption, and the effects of program intervention.
- Estimate achievable program and naturally occurring potentials and associated program costs.

Step 5: Scenario Analyses

- Recalculate potentials under alternate program scenarios. These scenarios relate to different levels of incentives offered to participants for energy efficiency measures. See Appendix A for further discussion on how program scenarios were run.

4.4 Estimating Achievable Potential

At the core of the achievable analysis is an adoption model that applies equally to the program and naturally occurring analyses. Whether as a result of natural market forces or aided by a program intervention, the rate at which measures are adopted are modeled is a function of the following factors:

- The availability of the adoption opportunity as a function of capital equipment turnover rates and changes in building stock over time
- Customer awareness of the efficiency measure
- The cost-effectiveness of the efficiency measure
- Market barriers associated with the efficiency measure.

The paragraphs below provide an overview of the adoption approach. The modeling approach is discussed in greater detail in Appendix A.

4.4.1 Availability

A crucial part of the model is a stock accounting algorithm that handles capital turnover and stock decay over a period of up to 20 years. In the first step of the achievable potential method, the model calculates the number of customers for whom each measure will apply. The input to this calculation is the total floor space available for the measure from the technical potential analysis, i.e., the total floor space multiplied by the applicability, not complete, and feasibility factors described previously. This is referred to as the eligible stock. The stock algorithm keeps track of the amount of floor space available for each efficiency measure in each year based on the total eligible stock and whether the application is new construction, retrofit, or replace-on-burnout.[9]

Retrofit measures are available for implementation by the entire eligible stock. The eligible stock is reduced over time as a function of adoptions[10] and building decay.[11] Replace-on-burnout measures are available only on an annual basis, approximated as equal to the inverse of the service life.[12] The annual portion of the eligible market that does not accept the replace-on-burnout measure does not have an opportunity again until the end of the service life.

New construction applications are available for implementation in the first year. Those customers that do not accept the measure are given subsequent opportunities corresponding to whether the measure is a replacement or retrofit-type measure.

[9] Replace-on-burnout measures are defined as the efficiency opportunities that are available only when the base equipment turns over at the end of its service life. For example, a high-efficiency chiller measure is usually only considered at the end of the life of an existing chiller. By contrast, retrofit measures are defined to be constantly available, for example, application of a window film to existing glazing.

[10] That is, each square foot that adopts the retrofit measure is removed from the eligible stock for retrofit in the subsequent year, and remains out of the eligible stock until the end of the measure's useful life.

[11] Buildings do not last forever. An input to the model is the rate of decay of the existing floor space. Floor space typically decays at a very slow rate.

[12] For example, a base-case technology with a service life of 15 years is only available for replacement to a high-efficiency alternative each year at the rate of 1/15 times the total eligible stock. For example, the fraction of the market that does not adopt the high-efficiency measure in year *t* will not be available to adopt the efficient alternative again until year *t* + 15.

4.4.2 Awareness

In the modeling framework, customers cannot adopt an efficient measure merely because there is stock available for conversion. Before they can make the adoption choice, they must be aware and informed about the efficiency measure. Thus, in the second stage of the process, the study calculates the portion of the available market that is informed. An initial user-specified parameter sets the initial level of awareness for all measures. Incremental awareness occurs in the model as a function of the amount of money spent on awareness/information building and how costly it is to reach each customer.

The study also controls for information retention. An information decay parameter in the model is used to control for the percentage of customers that will retain program information from one year to the next. Information retention is based on the characteristics of the target audience and the temporal effectiveness of the marketing techniques employed.

4.4.3 Adoption

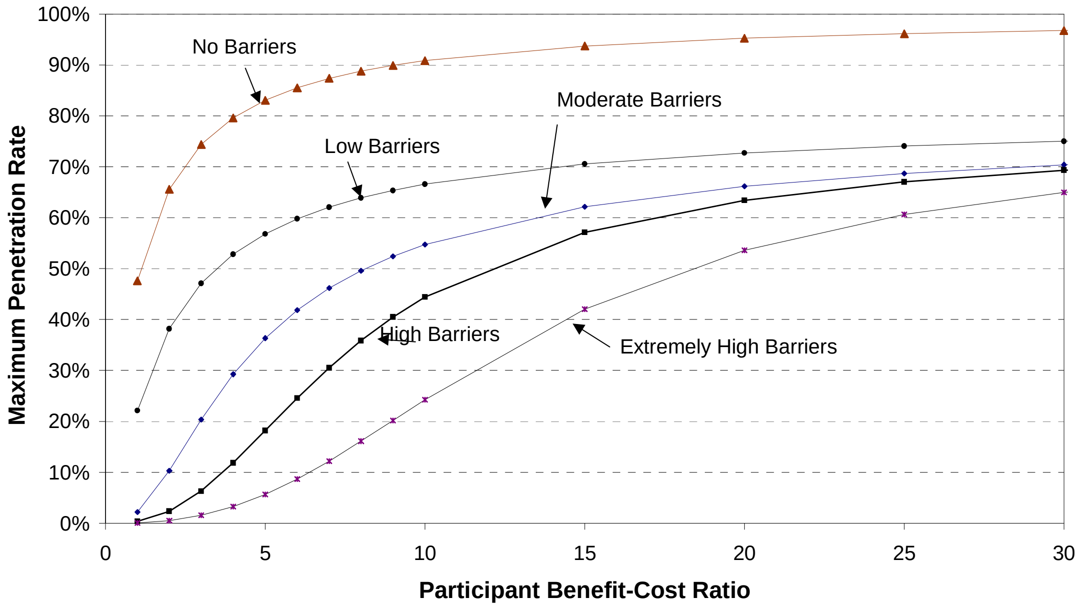
The portion of the total market that is available and informed can now face the choice of whether or not to adopt a particular measure. Only those customers for whom a measure is available for implementation (stage 1) and, of those customers, only those who have been informed about the program/measure (stage 2), are in a position to make the implementation decision.

In the third stage of the penetration process, the study calculates the fraction of the market that adopts each efficiency measure as a function of the participant test, which a benefit-cost ratio that compares the present value of customer bill savings to the present value of participant costs.

The study uses measure implementation curves to estimate the percentage of the informed market that will accept each measure based on the participant's benefit-cost ratio. The study provides enough flexibility so that each measure in each market segment can have a separate implementation rate curve.

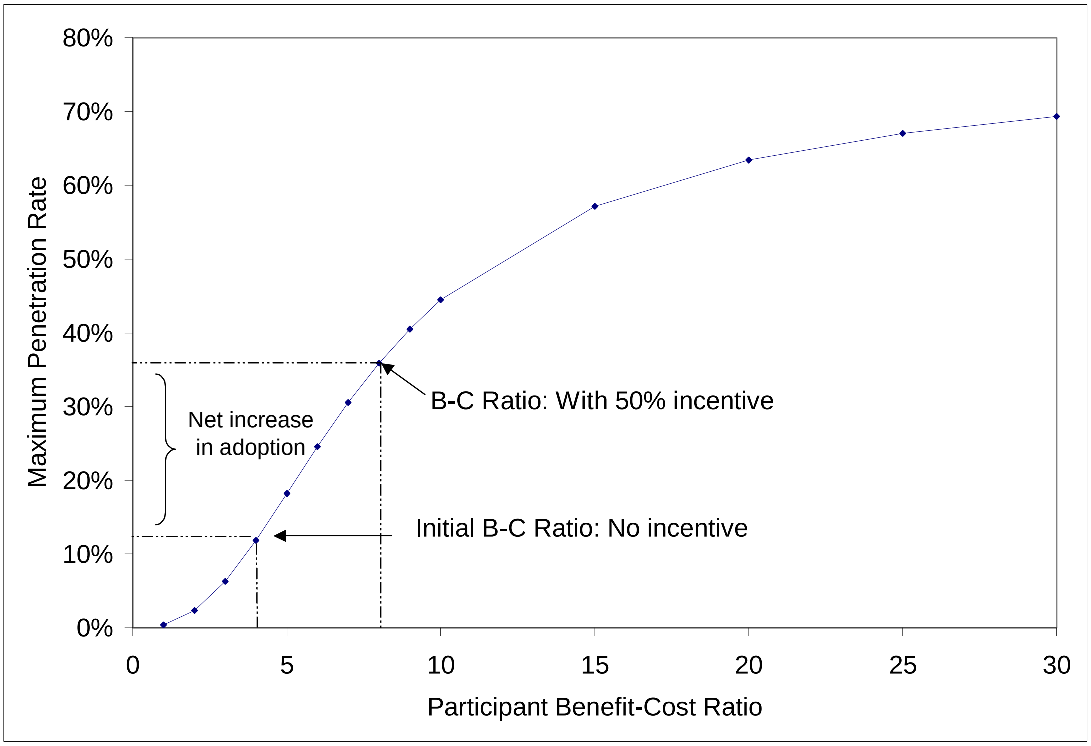
Figure 4-3 shows examples of the form of the adoption curve used in the model. The different curves represent different levels of market barriers. The research team calibrated the curves used in the model (by changing parameters representing market barriers) to produce base year program results that are calibrated to actual measure implementation results associated with National Grid's commercial efficiency programs over the past several years. Different curves are used to reflect different levels of market barriers for different efficiency measures.

Figure 4-3. Primary Measure Implementation Curves Used in Adoption Model



The study estimates adoption under both naturally occurring and program intervention situations. There are only two differences between the naturally occurring and program analyses. First, in any program intervention case in which measure incentives are provided, the participant benefit-cost ratios are adjusted based on the incentives. Thus, if an incentive that pays 20 cents per kWh saved is applied in the program analysis, the participant benefit-cost ratio will increase, since the incentive offsets part of the cost. The effect on the amount of adoption estimated will depend on where the pre- and post-incentive benefit-cost ratios fall on the curve. This effect is illustrated in Figure 4-4.

Figure 4-4. Illustration of Effect of Incentives on Adoption Level as Characterized in Implementation Curves



5. ENERGY EFFICIENCY RESULTS

5.1 Energy Efficiency Baseline Analysis

This section presents a baseline analysis of energy use in National Grid Massachusetts' service territory. The purpose of this analysis is to provide a breakout of energy use by sector, building type and end use to provide a foundation for estimating demand side management /energy efficiency potentials.

5.1.1 Commercial End-Use Saturations - Electricity

As stated above, most (91 percent) of the equipment saturations (percent of commercial square footage having a specific end use) were calculated from the results of EM&V Project 41, using National Grid data. The exceptions are parking garage lighting, where the team used saturations from a 2012 DNV GL study conducted in Minnesota, and miscellaneous equipment, which were assumed to have 100 percent saturation. Four other saturations (office ventilation, and three lighting types in "other" buildings) were increased from the P41 values based on expert judgment, as they produced overall energy distributions inconsistent with the expectations of National Grid program staff.

The saturations used in the analysis are shown in Table 5-1. In some cases, the saturations may seem mutually inconsistent, such as when the saturations across lighting types add up to more than 100%. Any particular building area may be illuminated by more than one type of lighting, for example an office area with both fluorescent troffers and desk lamps designed for screw-based lamps. The study also accounts for the number of lamps of each particular type per applicable square foot (called the technology saturation, which can be thought of as an equipment density). The combination of the saturations below with the equipment densities gives a complete picture of the mix of equipment.

Table 5-1: Commercial Electric End-Use Saturations by Base Measure

End-use Saturations	Cam-pus	Educa-tion	Food Sales	Food Service	Health care	Hosp-itals	Lodg-ing	Office	Other	Public Assem-bly	Retail	Ware-house
Base Fluorescent Fixture, 4L4 Foot T8, 1EB	25%	92%	86%	67%	81%	63%	71%	93%	24%	47%	95%	93%
Base Other Fluorescent Fixture	16%	36%	32%	12%	4%	45%	24%	35%	0%	14%	7%	4%
Base Incandescent Lamp, 72W to Screw-in Replacement	19%	48%	46%	88%	64%	57%	53%	48%	11%	70%	16%	30%
Base CFL Lamp, 23W	18%	36%	13%	37%	69%	47%	61%	64%	55%	38%	12%	3%
Base Metal Halide, 400W	7%	67%	32%	20%	4%	45%	7%	16%	7%	21%	5%	63%
Base HID Parking Garage Lighting	18%	0%	0%	0%	7%	7%	2%	50%	7%	7%	0%	0%
Base CFL Exit Sign	100%	96%	88%	98%	76%	97%	89%	93%	24%	55%	96%	89%
Base Outdoor High Pressure Sodium 250W Lamp	19%	27%	10%	24%	42%	44%	32%	38%	10%	77%	1%	73%
Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	77%	11%	11%	0%	4%	100%	19%	6%	11%	16%	4%	0%
Base DX Packaged System, EER=10.3, 10 tons	8%	29%	68%	77%	57%	60%	9%	80%	3%	55%	68%	53%
Base Other Cooling	7%	2%	1%	2%	19%	1%	11%	9%	0%	0%	0%	1%
Base PTAC, EER=8.3, 1 ton	0%	77%	11%	12%	29%	4%	41%	4%	2%	18%	8%	0%
Base Fan Motor, 5hp, 1800rpm, 87.5%	81%	88%	43%	40%	40%	100%	62%	70%	12%	46%	36%	25%
Base Fan Motor, 15hp, 1800rpm, 91.0%	6%	4%	0%	0%	7%	40%	1%	4%	0%	2%	4%	0%
Base Fan Motor, 40hp, 1800rpm, 93.0%	1%	1%	9%	0%	0%	1%	0%	1%	0%	0%	4%	0%
Base Built-Up Refrigeration System	0%	60%	52%	91%	31%	68%	53%	18%	3%	62%	2%	26%
Base Self-Contained Refrigeration	98%	97%	100%	100%	96%	94%	99%	75%	92%	96%	24%	69%
Base Water Heating	90%	4%	17%	27%	22%	12%	55%	85%	10%	32%	92%	73%
Base Refrigerated Vending Machines	81.3%	33.3%	50.0%	21.0%	32.0%	69.0%	40.3%	27.7%	10.4%	48.7%	71.3%	76.0%
Base Non-Refrigerated Vending Machines	81.3%	33.3%	50.0%	21.0%	32.0%	69.0%	40.3%	27.7%	10.4%	48.7%	71.3%	76.0%
Base Oven	76%	45%	25%	10%	38%	0%	24%	11%	9%	75%	3%	0%
Base Fryer	0%	5%	7%	4%	0%	0%	4%	0%	0%	41%	0%	0%
Base Steamer	0%	41%	3%	21%	21%	0%	15%	3%	3%	42%	0%	0%
Base Hot Food Holding Cabinet	0.0%	65.5%	21.7%	30.5%	7.8%	37.4%	12.9%	9.4%	0.1%	49.5%	0.3%	0.0%
Base Compressed Air	0%	2%	0%	0%	6%	0%	0%	0%	0%	0%	0%	0%
Base Heating	5%	36%	64%	56%	43%	0%	9%	45%	24%	22%	5%	72%
Base Miscellaneous	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Base Whole Building	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

5.1.2 Commercial End-Use Saturations - Natural Gas

Most (92 percent) of the gas equipment saturations (percent of commercial square footage having a specific end use) were calculated from the results of EM&V Project 41, using National Grid data. The exception is miscellaneous gas uses, where the research team used saturations from a 2012 DNV GL study conducted in Minnesota. The saturations used in the analysis are shown in Table 5-2.

Table 5-2: Commercial Natural Gas End-Use Saturations by Base Measure

End-use Saturations	Campus	Education	Food Sales	Food Service	Health-care	Hos-pitals	Lodging	Office	Other	Public Assembly	Retail	Ware-house
Base Boiler	94%	96%	0%	3%	79%	100%	50%	24%	17%	92%	37%	0%
Base Cooking - Convection Oven	0%	56%	26%	49%	85%	66%	18%	77%	17%	3%	5%	0%
Base Cooking – Fryer	0%	0%	19%	46%	1%	66%	25%	72%	21%	2%	0%	0%
Base Cooking - Griddle	0%	0%	3%	39%	18%	71%	11%	27%	15%	2%	0%	0%
Base Cooking - Range	0%	40%	26%	49%	88%	5%	48%	81%	22%	91%	0%	0%
Base Cooking - Steamer	0%	37%	0%	13%	67%	66%	9%	74%	15%	1%	0%	0%
Base Furnace	0%	6%	52%	69%	5%	0%	6%	19%	8%	53%	27%	80%
Base Other Heat	3%	42%	30%	4%	79%	71%	69%	16%	40%	93%	27%	98%
Base Water Heating - high standby loss (as % of load)	100%	100%	37%	0%	0%	0%	94%	62%	8%	96%	42%	0%
Base Water Heating - low standby loss (as % of load)	0%	0%	37%	79%	90%	0%	0%	0%	0%	0%	0%	0%
Base Misc	33%	2%	0%	13%	0%	0%	0%	10%	10%	0%	0%	0%
Base Whole Building	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

5.1.3 Commercial End-Use Energy Intensities

The second major component of the baseline analysis is end-use energy intensity for each type of base equipment. This is the energy consumed per square foot of floor space having that equipment type. When used in the model, this is multiplied by the saturation-weighted floor space, not total floor space.

National Grid's Customer Analytics Group was able to provide detailed information about the building activity and floor space associated with each customer account for electricity and for industrial gas. This data was assembled from a variety of data sources, including property tax information. DNV GL used this data to calculate total building square feet and total electricity and natural gas use by building type, and from those overall energy intensities by building type. While the Customer Analytics data only accounted for about 2/3 of total non-residential electricity use, 80 percent of industrial gas use, and 17 percent of commercial gas use, the research team assumed that the energy intensity for the missing customers was similar to those of the customers for which there was data.

This overall energy intensity provided a calibration target against which to calibrate the end-use energy intensities. In order for the baseline analysis to represent National Grid's non-residential loads, the saturation-weighted end-use energy intensities for each building type had to add up to the overall target energy intensities.

To help with the breakout by end-use, DNV GL conducted building simulations of nine building prototypes using EnergyPlus, from which the research team calculated end-use energy intensities for the prototypes. In few cases were these intensities used directly in the model, as the team needed to ensure consistency with the target energy intensities. However, the team did rely on the simulations to guide allocations of energy between different end uses.

5.1.3.1 Electric

Table 5-3 shows the end-use electricity intensities for the commercial sector by base measure. Remember that these represent the energy use per square feet for businesses that have that end-use (for example, chiller annual kWh for non-Residential square feet with chillers). Because the saturation for each type of equipment is different, these values are not additive unless weighted by the equipment saturations. The bottom row of the table, whole building, corresponds to the overall target energy intensities from the Customer Analytics data.

Table 5-3: Commercial Electric End-Use Energy Intensities (kWh/sq ft with end-use)

kwh/sq ft	Campus	Education	Food Sales	Food Service	Health-care	Hos-pitals	Lodging	Office	Other	Public Assembly	Retail	Ware-house
Base Fluorescent Fixture, 4L4 Foot T8, 1EB	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
Base Other Fluorescent Fixture	0.2	0.1	0.0	1.1	0.2	0.2	0.5	1.1	0.0	0.6	4.4	0.0
Base Incandescent Lamp, 72W to Screw-in Replacement	0.3	0.1	0.8	7.0	1.2	0.4	1.0	0.5	0.8	1.9	4.8	0.3
Base CFL Lamp, 23W	4.0	0.0	0.3	0.5	1.0	0.5	0.4	0.3	0.9	0.4	1.3	0.3
Base Metal Halide, 400W	13.5	1.0	0.3	4.1	0.1	10.1	2.1	2.7	2.0	0.3	7.4	2.5
Base HID Parking Garage Lighting	0.2	0.0	0.0	0.0	0.8	0.8	2.1	2.0	4.0	2.0	0.0	0.0
Base CFL Exit Sign	0.0	0.0	0.0	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Base Outdoor High Pressure Sodium 250W Lamp	0.7	0.5	1.6	4.6	0.9	0.9	1.0	0.5	0.4	0.4	1.8	0.9
Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	0.6	0.4	0.0	0.0	2.9	3.0	0.2	0.8	0.3	0.6	0.8	0.00
Base DX Packaged System, EER=10.3, 10 tons	1.7	0.6	2.3	2.9	2.2	2.7	2.0	2.4	0.3	0.6	2.1	0.28
Base Other Cooling	1.1	1.2	0.3	3.4	0.1	0.9	0.0	0.6	0.1	1.0	0.1	1.81
Base PTAC, EER=8.3, 1 ton	0.2	0.3	0.1	0.1	1.2	1.2	4.6	0.8	0.3	2.3	0.3	0.8
Base Fan Motor, 5hp, 1800rpm, 87.5%	2.3	2.6	0.8	1.5	2.4	2.8	1.6	3.1	1.5	2.2	0.7	0.7
Base Fan Motor, 15hp, 1800rpm, 91.0%	2.3	2.6	0.8	1.5	2.4	2.8	1.6	3.1	1.5	2.2	0.7	0.7
Base Fan Motor, 40hp, 1800rpm, 93.0%	2.3	2.6	0.8	1.5	2.4	2.8	1.6	3.1	1.5	2.2	0.7	0.7
Base Built-Up Refrigeration System	0.3	0.18	10.0	3.0	0.3	0.4	0.15	0.08	0.3	0.3	0.2	6.200
Base Self-Contained Refrigeration	0.3	0.18	10.0	3.0	0.3	0.4	0.15	0.08	0.3	0.3	0.2	0.200
Base Water Heating	0.51	0.02	0.01	0.41	0.71	0.71	0.57	0.31	0.95	0.95	1.04	0.50
Base Refrigerated Vending Machines	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Base Non-Refrigerated Vending Machines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Base Oven	0.051	0.304	0.469	8.261	0.3	0.000	1.116	0.853	0.116	0.2	0.272	0.000
Base Fryer	0.000	0.091	1.602	23.865	0.0	0.000	0.174	0.028	0.000	0.1	0.000	0.000
Base Steamer	0.000	0.239	0.123	18.863	0.1	0.000	0.591	0.011	0.438	0.0	0.199	0.000
Base Hot Food Holding Cabinet	0.000	0.090	0.053	3.911	0.0	0.023	0.186	0.003	0.018	0.1	0.063	0.000
Base Compressed Air	0.2	0.08	0.47	0.62	0.42	0.42	0.06	0.21	0.72	0.72	0.39	0.20
Base Heating	0.96	0.20	0.55	0.34	0.98	0.98	0.49	0.58	0.39	0.39	0.07	0.36
Base Miscellaneous	2.5	1.4	1.1	2.0	3.1	5.9	1.2	2.9	21.2	1.3	1.0	0.7
Base Whole Building	10.3	10.6	27.5	28.2	12.2	24.1	11.4	12.7	24.4	7.3	12.4	6.5

5.1.3.2 Natural Gas

Customer Analytics data for commercial natural gas customers accounted for only 17 percent of commercial use. DNV GL therefore turned to a straightforward billing analysis to break out gas use by building type, relying on the NAICS codes in the billing data to identify building activity. Lacking any other data on square footage, however, the research team did use the energy intensities developed from the Customer Analytics data set to extrapolate to the population.

Table 5-4 shows the natural gas end-use energy intensities for the commercial sector by base measure. As with electric, these represent the energy use per square feet for businesses that have that end-use. Because the saturation for each type of equipment is different, these values are not additive unless weighted by the equipment saturations. The bottom row of the table, whole building, corresponds to the overall target energy intensities from the Customer Analytics data.

Table 5-4: Commercial Natural Gas End-Use Energy Intensities (kBtu/sq ft with end-use)

kBtu/sq ft	Campus	Education	Food Sales	Food Service	Health-care	Hos-pitals	Lodging	Office	Other	Public Assembly	Retail	Ware-house
Base Boiler	36.03	31.02	77.33	18.00	18.39	33.63	18.00	70.35	85.45	6.30	41.02	14.96
Base Cooking - Convection Oven	-	1.85	3.67	35.96	0.38	0.31	1.08	1.15	6.55	6.99	40.00	-
Base Cooking - Fryer	-	-	1.98	67.50	0.07	0.61	0.89	0.73	17.31	13.75	4.22	-
Base Cooking - Griddle	-	-	6.56	36.55	0.62	0.84	0.44	1.71	1.82	7.81	1.54	-
Base Cooking - Range	-	1.57	11.53	109.22	0.39	10.19	5.96	1.90	28.76	14.18	2.61	-
Base Cooking - Steamer	-	1.63	-	38.73	0.20	3.83	0.40	1.00	4.72	5.05	-	-
Base Furnace	36.03	31.02	77.33	18.00	18.39	33.63	18.00	70.35	85.45	6.30	41.02	14.96
Base Other Heat	36.03	31.02	77.33	18.00	18.39	33.63	18.00	70.35	85.45	6.30	41.02	14.96
Base Water Heating - high standby loss (as % of load)	12.76	2.00	1.00	40.50	5.00	35.53	23.83	18.00	25.00	16.42	5.00	-
Base Water Heating - low standby loss (as % of load)	12.76	2.00	1.00	40.50	5.00	35.53	23.83	18.00	25.00	16.42	5.00	-
Base Misc	18.42	0.36	0.87	1.34	-	23.22	-	10.00	10.00	12.02	-	-
Base Whole Building	53.50	49.02	69.26	166.99	35.33	61.85	48.34	57.96	71.12	44.26	41.58	26.65

5.1.4 Commercial Energy Use - Electricity

Energy use was calculated as the product of the number of square feet by building type, equipment saturation, and the end-use energy intensity. Energy use by building type and end-use is shown in Table 5-5. The breakdown is calibrated so that the resulting total energy use, 9,081,305 MWh, corresponds to National Grid's commercial load forecast.

The square footage by building type was developed from the Customer Analytics data discussed above. As previously noted the Customer Analytics data set represented only about 2/3 of the total energy use, and researchers assumed that the missing floor space had a similar distribution and similar energy intensities to the included customers. DNV GL used available data on total energy sales in conjunction with the energy intensities to extrapolate total square footage.

Table 5-5: Commercial Electric Floor Space (1000 sq ft) and Energy Use (MWh) by Building Type and End-Use

	Campus	Edu-cation	Food Sales	Food Service	Health-care	Hos-pitals	Lodging	Office	Other	Public Assem-bly	Retail	Wareho use	Total
1000s Sq ft	16,230	18,738	5,426	14,019	8,929	3,602	39,622	268,857	68,612	46,042	114,973	105,914	710,965
MWh													
Base Fluorescent Fixture, 4L4 Foot T8, 1EB	32,539	89,972	42,254	25,765	27,683	11,301	178,350	573,769	95,618	40,780	776,131	55,547	1,949,707
Base Other Fluorescent Fixture	536	608	51	1,899	51	324	4,540	106,727	2	3,929	37,233	142	156,042
Base Incandescent Lamp, 72W to Screw-in Replacement	1,041	634	1,982	86,682	7,001	803	20,953	63,570	6,181	60,450	88,330	8,715	346,342
Base CFL Lamp, 23W	11,965	295	219	2,771	5,985	876	10,073	46,229	33,921	7,459	17,750	1,079	138,621
Base Metal Halide, 400W	15,885	11,996	437	11,291	21	16,362	5,851	113,934	10,253	3,353	39,676	163,581	392,640
Base HID Parking Garage Lighting	591	0	0	0	478	193	1,683	267,903	17,861	5,993	0	0	294,701
Base CFL Exit Sign	487	849	204	2,461	926	236	2,760	23,555	902	3,553	5,058	1,509	42,500
Base Outdoor High Pressure Sodium 250W Lamp	2,234	2,235	901	15,543	3,235	1,364	12,511	55,814	2,474	13,110	2,612	71,278	183,310
Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	7,884	730	0	0	956	10,608	1,294	13,056	2,078	4,448	3,846	0	44,900
Base DX Packaged System, EER=10.3, 10 tons	2,233	3,004	8,424	31,061	11,181	5,808	7,121	512,990	628	15,500	164,631	15,834	778,417
Base Other Cooling	1,222	539	8	1,005	115	21	21	15,350	10	56	4	1,944	20,294
Base PTAC, EER=8.3, 1 ton	15	3,885	33	134	3,110	175	76,115	8,685	490	18,767	2,871	25	114,303
Base Fan Motor, 5hp, 1800rpm, 87.5%	30,083	42,480	1,880	8,453	8,500	10,087	39,300	583,420	12,852	46,106	29,153	18,554	830,868
Base Fan Motor, 15hp, 1800rpm, 91.0%	2,243	1,924	0	0	1,502	4,062	689	33,134	186	1,579	3,367	0	48,687
Base Fan Motor, 40hp, 1800rpm, 93.0%	429	512	412	0	0	53	0	11,870	186	0	3,031	156	16,648
Base Built-Up Refrigeration System	0	2,016	28,450	38,142	869	1,076	3,159	3,917	696	7,178	667	173,122	259,294
Base Self-Contained Refrigeration	5,094	3,288	54,255	42,057	2,664	1,487	5,879	16,498	18,958	11,083	6,515	14,680	182,461
Base Water Heating	7,450	15	9	1,551	1,366	295	12,459	71,114	6,307	14,104	110,129	38,408	263,206
Base Refrigerated Vending Machines	2,261	1,068	465	504	490	426	2,736	12,772	1,229	3,842	14,054	13,793	53,638
Base Non-Refrigerated Vending Machines	202	96	42	45	44	38	245	1,142	110	344	1,257	1,234	4,797
Base Oven	631	2,578	625	11,161	950	0	10,587	26,088	742	5,428	973	0	59,763

	Campus	Edu-cation	Food Sales	Food Service	Health-care	Hos-pitals	Lodging	Office	Other	Public Assem-bly	Retail	Wareho use	Total
Base Fryer	0	84	646	13,182	0	0	291	26	0	2,747	0	0	16,976
Base Steamer	0	1,850	23	54,986	246	0	3,541	91	968	764	14	0	62,484
Base Hot Food Holding Cabinet	0	1,111	62	16,709	15	31	953	85	1	2,855	21	0	21,842
Base Compressed Air	0	33	0	0	218	0	0	0	0	0	213	0	464
Base Heating	796	1,349	1,898	2,655	3,783	0	1,764	71,394	6,314	3,965	400	27,618	121,935
Base Miscellaneous	41,136	26,177	5,812	27,909	27,863	21,112	48,489	769,779	1,453,697	58,648	116,741	79,101	2,676,463
Base Whole Building	166,958	199,329	149,092	395,964	109,251	86,739	451,363	3,402,911	1,672,664	336,042	1,424,67 4	686,319	9,081,305
Total	**166,958**	**199,329**	**149,092**	**395,964**	**109,251**	**86,739**	**451,363**	**3,402,911**	**1,672,664**	**336,042**	**1,424,674**	**686,319**	**9,081,305**

Figure 5-1 and Figure 5-2 show the breakout of commercial electricity use by building type and end use, respectively.

Figure 5-1: Commercial Electric Energy Use by Building Type (GWh)

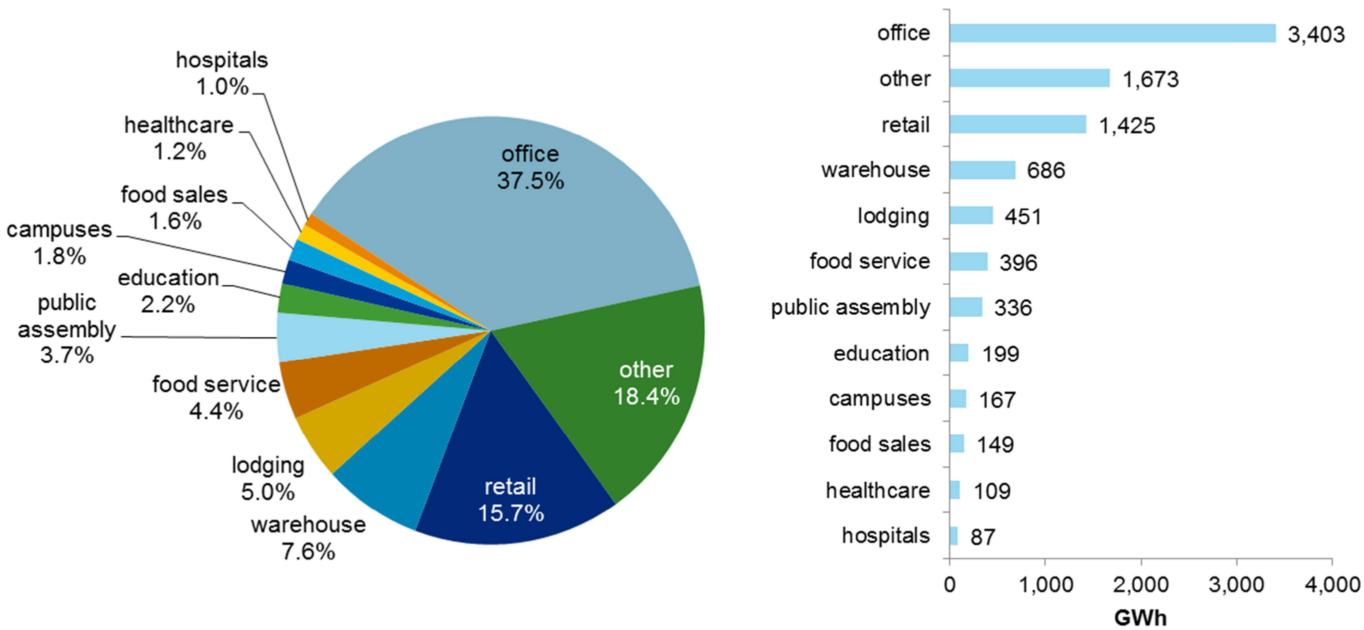
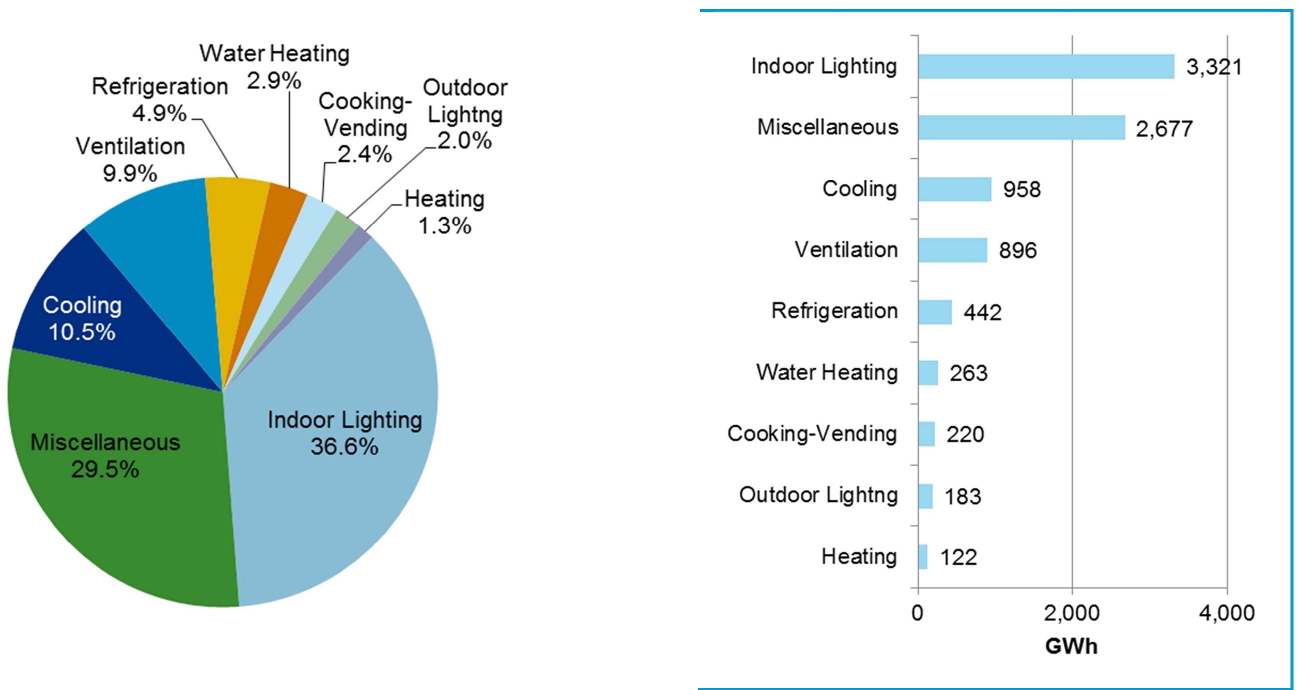


Figure 5-2: Commercial Electric Energy Use by End-Use (GWh)



5.1.5 Commercial Energy Use - Natural Gas

Natural gas use was calculated as the product of the number of square feet by building type, equipment saturation, and the end-use energy intensity. Energy use by building type and end-use is shown in Table 5-6. The breakdown is calibrated so that the resulting total energy use, 410,958,773 therms, corresponds to the commercial portion of sales from National Grid's billing database.

The square footage by building type was developed from the Customer Analytics data discussed above. As previously noted the Customer Analytics data set represented only a very small share (17 percent) of the total natural gas use in the commercial sector. However, alternative sources for data on floor space (such as using data from the Department of Energy's Commercial Building Energy Consumption Survey) did not offer any higher level of reliability. Lacking better data, researchers assumed that the missing floor space had similar energy intensities to the included customers. DNV GL used available data on total energy sales from the billing data in conjunction with the energy intensities to extrapolate total square footage.

Table 5-6: Commercial Natural Gas Floor Space (1000 sq ft) and Energy Use (Thousand Therms) by Building Type and End-Use

	Campus	Edu-cation	Food Sales	Food Service	Health-care	Hos-pitals	Lodging	Office	Other	Public Assem-bly	Retail	Ware-house	Total
1000s Sq ft	14,276	26,865	6,090	18,457	8,953	3,185	39,234	303,958	69,521	51,687	135,308	98,570	776,103
1000s Therms													
Base Boiler	4,816	8,042	0	97	1,296	1,071	3,548	51,220	10,124	2,998	20,814	0	104,025
Base Cooking - Convection Oven	0	279	57	3,231	29	6	76	2,681	757	110	2,550	0	9,777
Base Cooking - Fryer	0	0	23	5,748	0	13	89	1,594	2,522	149	18	0	10,156
Base Cooking - Griddle	0	0	12	2,599	10	19	18	1,393	194	81	6	0	4,335
Base Cooking - Range	0	168	179	9,850	31	17	1,121	4,684	4,393	6,642	11	0	27,095
Base Cooking - Steamer	0	162	0	903	12	81	15	2,265	505	15	0	0	3,958
Base Furnace	0	508	2,470	2,306	83	0	409	41,549	4,979	1,714	14,940	11,827	80,784
Base Other Heat	134	3,471	1,431	133	1,299	763	4,860	33,706	23,823	3,028	15,117	14,444	102,211
Base Water Heating - high standby loss (as % of load)	1,821	537	22	0	0	0	8,830	34,030	1,447	8,137	2,811	0	57,635
Base Water Heating - low standby loss (as % of load)	0	0	22	5,921	404	0	0	0	0	0	0	0	6,347
Base Misc	867	2	0	32	0	0	0	3,040	695	0	0	0	4,636
Base Whole Building	7,638	13,169	4,218	30,820	3,163	1,970	18,966	176,161	49,440	22,875	56,267	26,271	410,959
Total	**7,638**	**13,169**	**4,218**	**30,820**	**3,163**	**1,970**	**18,966**	**176,161**	**49,440**	**22,875**	**56,267**	**26,271**	**410,959**

Figure 5-3 and Figure 5-4 how the breakout of commercial natural gas use by building type and end use, respectively.

Figure 5-3: Commercial Natural Gas Energy Use by Building Type (Thousand Therms)

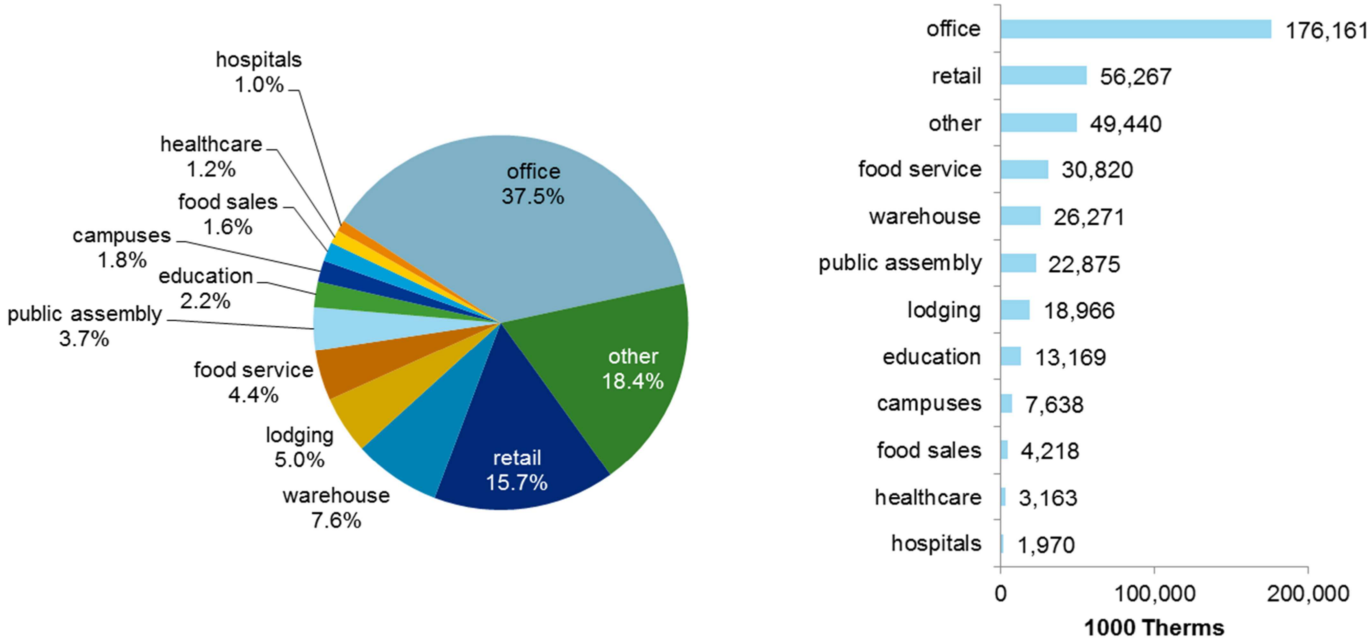
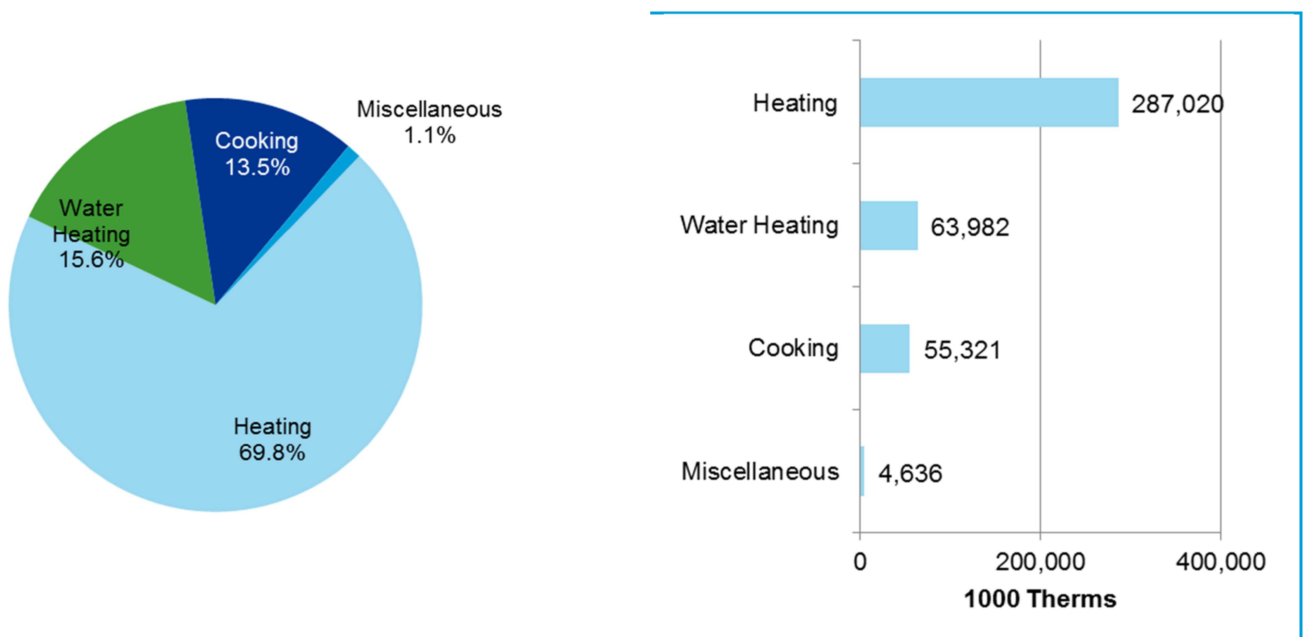


Figure 5-4: Commercial Natural Gas Energy Use by End-Use (Thousand Therms)



5.1.6 Commercial Electric Peak Demand

Annual 8,760 hourly data from National Grid was combined with end-use load shape data from DNV GL's end-use databases to allocate annual energy usage by building type into time-of-use (TOU) periods. Commercial summer peak demand intensities (kW per square foot) are shown in Table 5-7, and estimates of total summer peak demand by segment and end use are summarized in Table 5-8.

Table 5-7: Commercial Electric Demand Intensity by Building Type and End Use (kW/sq ft)

Peak demand kW/sq ft	Campus	Edu-cation	Food Sales	Food Service	Health-care	Hos-pitals	Lodging	Office	Other	Public Assembly	Retail	Ware-house
Base Fluorescent Fixture, 4L4 Foot T8, 1EB	0.0015	0.0013	0.0014	0.0005	0.0006	0.0007	0.0008	0.0005	0.0009	0.0004	0.0014	0.0001
Base Other Fluorescent Fixture	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0001	0.0002	0.0000	0.0001	0.0009	0.0000
Base Incandescent Lamp, 72W to Screw-in Replacement	0.0001	0.0000	0.0001	0.0014	0.0002	0.0001	0.0001	0.0001	0.0001	0.0004	0.0009	0.0000
Base CFL Lamp, 23W	0.0007	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003	0.0001
Base Metal Halide, 400W	0.0025	0.0002	0.0000	0.0008	0.0000	0.0015	0.0003	0.0006	0.0003	0.0001	0.0015	0.0005
Base HID Parking Garage Lighting	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0003	0.0004	0.0006	0.0004	0.0000	0.0000
Base CFL Exit Sign	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Base Outdoor High Pressure Sodium 250W Lamp	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	0.0005	0.0003	0.0000	0.0000	0.0018	0.0019	0.0001	0.0006	0.0001	0.0005	0.0006	0.0000
Base DX Packaged System, EER=10.3, 10 tons	0.0013	0.0004	0.0012	0.0014	0.0014	0.0017	0.0011	0.0018	0.0001	0.0005	0.0016	0.0002
Base Other Cooling	0.0009	0.0009	0.0001	0.0017	0.0000	0.0006	0.0000	0.0005	0.0000	0.0008	0.0001	0.0014
Base PTAC, EER=8.3, 1 ton	0.0002	0.0002	0.0000	0.0000	0.0008	0.0007	0.0024	0.0006	0.0002	0.0019	0.0002	0.0006
Base Fan Motor, 5hp, 1800rpm, 87.5%	0.0003	0.0003	0.0001	0.0002	0.0003	0.0004	0.0002	0.0006	0.0003	0.0005	0.0001	0.0001
Base Fan Motor, 15hp, 1800rpm, 91.0%	0.0003	0.0003	0.0000	0.0000	0.0003	0.0004	0.0002	0.0006	0.0003	0.0005	0.0001	0.0000
Base Fan Motor, 40hp, 1800rpm, 93.0%	0.0003	0.0003	0.0001	0.0000	0.0000	0.0004	0.0000	0.0006	0.0003	0.0000	0.0001	0.0001
Base Built-Up Refrigeration System	0.0000	0.0000	0.0013	0.0004	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0010
Base Self-Contained Refrigeration	0.0000	0.0000	0.0013	0.0004	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Base Water Heating	0.0001	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0002	0.0002	0.0001
Base Refrigerated Vending Machines	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Base Non-Refrigerated Vending Machines	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Base Oven	0.0000	0.0001	0.0001	0.0014	0.0000	0.0000	0.0002	0.0002	0.0000	0.0000	0.0001	0.0000
Base Fryer	0.0000	0.0000	0.0002	0.0041	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Base Steamer	0.0000	0.0000	0.0000	0.0032	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000
Base Hot Food Holding Cabinet	0.0000	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Base Compressed Air	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000
Base Heating	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Peak demand kW/sq ft	Campus	Edu-cation	Food Sales	Food Service	Health-care	Hos-pitals	Lodging	Office	Other	Public Assembly	Retail	Ware-house
Base Miscellaneous	0.0004	0.0002	0.0002	0.0003	0.0005	0.0009	0.0002	0.0005	0.0035	0.0002	0.0002	0.0001
Base Whole Building	0.0020	0.0023	0.0044	0.0053	0.0025	0.0057	0.0022	0.0035	0.0040	0.0018	0.0032	0.0011

Table 5-8: Commercial Electric Demand by Building Type and End Use (MW)

Peak demand estimates MW	Campus	Edu-cation	Food Sales	Food Service	Health-care	Hos-pitals	Lodging	Office	Other	Public Assembly	Retail	Ware-house	Total
Base Fluorescent Fixture, 4L4 Foot T8, 1EB	6.1	22.1	6.4	5.0	4.1	1.7	22.0	116.5	15.5	8.2	153.5	10.2	371.2
Base Other Fluorescent Fixture	0.1	0.1	0.0	0.4	0.0	0.0	0.6	21.7	0.0	0.8	7.4	0.0	31.1
Base Incandescent Lamp, 72W to Screw-in Replacement	0.2	0.2	0.3	16.8	1.0	0.1	2.6	12.9	1.0	12.2	17.5	1.6	66.4
Base CFL Lamp, 23W	2.2	0.1	0.0	0.5	0.9	0.1	1.2	9.4	5.5	1.5	3.5	0.2	25.2
Base Metal Halide, 400W	3.0	2.9	0.1	2.2	0.0	2.4	0.7	23.1	1.7	0.7	7.8	30.0	74.6
Base HID Parking Garage Lighting	0.1	0.0	0.0	0.0	0.1	0.0	0.2	54.4	2.9	1.2	0.0	0.0	58.9
Base CFL Exit Sign	0.1	0.2	0.0	0.5	0.1	0.0	0.3	4.8	0.1	0.7	1.0	0.3	8.2
Base Outdoor High Pressure Sodium 250W Lamp	0.0	0.0	0.0	0.4	0.0	0.0	0.1	0.4	0.0	0.2	0.1	0.6	1.8
Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	6.1	0.5	0.0	0.0	0.6	6.8	0.7	10.0	1.1	3.8	2.9	0.0	32.5
Base DX Packaged System, EER=10.3, 10 tons	1.7	2.2	4.3	15.2	7.2	3.7	3.7	392.5	0.3	13.1	125.8	11.9	581.6
Base Other Cooling	0.9	0.4	0.0	0.5	0.1	0.0	0.0	11.7	0.0	0.0	0.0	1.5	15.2
Base PTAC, EER=8.3, 1 ton	0.0	2.8	0.0	0.1	2.0	0.1	39.4	6.6	0.3	15.9	2.2	0.0	69.4
Base Fan Motor, 5hp, 1800rpm, 87.5%	3.4	4.7	0.3	1.3	1.1	1.3	5.0	114.2	2.3	9.5	5.0	3.9	152.0
Base Fan Motor, 15hp, 1800rpm, 91.0%	0.3	0.2	0.0	0.0	0.2	0.5	0.1	6.5	0.0	0.3	0.6	0.0	8.7
Base Fan Motor, 40hp, 1800rpm, 93.0%	0.0	0.1	0.1	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.5	0.0	3.1
Base Built-Up Refrigeration System	0.0	0.2	3.8	4.8	0.1	0.1	0.4	0.5	0.1	0.9	0.1	28.2	39.2
Base Self-Contained Refrigeration	0.6	0.4	7.2	5.3	0.3	0.2	0.7	2.1	2.4	1.4	0.8	2.4	23.9
Base Water Heating	1.3	0.0	0.0	0.3	0.2	0.0	1.5	10.2	0.9	2.5	18.0	5.8	40.7
Base Refrigerated Vending Machines	0.3	0.1	0.1	0.1	0.1	0.1	0.3	1.6	0.2	0.5	1.8	2.2	7.3
Base Non-Refrigerated Vending Machines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.2	0.8
Base Oven	0.1	0.4	0.1	1.9	0.2	0.0	1.7	6.4	0.1	0.9	0.2	0.0	12.0
Base Fryer	0.0	0.0	0.1	2.3	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	2.9
Base Steamer	0.0	0.3	0.0	9.5	0.0	0.0	0.6	0.0	0.2	0.1	0.0	0.0	10.7
Base Hot Food Holding Cabinet	0.0	0.2	0.0	2.9	0.0	0.0	0.2	0.0	0.0	0.5	0.0	0.0	3.7
Base Compressed Air	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1

Peak demand estimates MW	Campus	Edu-cation	Food Sales	Food Service	Health-care	Hos-pitals	Lodging	Office	Other	Public Assembly	Retail	Ware-house	Total
Base Heating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.2	0.6
Base Miscellaneous	5.8	3.9	0.9	4.1	4.3	3.3	6.4	124.0	242.9	8.3	20.4	14.9	439.3
Base Whole Building	32.3	42.2	23.7	73.9	22.7	20.6	88.5	932.2	277.6	83.6	369.5	114.1	2,081
Total	32.3	42.2	23.7	73.9	22.7	20.6	88.5	932.2	277.6	83.6	369.5	114.1	2,081.1

Figure 5-5 and Figure 5-6 show the breakout of commercial electricity use by building type and end use, respectively.

Figure 5-5: Commercial Peak Demand by Building Type (MW)

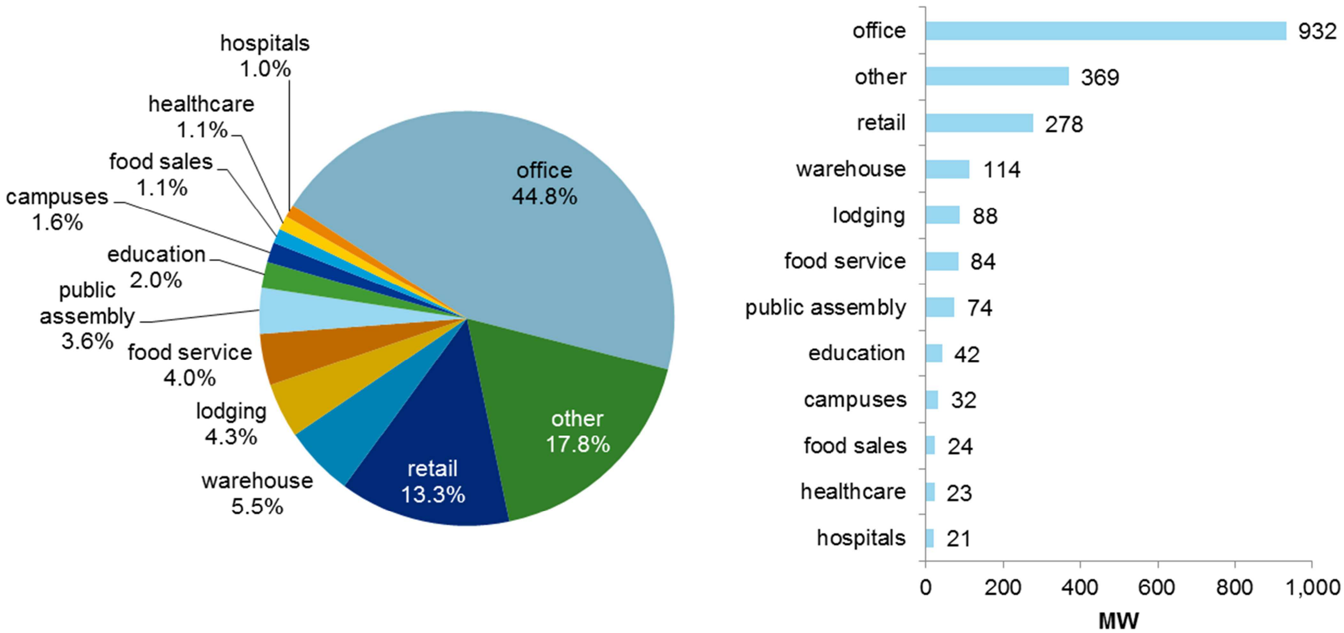
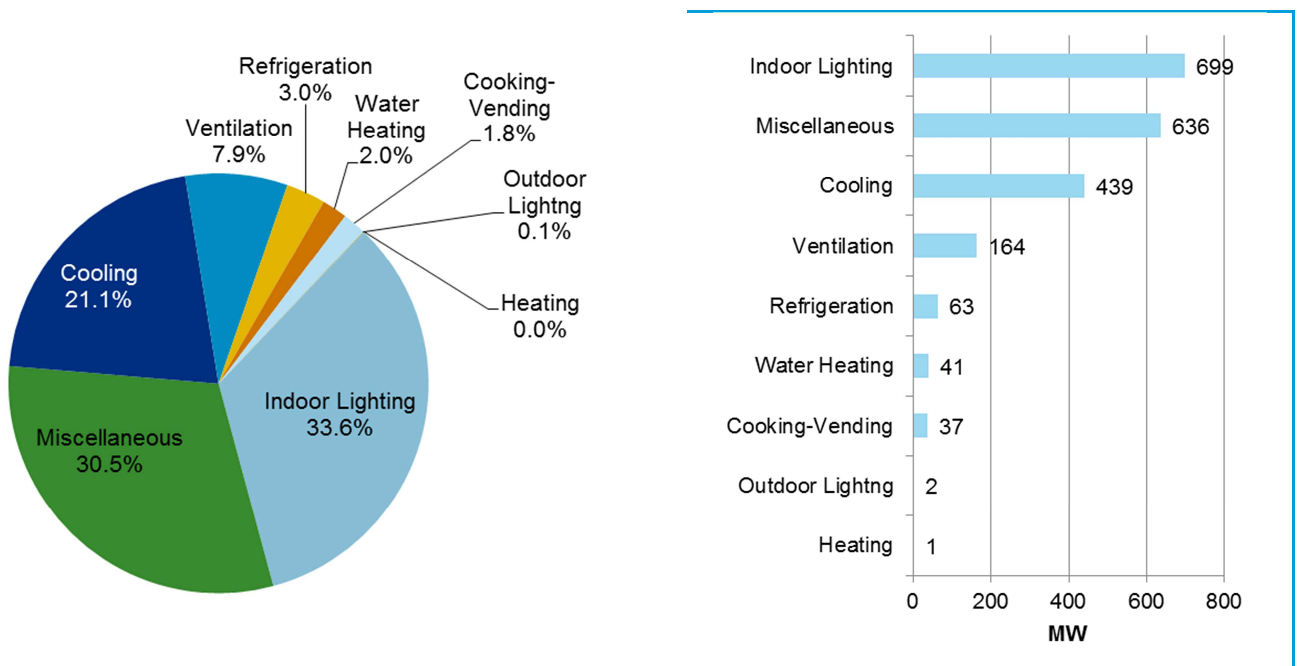


Figure 5-6: Commercial Peak Demand by End-Use (MW)



5.1.7 Industrial Baseline

The sample size of industrial buildings from Project 41 did not support statistically reliable estimates at the industry level. Without data to support a breakout, DNV GL analyzed industry as a single category for this study. National Grid's industrial electric customer mix includes a variety of industries including computers and electronics, plastics, fabricated metals, and food production.

5.1.7.1 Industrial Equipment Saturations - Electricity

The equipment saturations (percent of industrial square feet having an end use) were calculated primarily from the results of the EM&V Project 41 on-sites, using National Grid data. The exception was other process, which DNV GL drew from an on-site study conducted in Minnesota in 2012. The resulting saturations are shown in Table 5-9.

Table 5-9: Summary of Industrial Electric Equipment Saturations

	Saturation
Base Compressed Air	63.6%
Base Non-Cycling refrigerated air dryer	24.6%
Base <5 HP drive/fan/motor	35.0%
Base 6-20 HP drive/fan/motor	32.1%
Base 21-50 HP drive/fan/motor	8.1%
Base 51-100 HP drive/fan/motor	14.9%
Base 100+ HP drive/fan/motor	20.4%
Base Pumps	15.0%
Base Process Heating	8.3%
Base Process Cooling	29.5%
Base Other Process	4.7%
Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	50.8%
Base DX Packaged System, EER=10.3, 10 tons	19.1%
Base Ventilation	100.0%
Base Fluorescent Fixture, 4L4'T8, 1EB, 2015	41.1%
Base Other Fluorescent Fixture	17.1%
Base Metal Halide, 400W	16.4%
Base Outdoor High Pressure Sodium 250W Lamp	47.2%
Base Other	100.0%
Base Whole Building	100.0%

5.1.7.2 Industrial Equipment Saturations - Natural Gas

The equipment saturations (percent of industrial square feet having an end use) were calculated primarily from the results of the EM&V Project 41 on-sites, using National Grid data. The exception was CHP, which is not analyzed in the study but is included to get a complete picture of how natural gas is being used in the industrial sector (CHP total energy use is from an Energy Information Administration source and is independent of the saturation). The resulting saturations are shown in Table 5-10.

Table 5-10: Summary of Industrial Natural Gas Equipment Saturations

	Saturation
Base Hot Water Boiler	45%
Base Steam Boiler	21%
Base Furnace	2.9%
Base Process Heat	10%
Base Other Process	2.1%
Base HVAC	32%
Base CHP	20%
Base Other	25%
Base Whole Facility	100%

5.1.7.3 Industrial End-Use Energy Intensities - Electricity

Table 5-11 shows the end-use electricity intensities (EUIs) for the industrial sector by base measure. EUIs were developed from a variety of sources. Some were developed using a bottom-up approach based on wattage (lighting) or horsepower (motors), hours of use, load factors, and equipment densities from the EM&V Project 41 surveys. For process end uses, DNV GL relied on data from the 2013 Manufacturer End-Use Consumption Survey (MECS) conducted by the Energy Information Administration.

As with commercial, the end-use energy intensities apply to floor space identified as having the measure, and are applied to saturation-weighted square footage rather than total square footage.

Table 5-11: Industrial Electric End-Use Energy Intensities (kWh per End-Use Square Foot)

	kwh/sq ft
Base Compressed Air	1.35
Base Non-Cycling refrigerated air dryer	0.05
Base <5 HP drive/fan/motor	1.17
Base 6-20 HP drive/fan/motor	2.84
Base 21-50 HP drive/fan/motor	1.21
Base 51-100 HP drive/fan/motor	4.99
Base 100+ HP drive/fan/motor	18.79
Base Pumps	16.93
Base Process Heating	24.75
Base Process Cooling	4.56
Base Other Process	44.18
Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	1.12
Base DX Packaged System, EER=10.3, 10 tons	1.12
Base Ventilation	0.74
Base Fluorescent Fixture, 4L4'T8, 1EB, 2015	1.67
Base Other Fluorescent Fixture	0.27
Base Metal Halide, 400W	1.35
Base Outdoor High Pressure Sodium 250W Lamp	0.40
Base Other	1.09
Base Whole Building	18.67

5.1.7.4 Industrial End-Use Energy Intensities - Natural Gas

Table 5-12 shows the natural gas end-use energy intensities (EUIs) for the industrial sector by base measure. EUIs were developed using data from the 2013 Manufacturer End-Use Consumption Survey (MECS) conducted by the Energy Information Administration.

As with commercial, the end-use energy intensities apply to floor space identified as having the measure, and are applied to saturation-weighted square footage rather than total square footage.

Table 5-12: Industrial Natural Gas End-Use Energy Intensities (Therms per End-Use Square Foot)

	Therms/sq ft
Base Hot Water Boiler	0.13
Base Steam Boiler	1.44
Base Furnace	5.84
Base Process Heat	5.84
Base Other Process	3.78
Base HVAC	0.98
Base CHP	2.19
Base Other	0.30
Base Whole Facility	2.00

5.1.7.5 Industrial Building Stock and Energy Use - Electricity

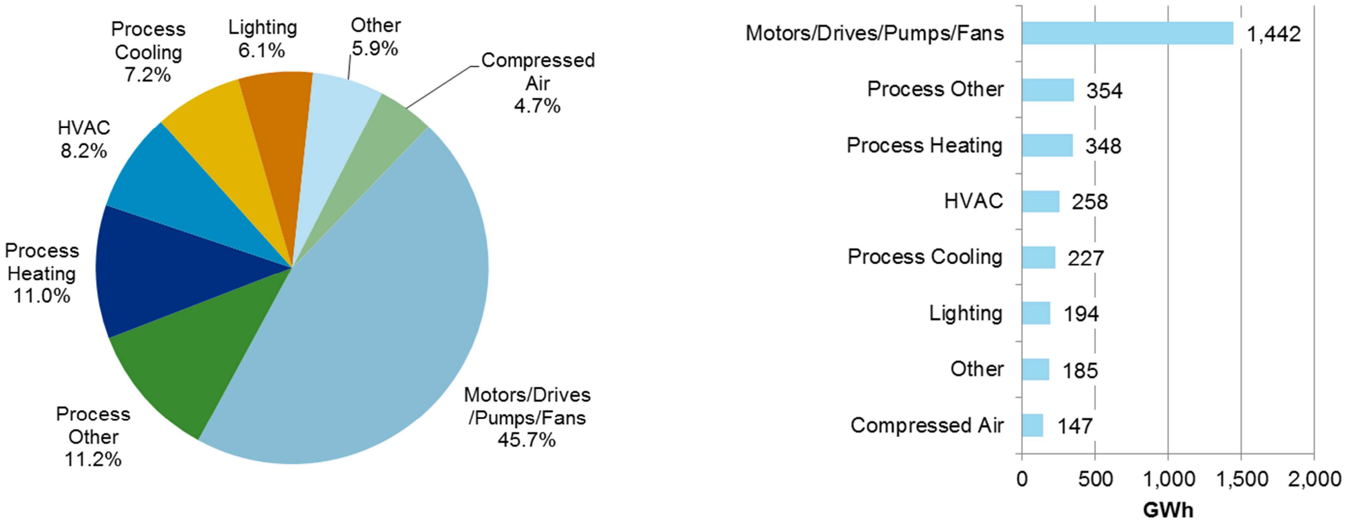
DNV GL used the 2010 MECs data to estimate the energy use by end use. The resulting total energy use, 3,154,169 MWh, corresponds to National Grid's commercial load forecast. As shown in Figure 5-7, motors and drives account for the largest portion of industrial sector electricity consumption.

As with the commercial sector, DNV GL used the data from Customer Analytics to estimate industrial floor space.

Table 5-13: Industrial Electric Floor Space (1000 sq ft) and Energy Use (GWh) by End-Use

	All Industrial
1000 sq ft	168,943
	MWh
Base Compressed Air	145,166
Base Non-Cycling refrigerated air dryer	2,037
Base <5 HP drive/fan/motor	68,944
Base 6-20 HP drive/fan/motor	153,801
Base 21-50 HP drive/fan/motor	16,656
Base 51-100 HP drive/fan/motor	125,838
Base 100+ HP drive/fan/motor	647,633
Base Pumps	429,156
Base Process Heating	347,820
Base Process Cooling	227,375
Base Other Process	353,579
Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	95,883
Base DX Packaged System, EER=10.3, 10 tons	36,030
Base Ventilation	125,761
Base Fluorescent Fixture, 4L4'T8, 1EB, 2015	116,304
Base Other Fluorescent Fixture	7,731
Base Metal Halide, 400W	37,616
Base Outdoor High Pressure Sodium 250W Lamp	32,084
Base Other	184,757
Base Whole Facility	3,154,169

Figure 5-7: Industrial Electric Energy Use by End-Use (GWh)



5.1.7.6 Industrial Building Stock and Energy Use - Natural Gas

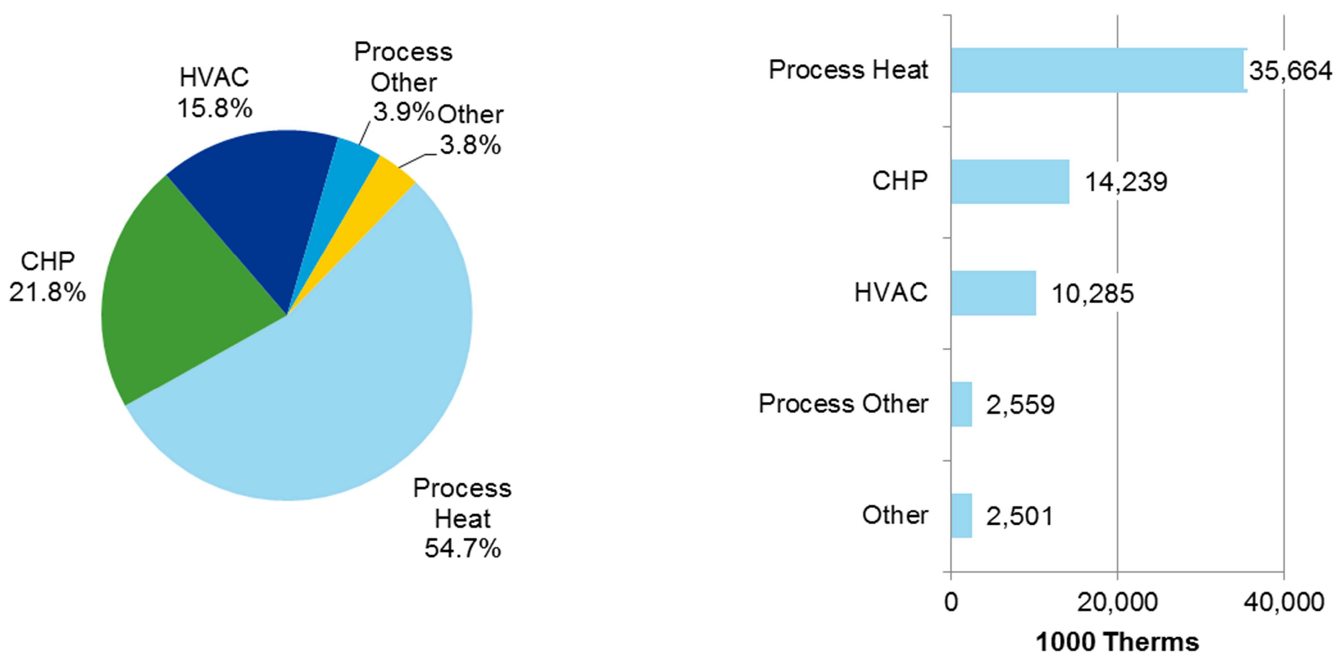
DNV GL used the 2010 MECs data to estimate the energy use by end use. The resulting total energy use, 65,247,603 therms, corresponds to the industrial portion of sales from National Grid's billing database. As shown in Figure 5-8, process heat accounts for the majority of industrial sector electricity consumption.

As with the commercial sector, DNV GL used the data from Customer Analytics to estimate industrial floor space. In contrast to the commercial gas sector, the Customer Analytics data accounted for a large share (81 percent) of industrial natural gas use.

Table 5-14: Industrial Natural Gas Floor Space (1000 sq ft) and Energy Use (Therms) by End-Use

	All Industrial
1000 Square Feet	32,566
	Therms
Base Hot Water Boiler	1,897,795
Base Steam Boiler	9,641,259
Base Furnace	5,538,348
Base Process Heat	18,586,608
Base Other Process	2,558,594
Base HVAC	10,284,587
Base CHP	14,239,087
Base Other	2,501,324
Base Whole Facility	65,247,603

Figure 5-8: Industrial Energy Use by End-Use (Thousand Therms)



5.1.7.7 Industrial Electric Peak Demand

Similar to the commercial sector, National Grid's annual hourly 8,760 load data was combined with non-residential end-use load shapes from DNV GL's end-use databases to allocate annual energy usage to time-of-use (TOU) periods. DNV GL also used the load shape data to develop factors relating peak demand to average energy by TOU period, then used these factors to convert summer peak period energy use to summer peak demand. Non-residential peak demand intensity (kw per square foot) is summarized in Table 5-15, and overall peak demand by end use is summarized in Table 5-16.

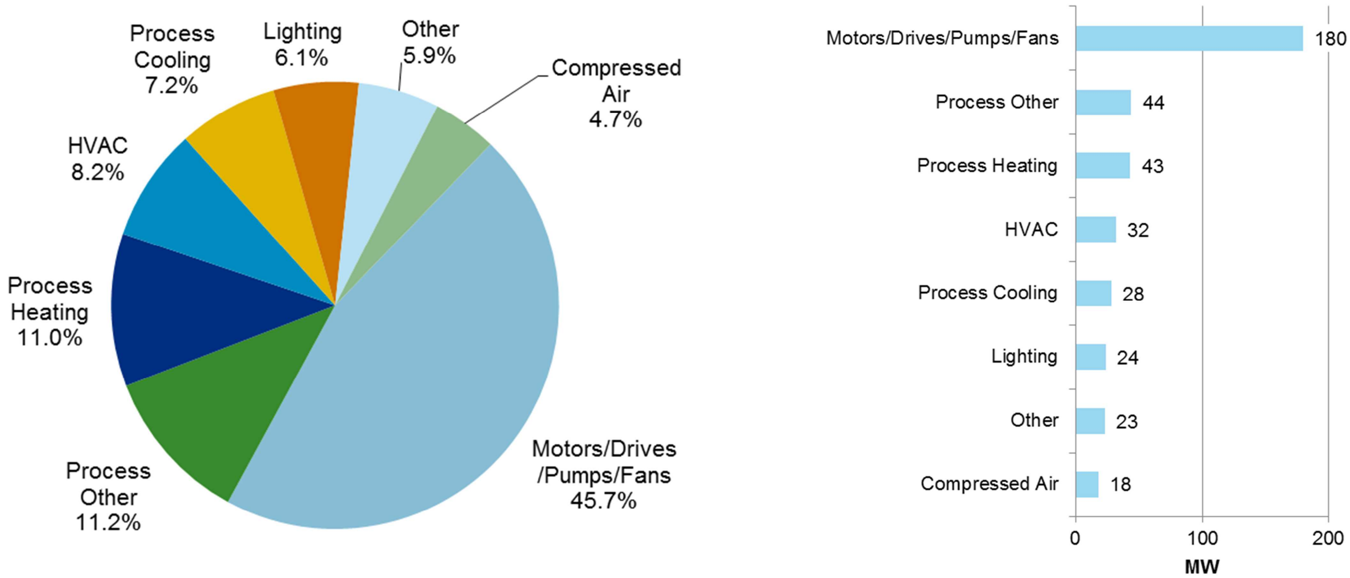
Table 5-15: Industrial Electric Demand Intensity by End Use (kW/sq ft)

Peak demand estimates MW	Total
Base Compressed Air	0.00017
Base Non-Cycling refrigerated air dryer	0.00001
Base <5 HP drive/fan/motor	0.00015
Base 6-20 HP drive/fan/motor	0.00035
Base 21-50 HP drive/fan/motor	0.00015
Base 51-100 HP drive/fan/motor	0.00062
Base 100+ HP drive/fan/motor	0.00234
Base Pumps	0.00211
Base Process Heating	0.00308
Base Process Cooling	0.00057
Base Other Process	0.00550
Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	0.00014
Base DX Packaged System, EER=10.3, 10 tons	0.00014
Base Ventilation	0.00009
Base Fluorescent Fixture, 4L4'T8, 1EB, 2015	0.00021
Base Other Fluorescent Fixture	0.00003
Base Metal Halide, 400W	0.00017
Base Outdoor High Pressure Sodium 250W Lamp	0.00005
Base Other	0.00014
Base Whole Building	0.00233

Table 5-16: Industrial Electric Demand by End Use (MW)

Peak demand estimates MW	Total
Base Compressed Air	18.1
Base Non-Cycling refrigerated air dryer	0.3
Base <5 HP drive/fan/motor	8.6
Base 6-20 HP drive/fan/motor	19.2
Base 21-50 HP drive/fan/motor	2.1
Base 51-100 HP drive/fan/motor	15.7
Base 100+ HP drive/fan/motor	80.7
Base Pumps	53.5
Base Process Heating	43.3
Base Process Cooling	28.3
Base Other Process	44.1
Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	11.9
Base DX Packaged System, EER=10.3, 10 tons	4.5
Base Ventilation	15.7
Base Fluorescent Fixture, 4L4'T8, 1EB, 2015	14.5
Base Other Fluorescent Fixture	1.0
Base Metal Halide, 400W	4.7
Base Outdoor High Pressure Sodium 250W Lamp	4.0
Base Other	23.0
Base Whole Building	393
Total	393

Figure 5-9: Industrial Peak Demand by End-Use (MW)



5.2 Technical and Economic Potential Results

This section contains a summary of findings from the analysis of technical and economic savings potential of electric energy efficiency efforts in National Grid's Massachusetts service territory. Technical potential is defined as the complete and immediate penetration of all measures analyzed in applications where they were deemed technically feasible from an engineering perspective. Economic potential is defined as the technical potential of those energy conservation measures that are cost-effective when compared to supply-side alternatives. All measures with a TRC greater than one are considered to have economic potential.

In the bottom-up modeling approach, analysts first estimate technical potential for energy savings by integrating key measure and market segment parameters using the following equation:

Equation 1: Technical Potential of an Efficient Measure

$$\text{Technical Potential of Efficient Measure} = \text{Total sq. ft. or \# of Dwellings} \times \text{Base Case Equipment EUI or UEC} \times \text{Applicability Factor} \times \text{Not Complete Factor} \times \text{Feasibility Factor} \times \text{Savings Factor}$$

Where:

- Square feet is the total floor space for all buildings in the market segment.
- Base case equipment Energy Use Intensity (EUI) is the energy used per square foot by each base case technology in each market segment. This is the consumption of the energy-using equipment that the efficient technology replaces or affects. For example, if the

efficient measure were a screw-based LED lamp replacing a screw-based CFL, the base EUI would be the annual kWh per square foot of an equivalent CFL.

- Applicability factor is the fraction of the floor space that is applicable for the efficient technology in a given market segment; for the example above, the percentage of floor space lit by CFLs. This input was developed through results of the Project 41 on-site surveys and Baseline Analysis.
- Not complete factor is the fraction of applicable floor space that has not yet been converted to the efficient measure; that is, one minus the fraction of floor space that already has the EE measure installed. DNV GL relied on the results of the Project 41 on-site surveys to estimate this value when possible and utilized other recent saturation surveys and internal databases for other measures not included in the saturation surveys.
- Feasibility factor is the fraction of the applicable floor space that is technically feasible for conversion to the efficient technology from an engineering perspective. DNV GL engineers familiar with National Grid’s service territory reviewed these values to ensure they were consistent with National Grid’s building stock.
- Savings factor is the reduction in energy consumption resulting from application of the efficient technology. DNV GL estimated energy savings through the use of sources including Massachusetts Technical Resource Manual (TRM), other regionally appropriate TRMs, National Grid’s program tracking data, Motor Master International, the IAC Database, and other engineering calculations.

Technical potential for peak demand reduction is calculated analogously.

Economic potential is then assessed by first developing a supply-curve analysis to eliminate double counting of measure savings. On a market segment and end-use/technology basis, measures are stacked in order of cost-effectiveness, and the energy consumption of the system being affected by the efficiency measures decreases as each measure is applied. For example, if a low wattage high performance T8 lamp is more cost effective that installing occupancy sensors, then the study assumes that the lamp measure is implemented first. The savings for the occupancy sensors are then calculated as the measure being installed on the higher efficiency lamp, rather than the base lamp. Each subsequent measure takes into account the savings of the measures that preceded it. The combined savings of the lamp and occupancy sensor are the same, regardless of the implementation order, assuming both are installed. But once the first, more cost-effective, measure is installed, the less cost-effective measure may no longer pass the TRC test and would not count toward economic potential.

In addition to the question of measure ordering, some measures compete directly with each other for the same opportunity, such as screw-based CFLs and LEDs competing for the same sockets. These measures are also ordered by cost effectiveness, but in this case the less cost-effective measure is reassessed on the margin, based on the marginal costs and savings relative to the higher efficiency measure. For example, if the CFL is more cost effective, the research team then looks at the price premium of the LED compared to the CFL, and the additional savings of the LED relative to the CFL, and calculates a new TRC ratio. If the less cost-effective measure still passes the TRC test on the margin, it is included in economic potential. But note that this methodology only attributes the marginal savings to the LED, while the bulk of the savings (in this example) would be attributed to the CFL, even though it is the LED that is ultimately installed in the socket.

After eliminating double counting of savings, the benefits and costs associated with a given measure and market segment are compared using the TRC test. Measures with a TRC ratio greater than 1.0 will be passed on to the achievable potential analysis.

5.2.1 Overall Technical and Economic Potential - Electric

In this section, DNV GL present the technical and economic potential results for all electric measures considered in the study. Figure 5-10 and Figure 5-11 present the overall estimates of total technical and economic potential for electrical energy and peak demand savings for National Grid for the 2016 to 2018 and 2016 to 2025 time periods.

Figure 5-10. Estimated Electrical and Technical Economic Potential, 2016-2018

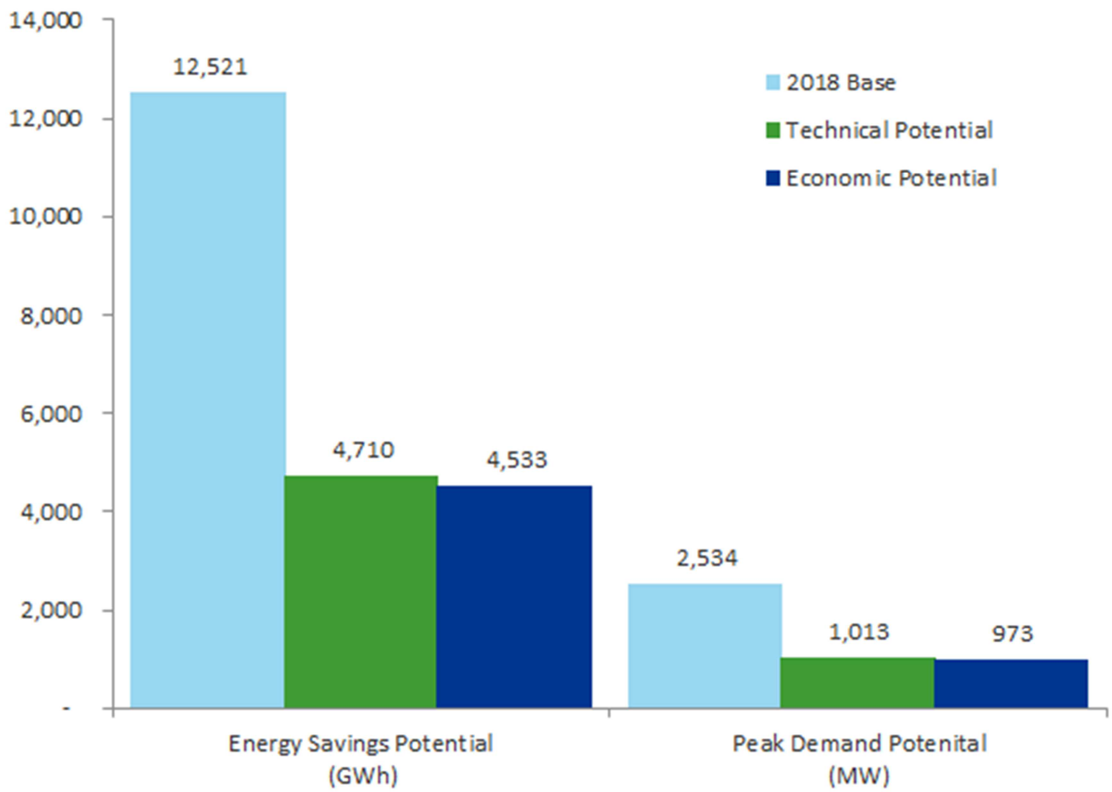


Figure 5-11: Estimated Electric Technical and Economic Potential, 2016-2025

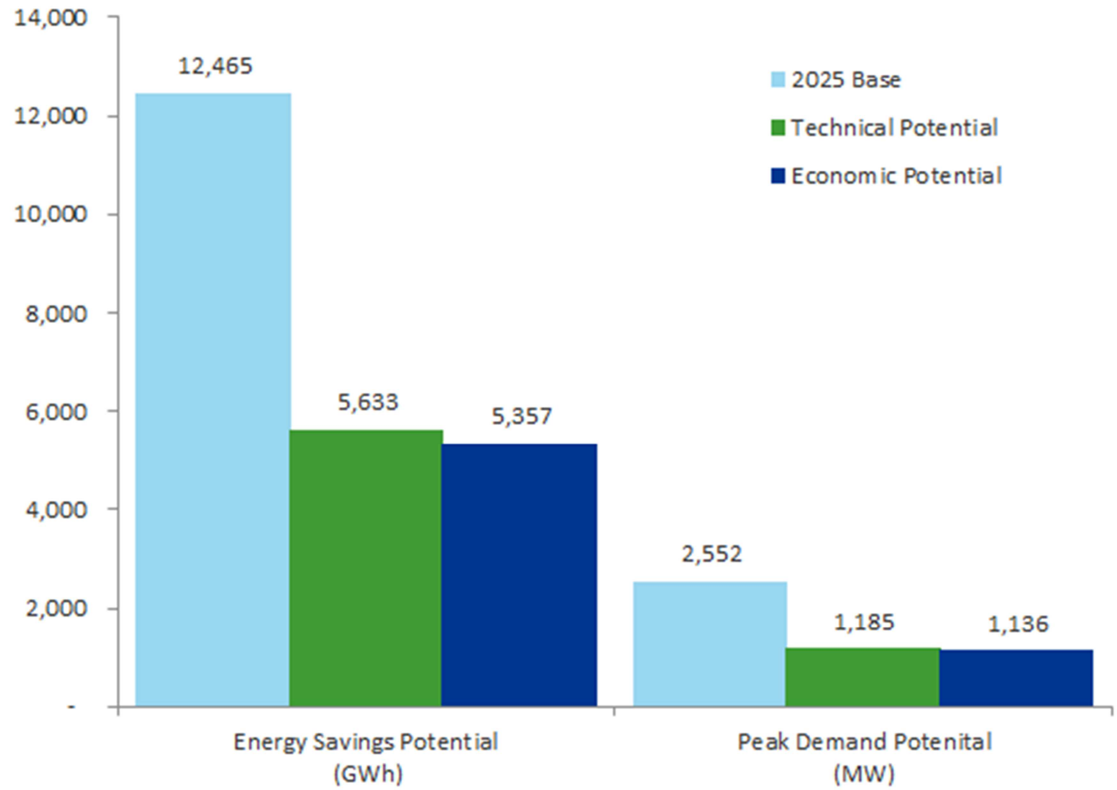


Table 5-17 and Table 5-18 show technical and economic potential for energy and demand for the 2016 to 2018 time frame, respectively. The values of both energy savings and peak-demand reductions are incorporated into the measure TRC test.

- **Energy Savings:** Technical potential is estimated at 4,710 GWh per year, and economic potential at 4,533 GWh per year by 2018 (about 38 and 36 percent of base 2018 usage, respectively).
- **Peak-Demand Savings:** Technical potential is estimated at 1,013 MW and economic potential at 973 MW by 2018 (about 24 and 23 percent of base 2018 demand, respectively).

Table 5-17: Estimated Technical and Economic Usage Savings Potential, 2016-2018 – Electric

Sector	2018 Base Usage (GWh)	Technical Potential (GWh)	Technical as Percent of Sector Base	Economic Potential (GWh)	Economic as Percent of Sector Base
Commercial	9,318	3,881	42%	3,792	41%
Industrial	3,203	828	26%	741	23%
Total	**12,521**	**4,710**	**38%**	**4,533**	**36%**

Table 5-18: Estimated Technical and Economic Demand Savings Potential, 2016-2018 – Electric

Sector	2018 Base Demand (MW)	Technical Potential (MW)	Technical as Percent of Sector Base	Economic Potential (MW)	Economic as Percent of Sector Base
Commercial	2,135	918	43%	891	42%
Industrial	399	95	24%	82	21%
Total	**2,534**	**1,013**	**40%**	**973**	**38%**

Table 5-19 and Table 5-20 show technical and economic potential for energy and demand for the 2016 to 2025 time frame, respectively. The values of both energy savings and peak-demand reductions are incorporated into the measure TRC test.

- **Energy Savings:** Technical potential is estimated at 5,633GWh per year, and economic potential at 5,357GWh per year by 2025 (about 45 and 43 percent of base 2025 usage, respectively).
- **Peak-Demand Savings:** Technical potential is estimated at 1,185 MW and economic potential at 1,136 MW by 2025 (about 39 and 37 percent of base 2025 demand, respectively).

Table 5-19: Estimated Technical and Economic Usage Savings Potential, 2016-2025 - Electric

Sector	2025 Base Usage (GWh)	Technical Potential (GWh)	Technical as Percent of Sector Base	Economic Potential (GWh)	Economic as Percent of Sector Base
Commercial	9,554	4,764	50%	4,567	48%
Industrial	2,910	868	30%	789	27%
Total	**12,465**	**5,633**	**45%**	**5,357**	**43%**

Table 5-20: Estimated Technical and Economic Demand Savings Potential, 2016-2025 - Electric

Sector	2025 Base Demand (MW)	Technical Potential (MW)	Technical as Percent of Sector Base	Economic Potential (MW)	Economic as Percent of Sector Base
Commercial	2,190	1,083	49%	1,046	48%
Industrial	363	102	28%	90	25%
Total	**2,552**	**1,185**	**46%**	**1,136**	**45%**

5.2.2 Overall Technical and Economic Potential - Gas

Figure 5-12 and Figure 5-13 presents the overall estimates of total technical and economic potential for natural gas energy savings for National Grid for the 2016 to 2018 and 2016 to 2025 time periods.

Figure 5-12. Estimated Natural Gas Savings Potential, 2016-2018

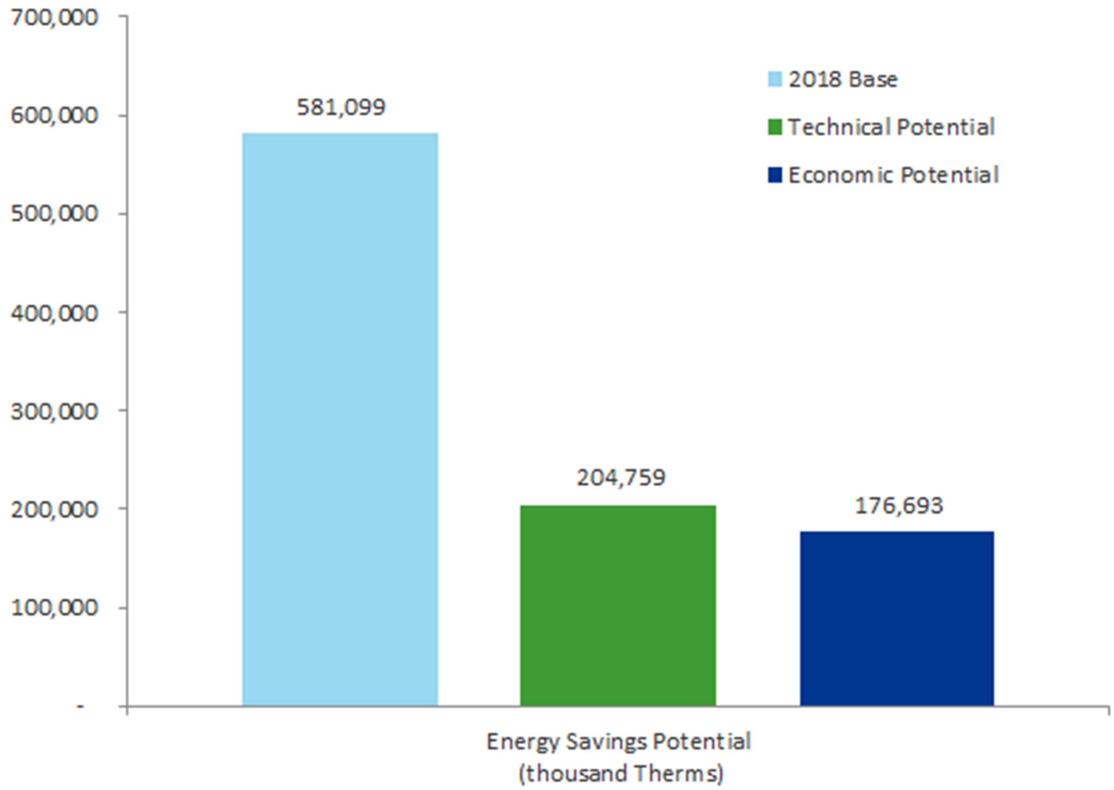


Figure 5-13. Estimated Natural Gas Technical and Economic Potential, 2016-2025

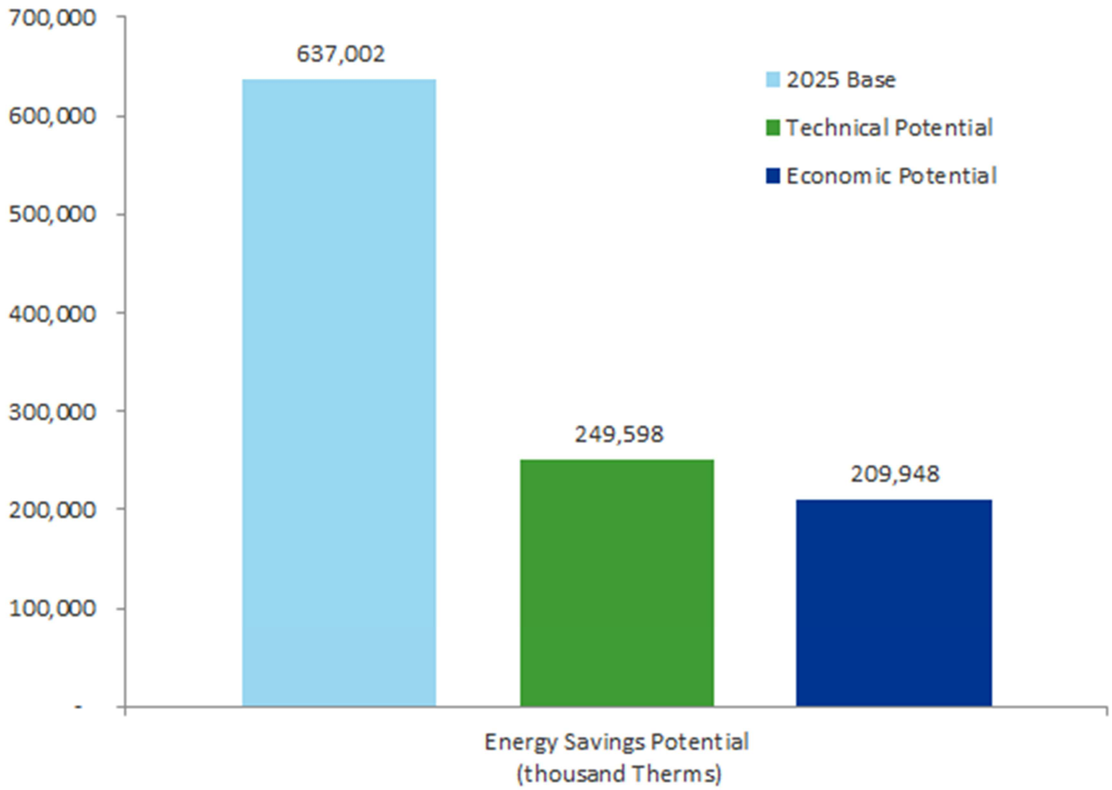


Table 5-21 and Table 5-22 show technical and economic potential for gas. The values of the energy savings are incorporated into the measure TRC test. Technical potential is estimated at 204,759 thousand therms per year, and economic potential at 176,693 thousand therms per year by 2018 (about 35 and 30 percent of base 2018 usage, respectively).

Table 5-21. Estimated Technical and Economic Demand Savings Potential, 2016-2018 – Natural Gas

Sector	2018 Base Usage (thousand Therms)	Technical Potential (thousand Therms)	Technical as Percent of Sector Base	Economic Potential (thousand Therms)	Economic as Percent of Sector Base
Commercial	512,915	184,472	36%	158,672	31%
Industrial	68,184	20,287	30%	18,021	26%
Total	**581,099**	**204,759**	**35%**	**176,693**	**30%**

Table 5-22. Estimated Technical and Economic Demand Savings Potential, 2016-2025 – Natural Gas

Sector	2025 Base Usage (thousand Therms)	Technical Potential (thousand Therms)	Technical as Percent of Sector Base	Economic Potential (thousand Therms)	Economic as Percent of Sector Base
Commercial	551,417	225,886	41%	188,610	34%
Industrial	85,585	23,712	28%	21,338	25%
Total	**637,002**	**249,598**	**39%**	**209,948**	**33%**

5.2.3 Base Case Technical and Economic Potential Detail

This section describes technical and economic potential in more detail, and further describes potentials by sector, state, building type, and by end use.

5.2.3.1 Potentials by Sector – Electric

Figure 5-14 and Figure 5-15 present the sector (commercial vs. industrial) breakdown of technical and economic potential as compared to the total base consumption and demand in 2018, while Figure 5-16 and Figure 5-17 present the same information for the ten year time frame.

Figure 5-14: Technical and Economic Potential Energy Savings by Sector, 2016-2018 – Electric

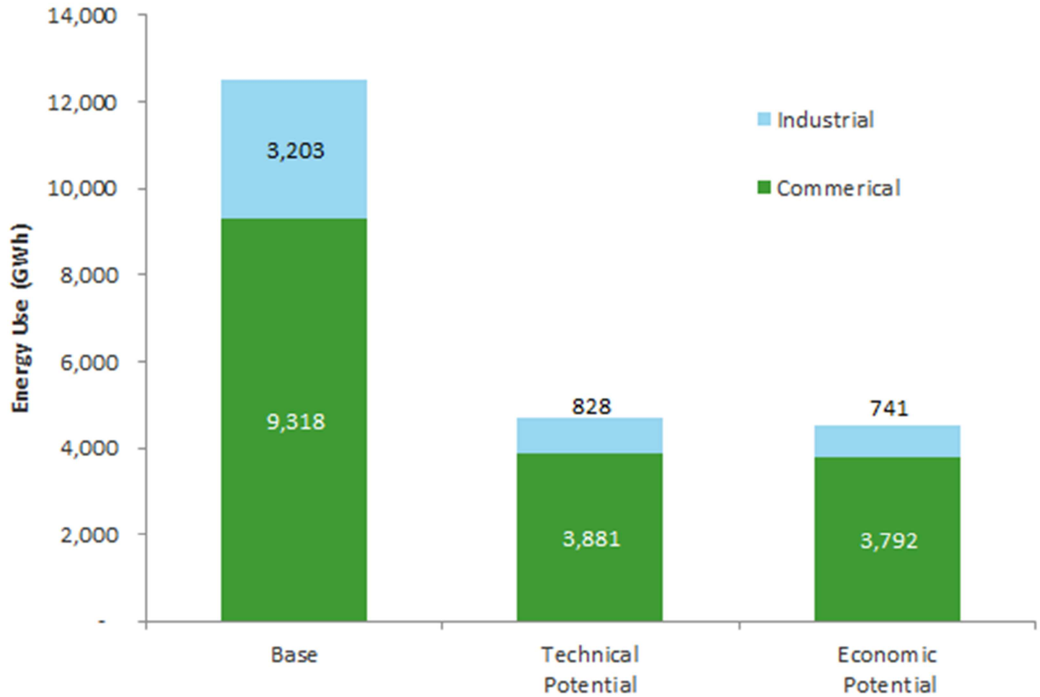


Figure 5-15: Technical and Economic Potential Peak Demand Savings by Sector, 2016-2018 – Electric

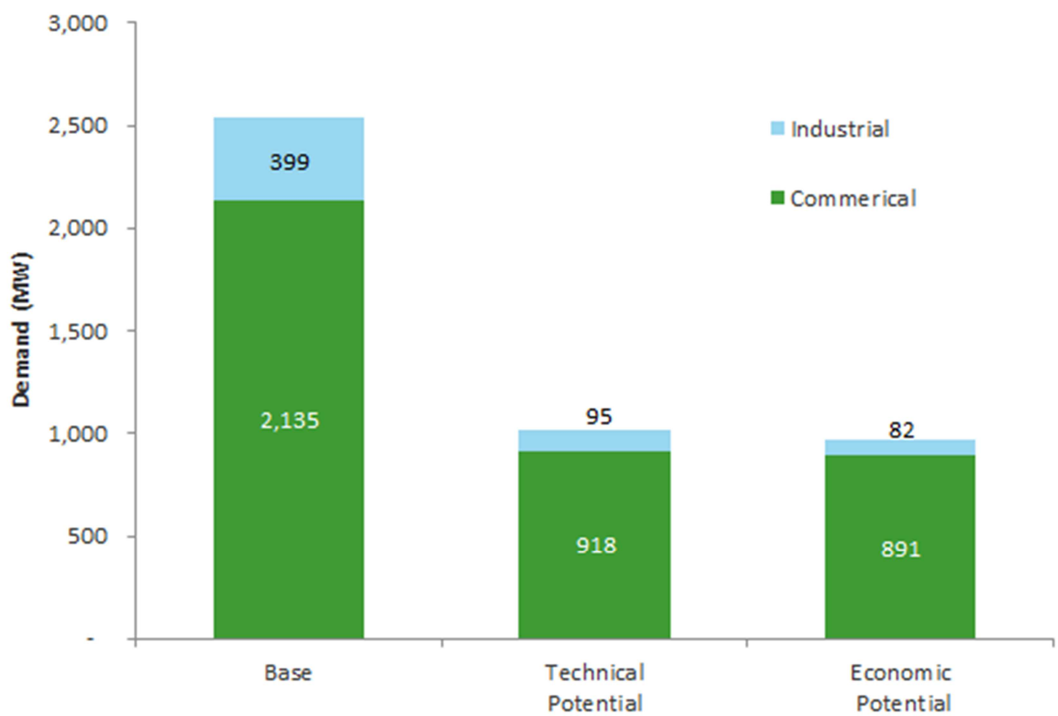


Figure 5-16: Technical and Economic Potential Energy Savings by Sector, 2016- 2025 - Electric

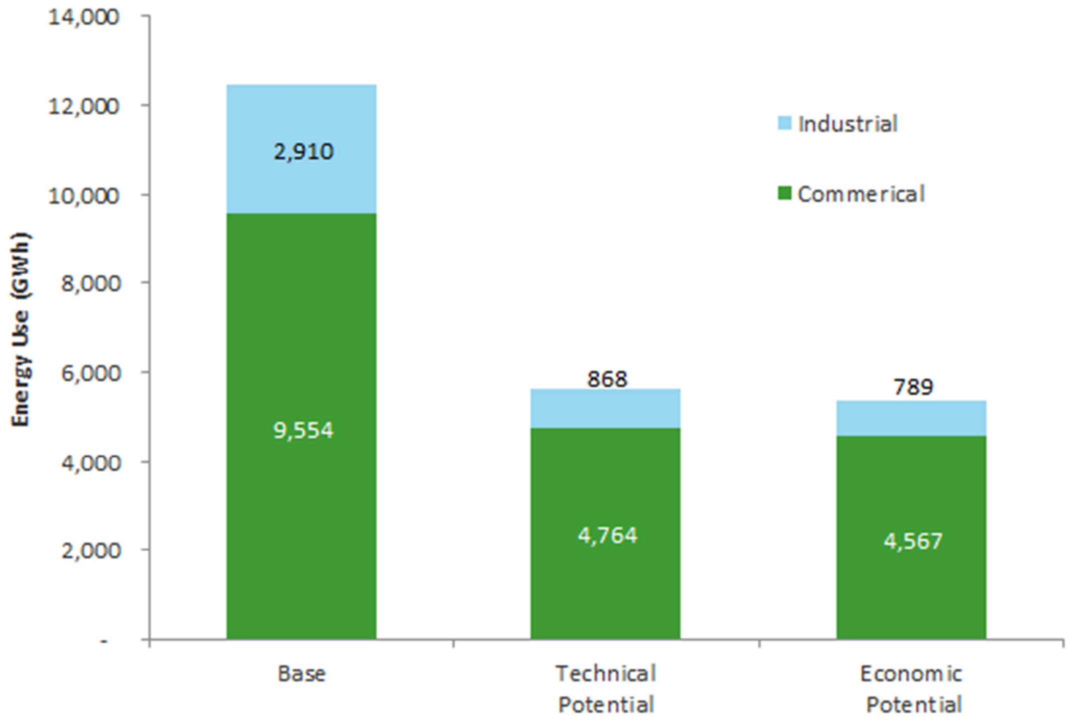


Figure 5-17: Technical and Economic Potential Demand Savings by Sector, 2016-2025 - Electric

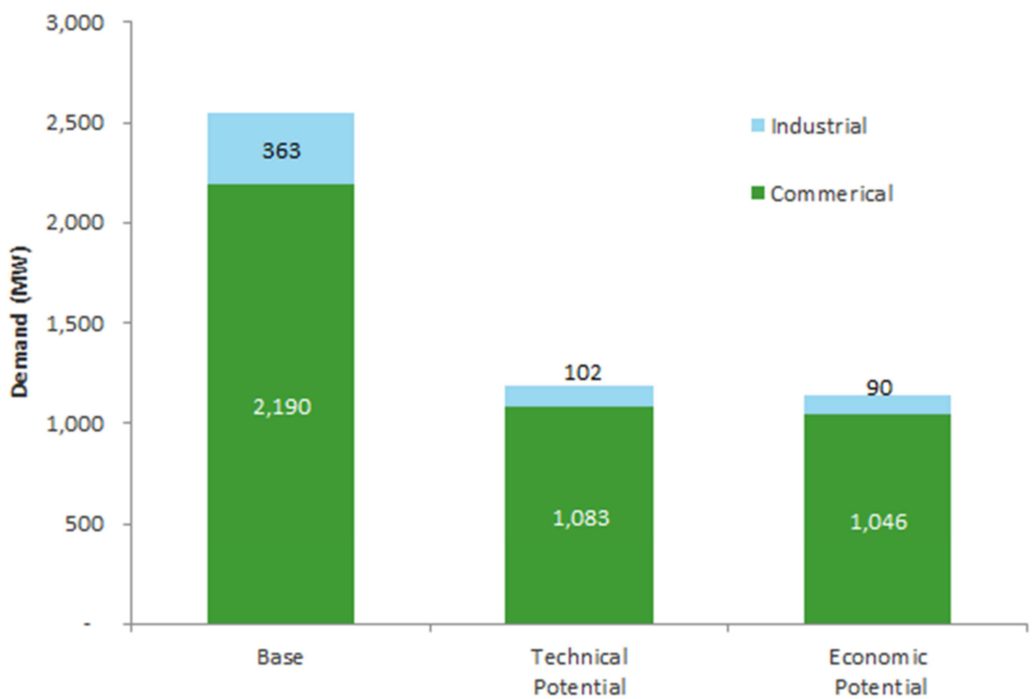


Table 5-23 and Table 5-24 show the contribution of technical and economic potential from each sector for 2018, also broken down by retrofit ("existing") versus new construction/replace on burnout/normal replacement markets ("new"). These tables also compare the potential savings of each sector to base consumption.

Table 5-23: Technical and Economic Potential Energy Savings by Sector and Vintage, 2016-2018 – Electric

Sector Type	2018 Base Energy Usage (GWh)	Technical Potential (GWh)	Technical as Percent of Sector Base	Economic Potential (GWh)	Economic as Percent of Sector Base
Commercial Existing	7,037	3,043	43%	3,017	43%
Commercial New	2,281	838	37%	774	34%
Commercial Subtotal	*9,318*	*3,881*	*42%*	*3,792*	*41%*
Industrial Existing	2,430	726	30%	643	26%
Industrial New	773	102	13%	98	13%
Industrial Subtotal	*3,203*	*828*	*26%*	*741*	*23%*
Total	**12,521**	**4,710**	***38%***	**4,533**	***36%***

*Number may be slightly off due to rounding

Table 5-24: Technical and Economic Potential Demand Savings by Sector and Vintage, 2016-2018 - Electric

Sector Type	2018 Base Energy Usage (MW)	Technical Potential (MW)	Technical as Percent of Sector Base	Economic Potential (MW)	Economic as Percent of Sector Base
Commercial Existing	1,613	742	46%	723	45%
Commercial New	525	176	34%	168	32%
Commercial Subtotal	*2,135*	*918*	*43%*	*891*	*42%*
Industrial Existing	303	83	27%	70	23%
Industrial New	96	13	13%	12	13%
Industrial Subtotal	*399*	*95*	*24%*	*82*	*21%*
Total	**2,534**	**1,013**	***40%***	**973**	***38%***

*Number may be slightly off due to rounding

Table 5-25 and Table 5-26 show the contribution of technical and economic potential from each sector for 2025 also broken down by existing versus new markets. These tables also compare the potential savings of each sector to base consumption. The commercial sector has higher technical and economic energy savings potential in relation to base energy use than does the industrial sector.

Table 5-25: Technical and Economic Potential Energy Savings by Sector and Vintage, 2016-2025 – Electric

Sector Type	2025 Base Energy Usage (GWh)	Technical Potential (GWh)	Technical as Percent of Sector Base	Economic Potential (GWh)	Economic as Percent of Sector Base
Commercial Existing	4,543	2,459	54%	2,438	54%
Commercial New	5,011	2,305	46%	2,129	42%
Commercial Subtotal	*9,554*	*4,764*	*50%*	*4,567*	*48%*
Industrial Existing	1,397	587	42%	520	37%
Industrial New	1,513	282	19%	270	18%
Industrial Subtotal	*2,910*	*868*	*30%*	*789*	*27%*
Total	**12,465**	**5,633**	***45%***	**5,357**	***43%***

*Number may be slightly off due to rounding

Table 5-26: Technical and Economic Potential Demand Savings by Sector and Vintage, 2016-2025- Electric

Sector Type	2025 Base Energy Usage (MW)	Technical Potential (MW)	Technical as Percent of Sector Base	Economic Potential (MW)	Economic as Percent of Sector Base
Commercial Existing	1,038	599	58%	584	56%
Commercial New	1,151	484	42%	462	40%
Commercial Subtotal	*2,190*	*1,083*	*49%*	*1,046*	*48%*
Industrial Existing	174	67	38%	57	33%
Industrial New	189	35	18%	33	18%
Industrial Subtotal	*363*	*102*	*28%*	*90*	*25%*
Total	**2,552**	**1,185**	***46%***	**1,136**	***45%***

*Number may be slightly off due to rounding

5.2.3.2 Potentials by Sector – Natural Gas

The figures below present the sector (commercial vs. industrial) breakdown of technical and economic potential as compared to the total base consumption in 2018 and 2025, respectively.

Figure 5-18. Technical and Economic Potential Energy Savings by Sector, 2016-2018 – Natural Gas

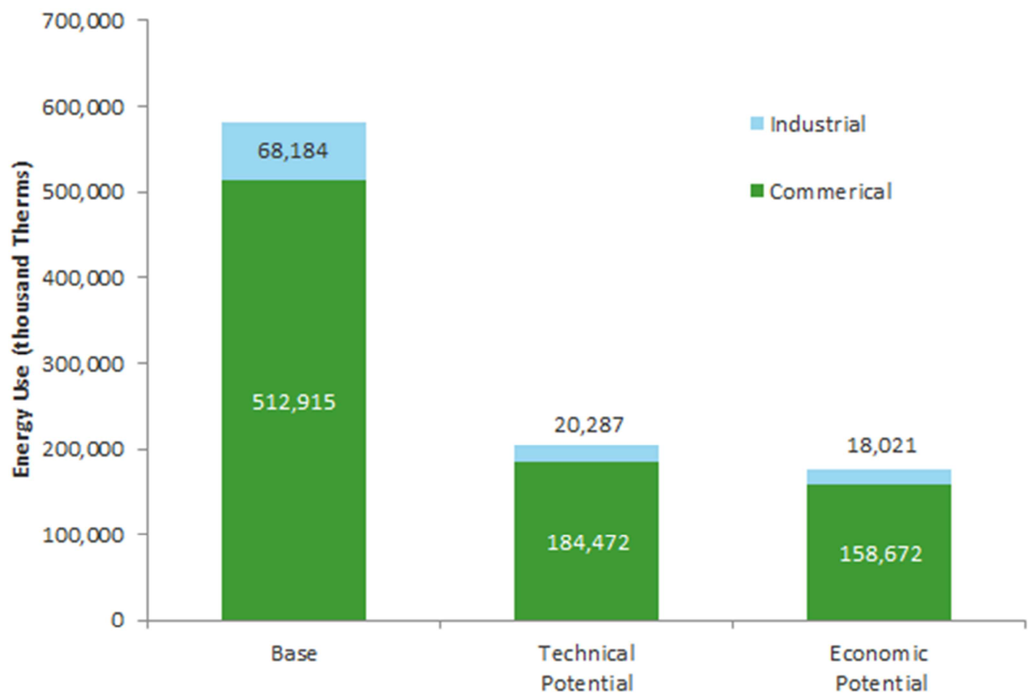


Figure 5-19. Technical and Economic Potential Energy Savings by Sector, 2016- 2025 – Natural Gas

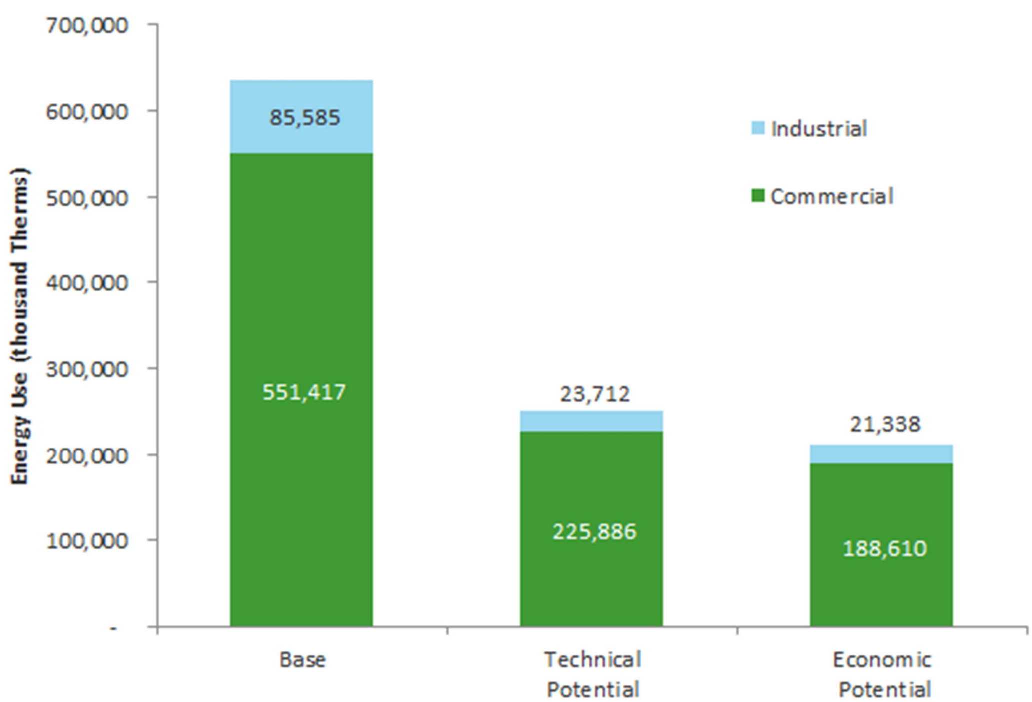


Table 5-27 and Table 5-28 show the contribution of technical and economic potential from each sector for 2018 and 2025, respectively, which are also broken down by retrofit versus new construction/ replace on burnout/normal replacement markets. These tables also compare the potential savings of each sector to base consumption. The commercial sector has higher technical and economic energy savings potential in relation to base energy use than does the industrial sector.

Table 5-27. Technical and Economic Potential Energy Savings by Sector Type, 2015-2018 – Natural Gas (thousand therms)

Sector Type	2018 Base Energy Usage (thousand therms)	Technical Potential (thousand therms)	Technical as Percent of Sector Base	Economic Potential (thousand therms)	Economic as Percent of Sector Base
Commercial Existing	435,654	144,907	33%	127,567	29%
Commercial New	77,261	39,565	51%	31,105	40%
Commercial Subtotal	*512,915*	*184,472*	*36%*	*158,672*	*31%*
Industrial Existing	51,439	16,517	32%	14,531	28%
Industrial New	16,745	3,769	23%	3,490	21%
Industrial Subtotal	*68,184*	*20,287*	*30%*	*18,021*	*26%*
Total	581,099	204,759	35%	176,693	30%

*Number may be slightly off due to rounding

Table 5-28. Technical and Economic Potential Energy Savings by Sector Type, 2016-2025 – Natural Gas (Thousand Therms)

Sector Type	2025 Base Energy Usage (thousand therms)	Technical Potential (thousand therms)	Technical as Percent of Sector Base	Economic Potential (thousand therms)	Economic as Percent of Sector Base
Commercial Existing	343,863	117,083	34%	103,072	30%
Commercial New	207,554	108,803	52%	85,538	41%
Commercial Subtotal	*551,417*	*225,886*	*41%*	*188,610*	*34%*
Industrial Existing	40,601	13,346	33%	11,741	29%
Industrial New	44,984	10,366	23%	9,597	21%
Industrial Subtotal	*85,585*	*23,712*	*28%*	*21,338*	*25%*
Total	637,002	249,598	39%	209,948	33%

*Number may be slightly off due to rounding

5.2.3.3 Potentials by Building Type - Electric

This section presents technical and economic potential by commercial building type to provide more detail about where potential savings exist in National Grid's service territory.

Figure 5-20 and Figure 5-21 show the building type breakdown of commercial and industrial potential for 2018. Here, the industrial sector is included as a building type. Industrial buildings account for about 14 percent of the economic energy and 8 percent of the economic demand potential, while offices account for about 31 percent of the economic energy and 48 percent of the economic demand potential. This is followed by other (miscellaneous) buildings (13 percent of energy and 18 percent of demand potential). All other building types account for less than 10 percent of energy and demand potential.

Figure 5-20: Energy Savings Potential by Building Type, 2016-2018

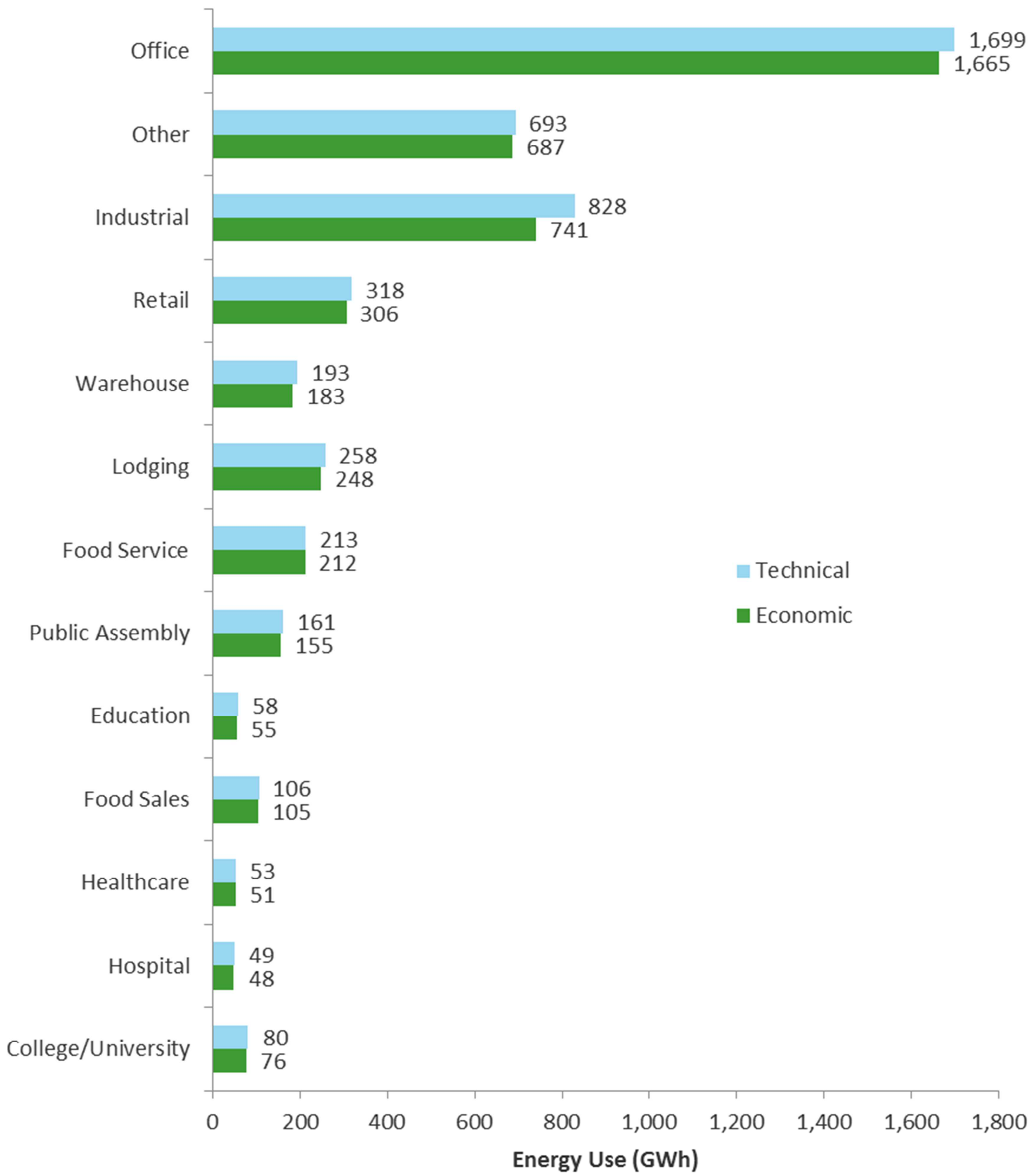


Figure 5-21: Demand Savings Potential by Building Type, 2016-2018

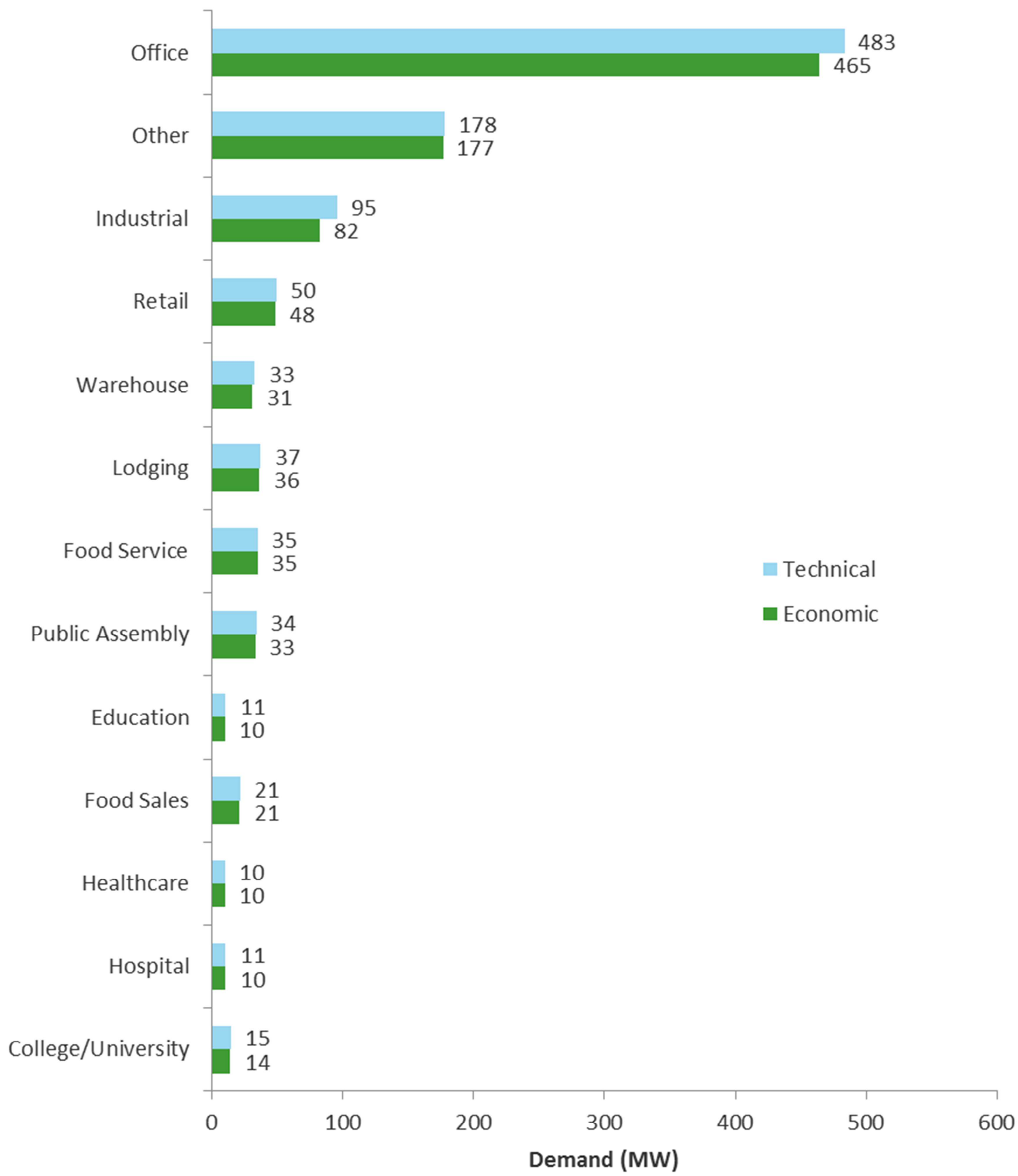


Table 5-29 shows the building type breakdown of commercial and industrial potential for 2018.

Table 5-29: Energy and Demand Savings Potential by Building Type, 2018.

Building Type	Energy (GWh)		Demand(MW)	
	Technical	Economic	Technical	Economic
College/University	80	76	15	14
Hospital	49	48	11	10
Healthcare	53	51	10	10
Food Sales	106	105	21	21
Education	58	55	11	10
Public Assembly	161	155	34	33
Food Service	213	212	35	35
Lodging	258	248	37	36
Warehouse	193	183	33	31
Retail	318	306	50	48
Industrial	828	741	95	82
Other	693	687	178	177
Office	1,699	1,665	483	465
Total	**4,710**	**4,533**	**1,013**	**973**

Figure 5-22 and Figure 5-23 show the building type breakdown of commercial and industrial potential for 2025. Here, the industrial sector is included as a building type. Industrial buildings account for about 15 percent of the economic energy and 8 percent of the economic demand potential, while offices account for about 36 percent of the economic energy and 46 percent of the economic demand potential. This is followed by other (miscellaneous) buildings (16 percent of energy and 19 percent of demand potential). All other building types account for less than 10 percent of energy and demand potential.

Figure 5-22: Energy Savings Potential by Building Type, 2016-2025

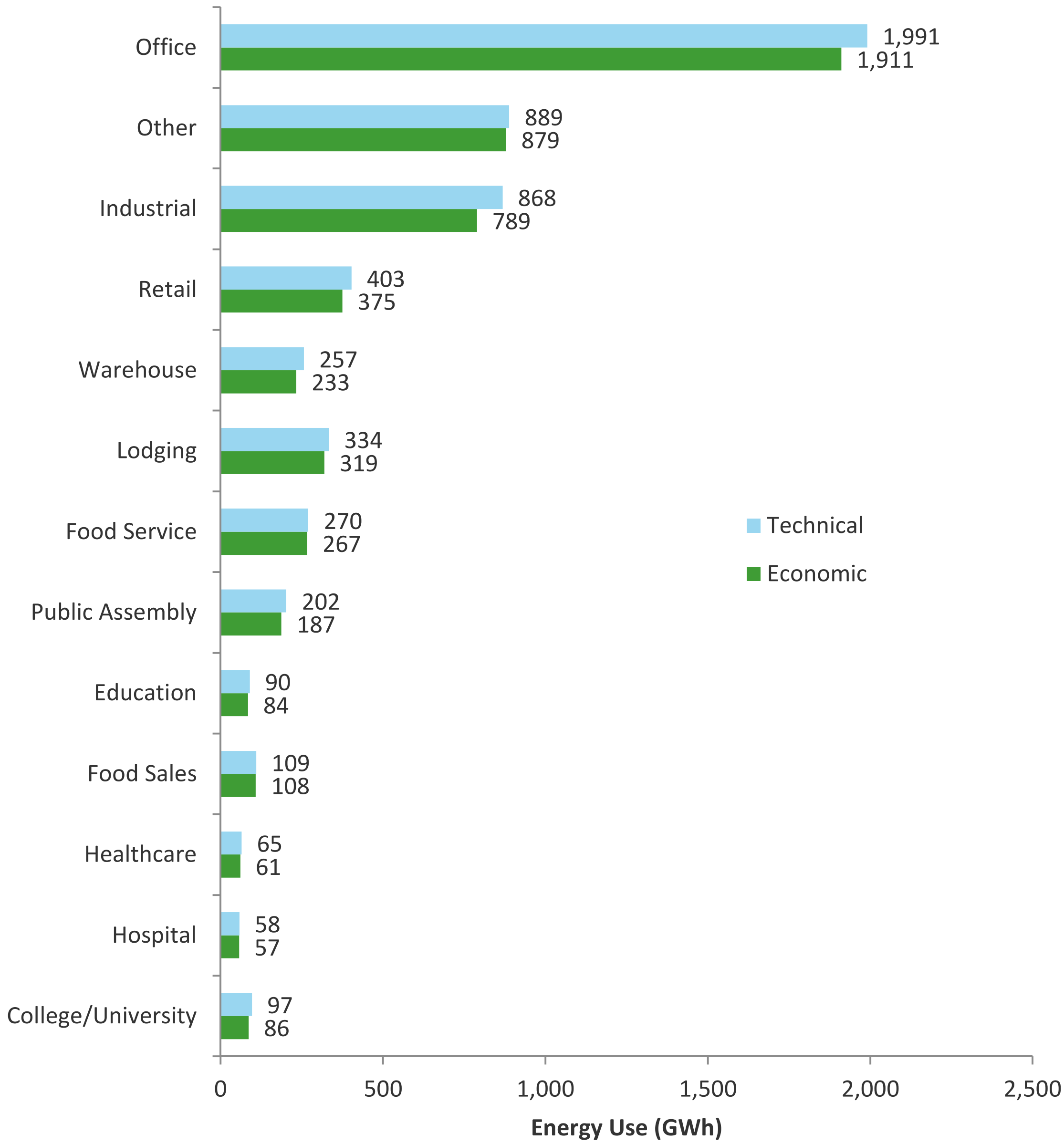


Figure 5-23. Demand Savings Potential by Building Type, 2016-2025

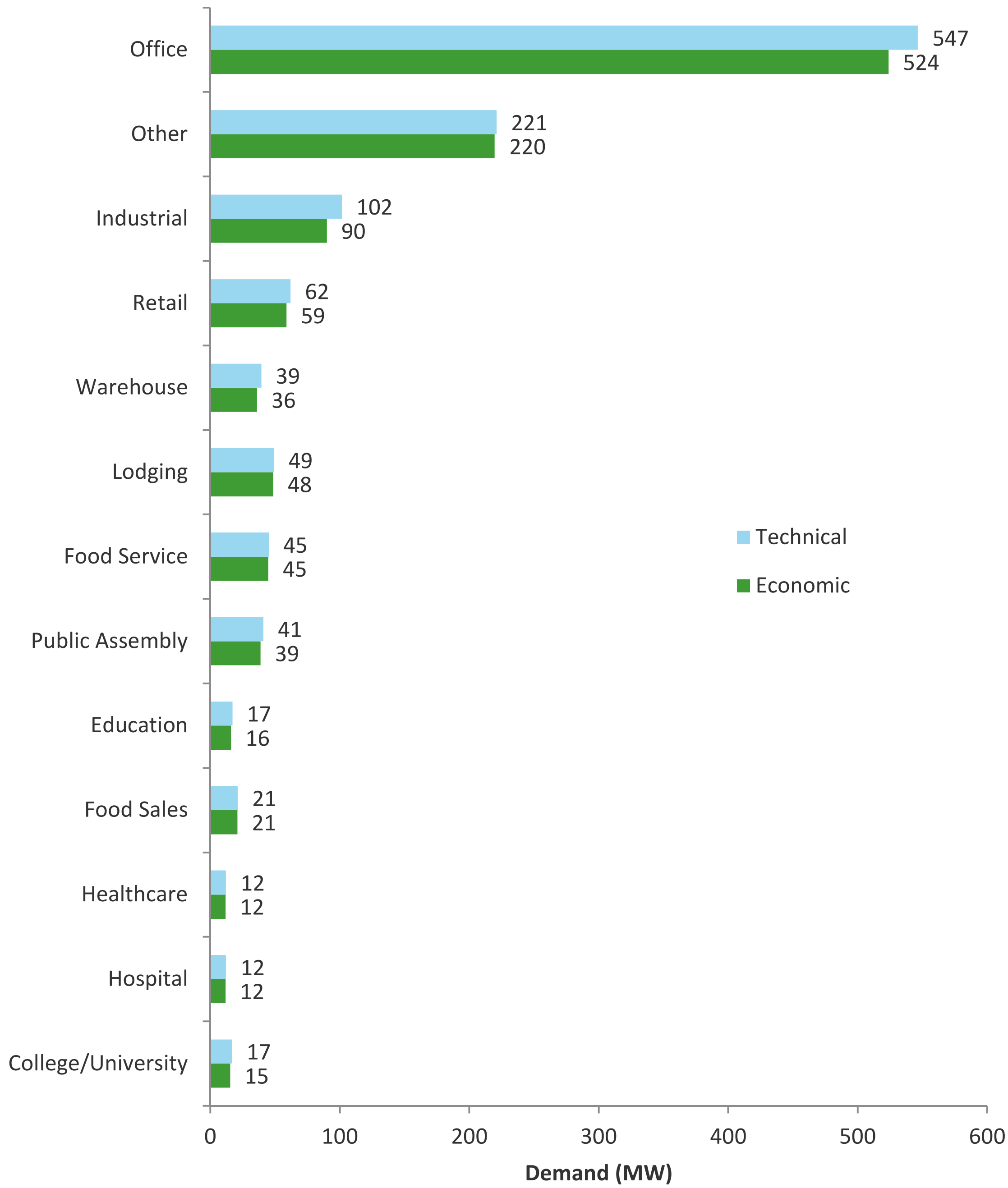


Table 5-30 also presents energy and demand savings potential by building type.

Table 5-30: Energy and Demand Savings Potential by Building Type, 2025

Building Type	Energy (GWh)		Demand(MW)	
	Technical	Economic	Technical	Economic
College/University	97	86	17	15
Hospital	58	57	12	12
Healthcare	65	61	12	12
Food Sales	109	108	21	21
Education	90	84	17	16
Public Assembly	202	187	41	39
Food Service	270	267	45	45
Lodging	334	319	49	48
Warehouse	257	233	39	36
Retail	403	375	62	59
Industrial	868	789	102	90
Other	889	879	221	220
Office	1,991	1,911	547	524
Total	**5,633**	**5,357**	**1,185**	**1,136**

5.2.3.4 Potential by Building Type – Natural Gas

This section presents technical and economic potential by commercial building type to provide more detail about where potential gas savings exist in National Grid's service territory. Figure 5-24 shows the building type breakdown of commercial and industrial gas potential for 2018. Here, the industrial sector is included as a building type. Industrial buildings account for about 10 percent of the economic energy potential, while offices account for about 41 percent of the economic energy potential. This is followed by retail buildings, which account for 13 percent of economic energy potential. All other building types account for 36 percent of economic energy potential.

Figure 5-24. Natural Gas Energy Savings Potential by Building Type, 2016-2018

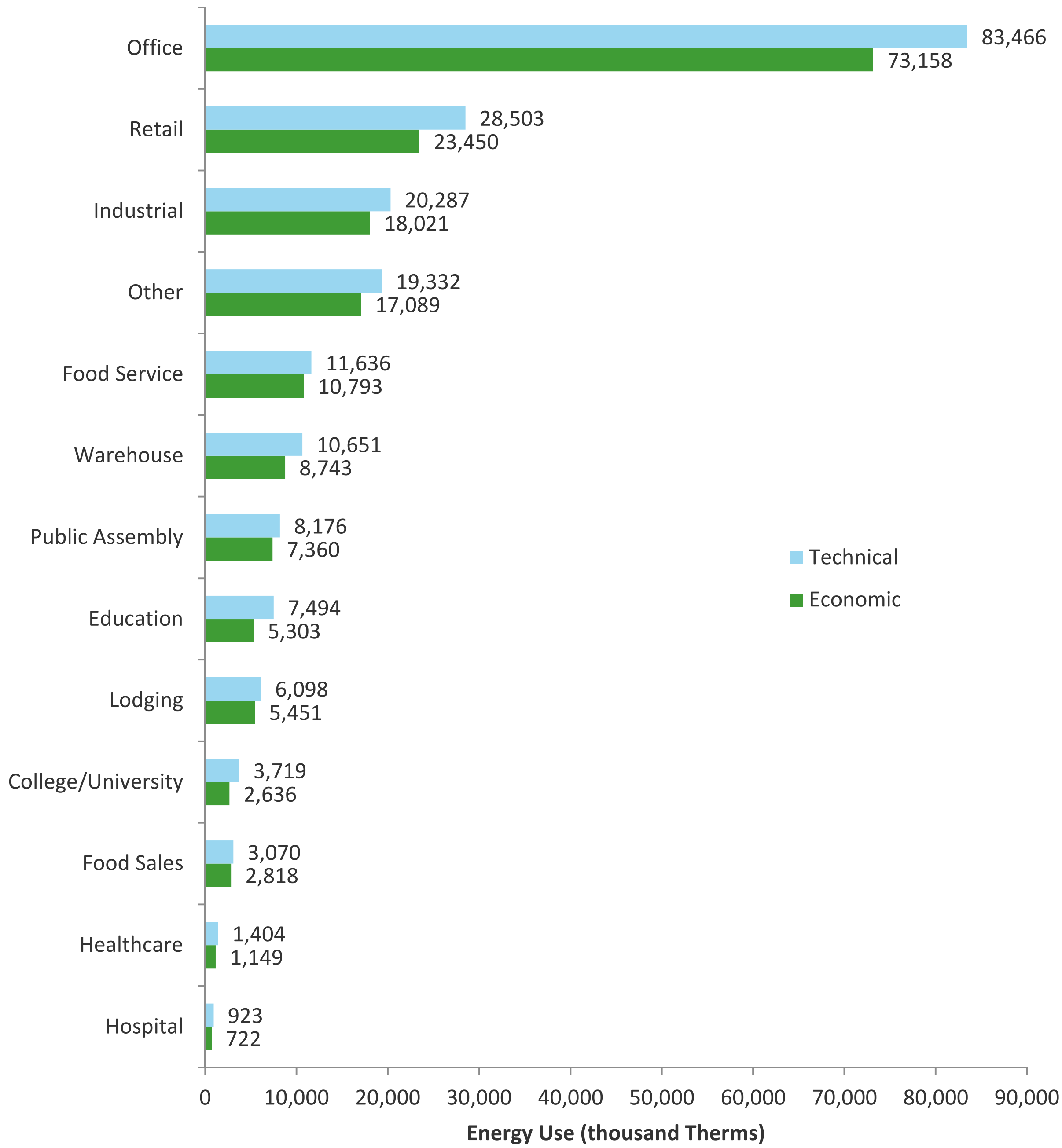


Table 5-31 shows the building type breakdown of commercial and industrial gas potential for 2018.

Table 5-31. Natural Gas Energy Savings Potential by Building Type, 2018

Building Type	Energy (thousand therms)	
	Technical	Economic
Hospital	923	722
Healthcare	1,404	1,149
Food Sales	3,070	2,818
College/University	3,719	2,636
Lodging	6,098	5,451
Education	7,494	5,303
Public Assembly	8,176	7,360
Warehouse	10,651	8,743
Food Service	11,636	10,793
Other	19,332	17,089
Industrial	20,287	18,021
Retail	28,503	23,450
Office	83,466	73,158
Total	**204,759**	**176,693**

Figure 5-25 shows the building type breakdown of commercial and industrial potential for 2025. Here, the industrial sector is included as a building type. Industrial buildings account for about 10 percent of the economic energy potential, while offices account for about 41 percent of the economic energy potential. This is followed by retail buildings, which account for 13 percent of economic energy potential. All other building types account for 36 percent of economic energy potential.

Figure 5-25. Natural Gas Energy Savings Potential by Building Type, 2016-2025

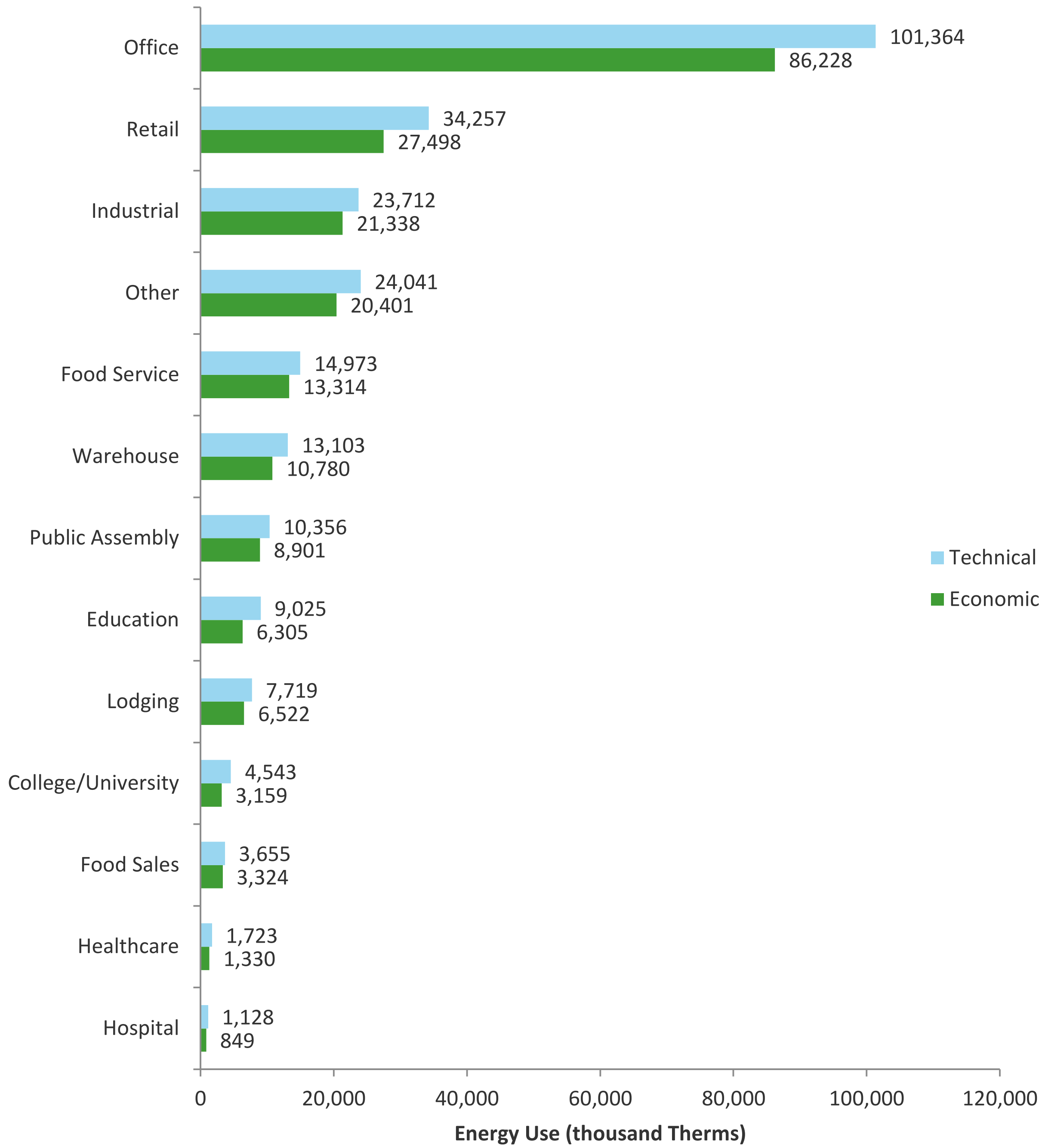


Table 5-32 also presents gas energy savings potential by building type.

Table 5-32. Natural Gas Energy Savings Potential by Building Type, 2025

Building Type	Energy (thousand therms)	
	Technical	Economic
Hospital	1,128	849
Healthcare	1,723	1,330
Food Sales	3,655	3,324
College/University	4,543	3,159
Lodging	7,719	6,522
Education	9,025	6,305
Public Assembly	10,356	8,901
Warehouse	13,103	10,780
Food Service	14,973	13,314
Other	24,041	20,401
Industrial	23,712	21,338
Retail	34,257	27,498
Office	101,364	86,228
Total	**249,598**	**209,948**

5.3 Achievable (Program) Potential

This section provides a high-level summary of the achievable potential analysis, based on the results of the technical and economic potential analyses. The detailed outputs of the achievable analysis are included in the appendices.

In contrast to the technical and economic potential estimates which are based on measure-level costs and savings, the estimates of achievable potential take into account market conditions such as awareness and other factors that affect the adoption of efficiency measures. As further described in Section 4.4, the method of estimating measure adoption takes into account market barriers and program incentives and reflects actual consumer and business implicit discount rates. This portion of the analysis also includes program marketing and administrative budgets as they impact the savings potential and are used in the analysis of the total resource cost and other cost benefit tests.

In this analysis, achievable potential refers to the amount of savings that would occur in response to one or more specific program interventions. Gross or total market savings shown in this section includes net savings and savings attributable to program free-riders – those customers who would have installed the measure in the absence of the program. Net or program savings associated with program potential are savings that are projected beyond those that would occur naturally in the absence of any market intervention.

The achievable analysis typically begins by calibrating budgets and savings to recent program results.[13] Based on input from National Grid staff, DNV GL set incentives as a specified cents per kWh saved by end-use and implementation type, based on National Grid's 2014 program data. In National Grid's current programs, lighting incentives are implemented in this way, while other measures are still incented at a percent of incremental cost (industrial for example pays 50 percent of incremental cost for retrofit measures and 75 percent for new and replace-on-burnout measures). The research team used the cents per kWh approach because National Grid intends to move in that direction for all its programs, but the mismatch between the modeling approach and actual practice in 2014 (the calibration year) made it difficult to line the results up perfectly with the results of the 2014 program. Because the research team was attempting to match National Grid's current programs, this is referred to as the business-as-usual (BAU) scenario.

Because achievable potential depends on the type and degree of intervention applied, per the direction of National Grid, DNV GL also developed potential estimates under two alternative funding scenarios: a 25 Percent Plus and 75 Percent Plus scenario with each scenario defined as follows:

- 25 Percent Plus: Increased customer incentives, expressed as dollars per kWh of savings, by 25 percent, not to exceed 100 percent of incremental costs. In the commercial model, 36 percent of measures capped out at 100 percent incentives under this scenario; in the industrial model 27 percent did. The average incentive (as a percent of incremental cost) paid under the scenario in 2016 was 72 percent for commercial and 79 percent for industrial.
- 75 Percent Plus: Increase customer incentives by 75 percent over the base costs, again not to exceed 100 percent of incremental costs. A 75 percent increase pushes most measures to the 100 percent cap. In the commercial model, 45 percent of measures capped out at 100 percent incentives under this scenario; in the industrial model 42 percent did. The average incentive paid under the scenario in 2016 was 81 percent for commercial and 91 percent for industrial.

DNV GL estimated program energy and peak demand savings under each scenario for the 2016 to 2025 and 2016 to 2018 period.

5.3.1 Electric

Table 5-33 presents the overall results of the electric energy efficiency potential analysis for the 2016 to 2018 period. Technical, economic, and achievable (program) potential estimates, to the extent possible, exclude customers who do not pay a systems benefit charge.[14] The research team accomplished this by omitting the floor space for these customers from the building stock estimates used in the analysis.

13 The calibration stage only includes measures that can be mapped to National Grid programs. All cost-effective measures are included in the funding scenario analyses.

14 Customers who do not pay a benefit charge are not eligible to participate in National Grid's DSM programs and were, to the extent possible, excluded from the technical, economic and program savings analyses.

Table 5-33: Summary of Cumulative Electric Energy Efficiency Savings, 2016-2018

Energy Efficiency 2016-2018	Technical Potential	Economic Potential	Achievable Program Savings Potential: Business as Usual	Achievable Program Savings Potential: 25% Plus Incentives	Achievable Program Savings Potential: 75% Plus Incentives	Naturally Occurring Savings Potential
Energy Savings-GWh	4,710	4,533	686	761	867	34
Demand Savings-MW	1,013	973	127	141	160	6
Cumulative Program Costs-Real, $ Million	N/A	N/A	$216	$270	$356	N/A

Table 5-34 shows the same results for the 2016 to 2025 time frame.

Table 5-34: Summary of Cumulative Electric Energy Efficiency Savings, 2016-2025

Energy Efficiency 2016-2025	Technical Potential	Economic Potential	Achievable Program Savings Potential: Business as Usual	Achievable Program Savings Potential: 25% Plus Incentives	Achievable Program Savings Potential: 75% Plus Incentives	Naturally Occurring Savings Potential
Energy Savings-GWh	5,633	5,357	1,597	1,728	1,941	97
Demand Savings-MW	1,185	1,136	309	336	380	16
Cumulative Program Costs-Real, $ Million	N/A	N/A	$573	$689	$895	N/A

Table 5-35 shows the results of the achievable analysis as compared to base consumption, technical potential, and economic potential for the 2016 to 2018 time frame. The energy savings estimates from the BAU scenario are 6 percent of base, the estimates from the 25% plus scenario are 6 percent of base and the estimates from the 75% plus scenario are 7 percent of base.

Table 5-35. Three Year Cumulative Annual Potential (2016-2018) – GWh

Sector	2018 Base Energy Use	Three Year Cumulative Annual Potential - GWh					
		Technical Potential	Economic Potential	BAU Scenario (Net)	25% Plus Scenario (Net)	75% Plus Scenario (Net)	Naturally Occurring
Commercial	9,318	3,881	3,792	546	599	663	25
Savings % of Base		**42%**	**41%**	**6%**	**6%**	**7%**	**0.3%**
Industrial	3,203	828	741	140	162	204	8
Savings % of Base		**26%**	**23%**	**4%**	**5%**	**6%**	**0.3%**
Total	12,521	4,710	4,533	686	761	867	34
Savings % of Base		**38%**	**36%**	**6%**	**6%**	**7%**	**0.3%**

Table 5-36 shows the same results for the 2016 to 2025 time frame. The achievable energy savings estimates from the BAU scenario are 13 percent of base consumption; while overall energy savings under the 25 Percent Plus scenario are projected to be 14 percent of base consumption. Finally, under the 75 Percent Plus scenario, energy savings estimates are 16 percent of base consumption.

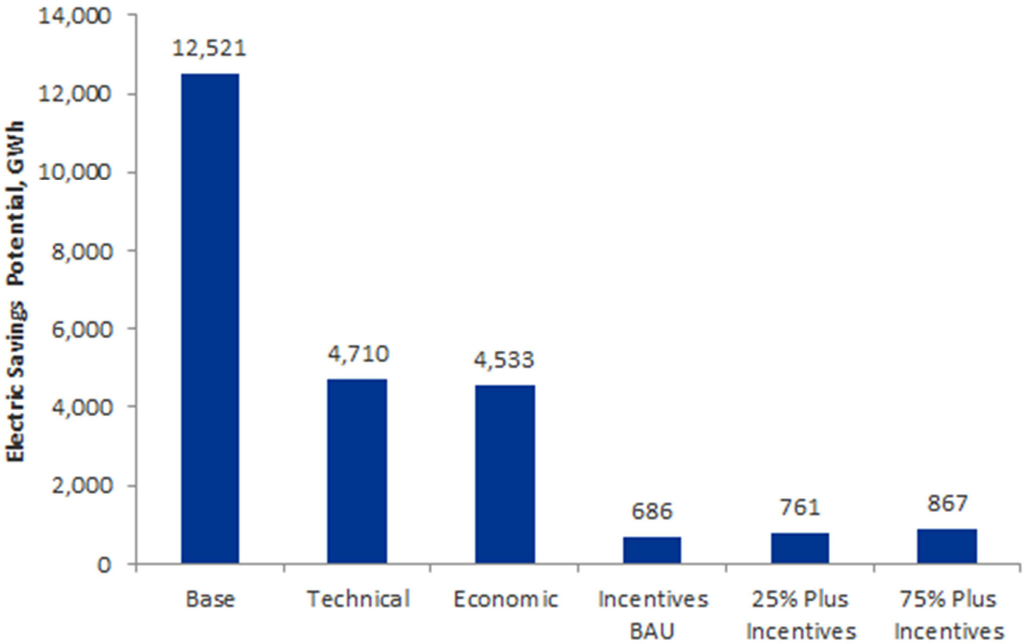
Table 5-36. Ten Year Cumulative Annual Potential (2016-2025) – GWh

Sector	2025 Base Energy Use	Ten Year Cumulative Annual Potential - GWh					
		Technical Potential	Economic Potential	BAU Scenario (Net)	25% Plus Scenario (Net)	75% Plus Scenario (Net)	Naturally Occurring
Commercial	9,554	4,764	4,567	1,275	1,378	1,512	69
Savings % of Base		**50%**	**48%**	**13%**	**14%**	**16%**	**1%**
Industrial	2,910	868	789	322	350	429	28
Savings % of Base		**30%**	**27%**	**11%**	**12%**	**15%**	**1%**
Total	12,465	5,633	5,357	1,597	1,728	1,941	97
Savings % of Base		**45%**	**43%**	**13%**	**14%**	**16%**	**1%**

Estimates of electric energy savings potential are presented in the figures below. These savings reflect cumulative annual potential savings over both the 3-year and 10-year period. This can also be looked at as the annual savings potential of all installations through 2018 and 2025 respectively.

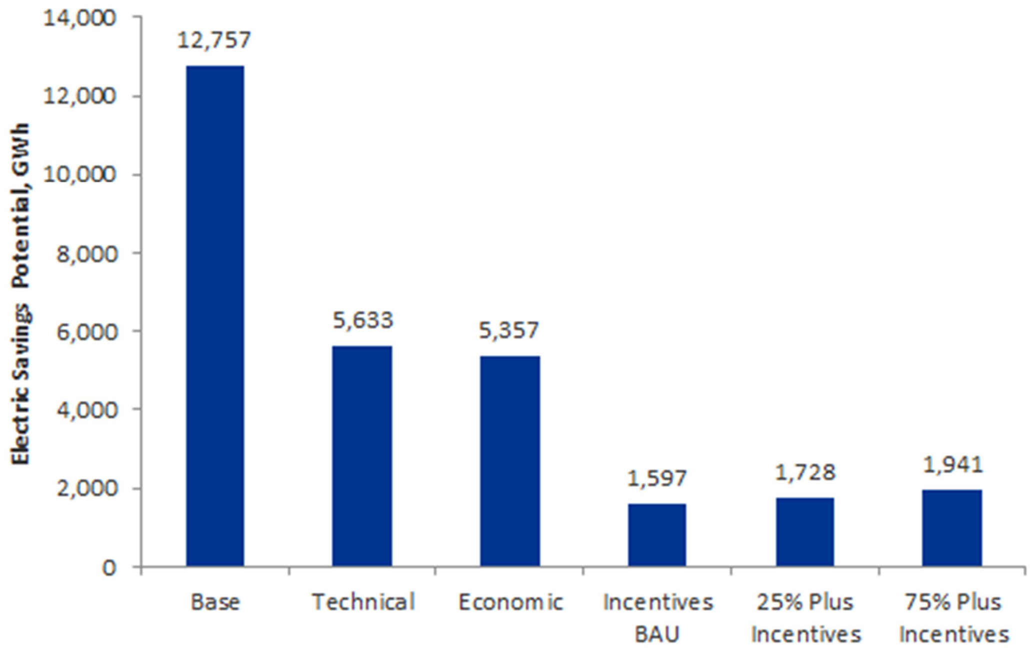
Under the 2016 to 2018 time period, technical potential is estimated at 4,710 GWh per year by 2018. Economic potential is estimated at 4,533 GWh by 2018. Achievable program potentials range between 867 GWh per year in the 75 Percent Plus scenario to 686 GWh per year for the BAU scenario. Economic potential for energy savings is estimated to be 36% percent of base 2018 energy use, while achievable potentials range from six percent of base usage in the BAU case to seven percent of base energy use in the 75 Percent Plus case.

Figure 5-26: Estimated Electric Energy Efficiency Savings Potential, 2016-2018



Under the ten-year period, technical potential is estimated at 5,633 GWh per year by 2025 and economic potential is estimated at 5,357 GWh by 2025. Achievable program potentials range between 1,941 GWh per year by 2025 in the 75 Percent Plus scenario to 1,597 GWh per year for the BAU scenario. Economic potential for energy savings is estimated to be 43% percent of base 2025 energy use. For the 2016 to 2025 year period, achievable potentials range from 13 percent of base usage in the BAU case to 16 percent of base energy use in the 75 Percent Plus case.

Figure 5-27: Estimated Electric Energy Efficiency Savings Potential, 2016-2025

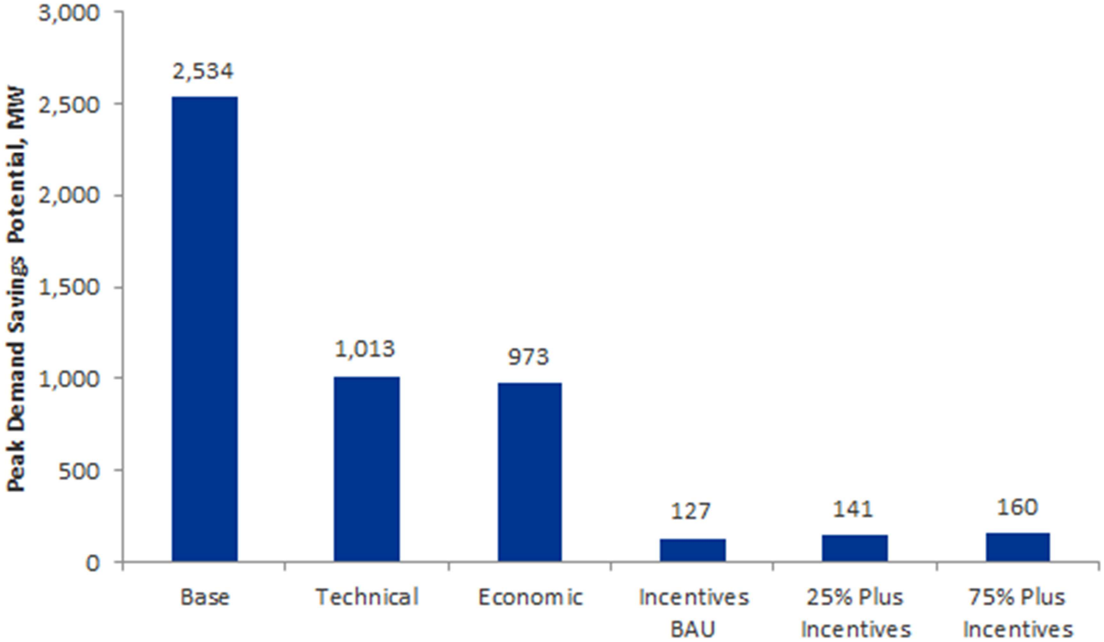


Cumulative peak demand savings potential estimates for both the 10-year and 3-year periods are provided in the figures below.[15]

Technical potential is estimated at 1,013 MW for the 3-year period while economic potential is estimated at 973 MW. Cumulative achievable program potential ranges between 160 MW in the 75 Percent Plus incentive case down to 127 MW in the BAU case. Economic potential for peak demand savings is estimated to be 38 percent of base peak demand and achievable potentials range from five percent of base peak demand in the BAU case to six percent of base peak demand in the 75 Percent Plus incentive case.

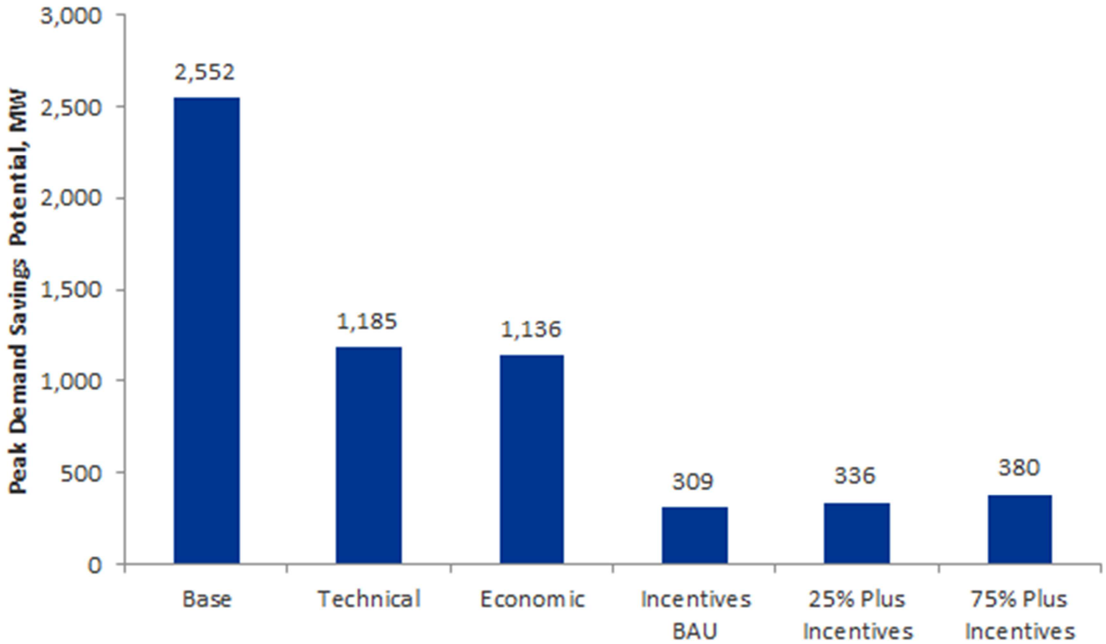
[15] The estimates of peak demand savings are from the installation of energy efficiency measures and do not include demand savings from demand response technologies such as direct load control or dynamic pricing.

Figure 5-28: Estimated Peak Demand Savings Potential, 2016-2018



Technical potential is estimated at 1,185 MW for the 10-year period. Economic potential is estimated at 1,136 MW for the 10-year period. For the 10-year period, cumulative achievable program potential ranges between 380 MW in the 75 Percent Plus incentive case down to 309 MW in the BAU case. Economic potential for peak demand savings is estimated to be 37 percent of base 2025 peak demand; achievable potentials range from 10 percent of base peak demand in the BAU case to 12 percent of base peak demand in the 75 Percent Plus incentive case.

Figure 5-3: Estimated Peak Demand Savings Potential, 2016-2025



5.3.2 Natural Gas

Table 5-37 presents the overall results of the electric energy efficiency potential analysis for the 2016 to 2018 time frame.

Table 5-37. Summary of Cumulative Gas Energy Efficiency Savings, 2016-2018

Energy Efficiency 2016-2018	Technical Potential	Economic Potential	Achievable Program Savings Potential: Business as Usual	Achievable Program Savings Potential: 25% Plus Incentives	Achievable Program Savings Potential: 75% Plus Incentives	Naturally Occurring Savings Potential
Energy Savings- thousand Therms	204,759	176,693	12,063	15,125	17,606	1,024
Cumulative Program Costs- Real, $ Million	N/A	N/A	$45	$52	$65	N/A

Table 5-38 shows the same results for the 2016 to 2025 period.

Table 5-38. Summary of Cumulative Gas Energy Efficiency Savings, 2016-2025

Energy Efficiency 2016-2025	Technical Potential	Economic Potential	Achievable Program Savings Potential: Business as Usual	Achievable Program Savings Potential: 25% Plus Incentives	Achievable Program Savings Potential: 75% Plus Incentives	Naturally Occurring Savings Potential
Energy Savings-thousand Therms	637,002	209,948	31,318	37,867	43,250	3,445
Cumulative Program Costs-Real, $ Million	N/A	N/A	$137	$156	$191	N/A

Table 5-39 shows the results of the achievable analysis as compared to base consumption, technical potential, and economic potential for the 2016 to 2018 time frame. The energy savings estimates from the BAU scenario are 2 percent of base, the estimates from the 25% plus scenario are 3 percent of base, and the estimates from the 75% plus scenario are 3 percent of base.

Table 5-39. Three Year Cumulative Potential (2016-2018) – thousand therms

Sector	2018 Base Energy Use	Three Year Cumulative Annual Potential – thousand therms					
		Technical Potential	Economic Potential	BAU Scenario (Net)	25% Plus Scenario (Net)	75% Plus Scenario (Net)	Naturally Occurring
Commercial	512,915	184,472	158,672	10,363	13,038	15,221	949
Savings % of Base		**36%**	**31%**	**2%**	**3%**	**3%**	**0.2%**
Industrial	68,184	20,287	18,021	1,700	2,087	2,384	75
Savings % of Base		**30%**	**26%**	**2%**	**3%**	**3%**	**0.1%**
Total	581,099	204,759	176,693	12,063	15,125	17,606	1,024
Savings % of Base		**35%**	**30%**	**2%**	**3%**	**3%**	**0.2%**

Table 5-40 shows the results of the achievable analysis as compared to base consumption, technical potential, and economic potential for the 2016 to 2025 time frame. The achievable energy savings estimates from the BAU scenario are 5 percent of base consumption and 15 percent of the economic potential. Overall energy savings under the 25 Percent Plus scenario are projected to be 6 percent of base consumption and under the 75 Percent Plus scenario energy savings estimates are 7 percent of base.

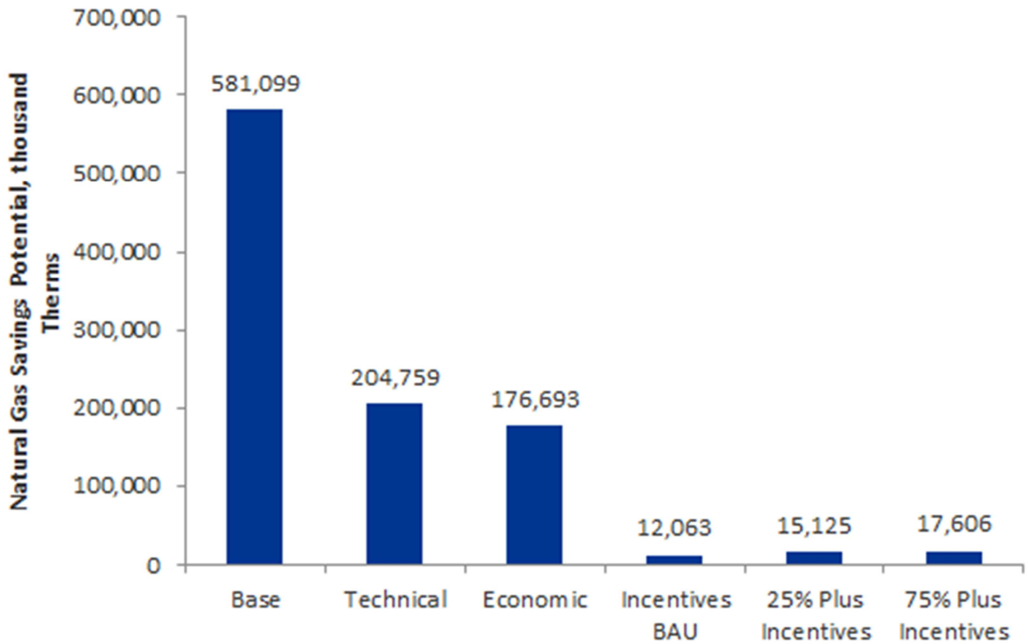
Table 5-40. Ten Year Cumulative Potential (2016-2025) - thousand therms

Sector	2025 Base Energy Use	Ten Year Cumulative Annual Potential – thousand therms					
		Technical Potential	Economic Potential	BAU Scenario (Net)	25% Plus Scenario (Net)	75% Plus Scenario (Net)	Naturally Occurring
Commercial	551,417	225,886	188,610	26,536	31,950	36,633	3,193
Savings % of Base		**41%**	**34%**	**5%**	**6%**	**7%**	**0.6%**
Industrial	85,585	23,712	21,338	4,782	5,917	6,617	251
Savings % of Base		**28%**	**25%**	**6%**	**7%**	**8%**	**0.3%**
Total	637,003	249,598	209,948	31,318	37,867	43,250	3,445
Savings % of Base		**39%**	**33%**	**5%**	**6%**	**7%**	**0.5%**

Estimates of natural gas energy savings potential are presented in the figures below. These savings reflect cumulative annual potential gas savings over the 3-year and 10-year period. This can also be looked at as the annual savings potential of all installations through 2018 and 2025 respectively.

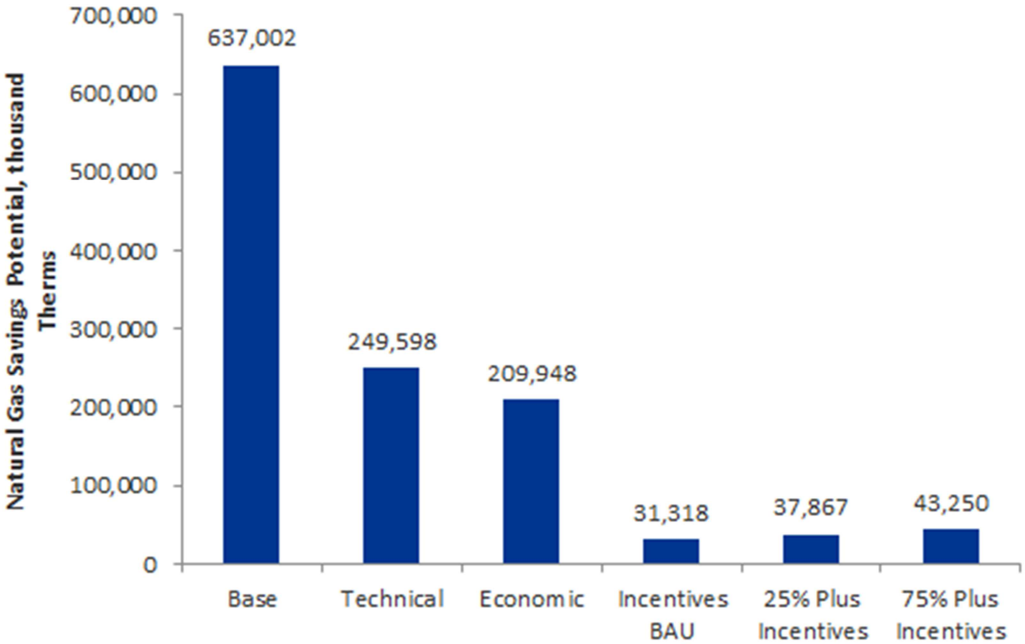
Under the three-year time frame, technical potential is estimated at 204,759 thousand therms per year by 2018. Economic potential is estimated at 176,693 thousand therms by 2018. Achievable program potentials range between 12,063 thousand therms per year for the BAU scenario to 17,606 thousand therms per year by 2018 in the 75 Percent Plus scenario. Economic potential for energy savings is estimated to be 30 percent of base 2018 energy use while achievable potentials range from two percent of base usage in the BAU case to three percent of base energy use in the 75 Percent Plus case.

Figure 5-29. Estimated Gas Energy Efficiency Savings Potential, 2016-2018



Under the 2016 to 2025 time frame, technical potential is estimated at 249,598 thousand therms per year by 2025 and economic potential is estimated at 209,948 thousand therms by 2025. Achievable program potentials range between 31,318 thousand therms per year for the BAU scenario to 43,250 thousand therms per year by 2025 in the 75 Percent Plus scenario. Economic potential for energy savings is estimated to be 33 percent of base 2025 energy use. For the 2016 to 2025 year period, achievable potentials range from 5 percent of base usage in the BAU case to 7 percent of base energy use in the 75 Percent Plus case.

Figure 5-30. Estimated Gas Energy Efficiency Savings Potential, 2016-2025



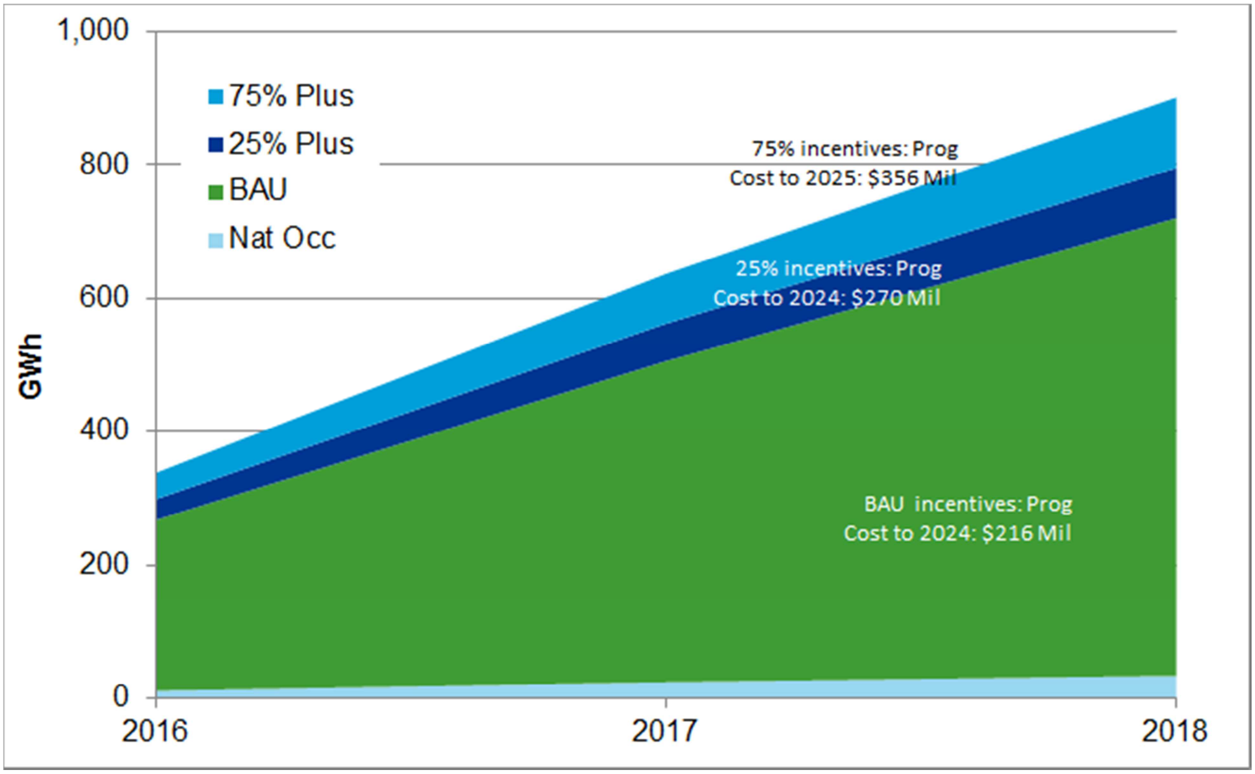
5.3.3 Achievable (Program) Potential – Detailed Results - Electric

5.3.3.1 2016 to 2018 Time Frame

Figure 5-31 shows the estimates of achievable potential savings over the 2016 to 2018 time frame. As shown in this figure, by 2018 cumulative net[16] energy savings are projected to be 720 GWh under the BAU scenario, 795 GWh under the 25 Percent Plus scenario and 901 GWh under the 75 Percent Plus scenario. In each scenario, savings increase over time. A breakdown of the program costs can be seen below.

[16] Throughout this section, *net* refers to savings beyond those estimated to be naturally occurring; that is, from customer adoptions that would occur in the absence of any programs or standards.

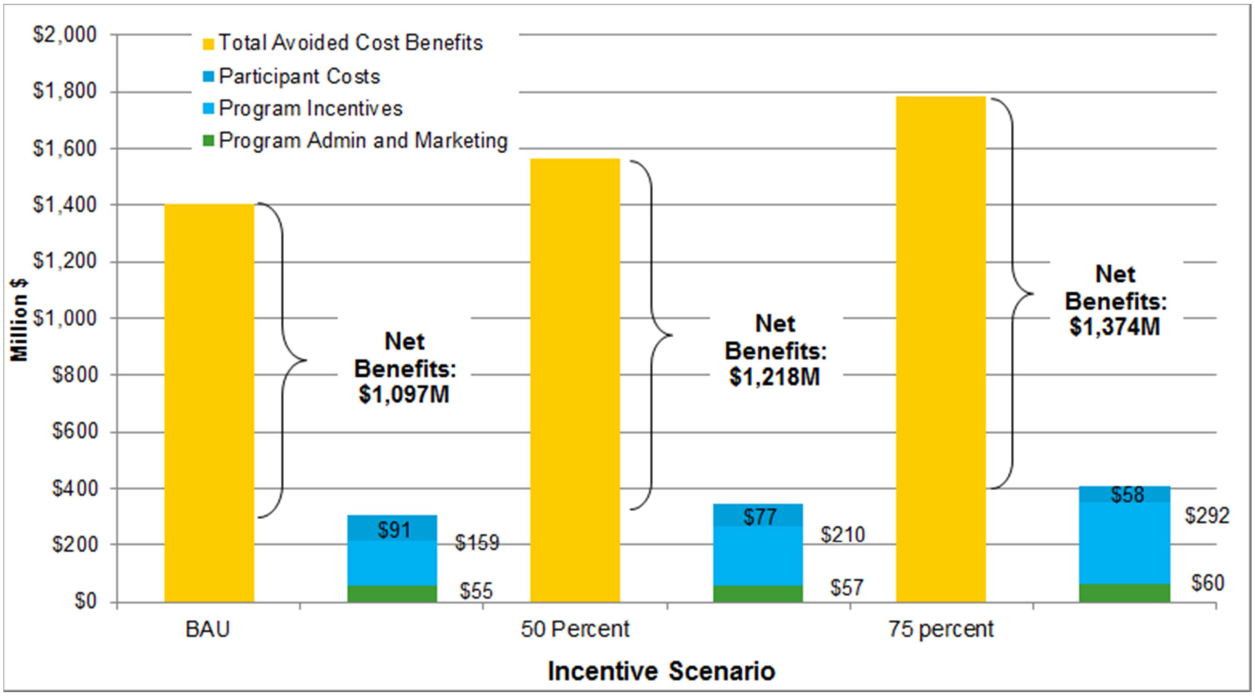
Figure 5-31: Achievable Electric Energy Savings (GWh): All Evaluated Sectors



The present value of program costs (including program incentives and program admin and marketing) is $216 million under the BAU scenario, $270 million under the 25 Percent Plus scenario and $356 million under the 75 Percent Plus scenario for the 3-year period.[17]

[17] It should be noted that a portion of all participant costs are negative costs due to free-riders. As the participant cost get closer to zero for all participants, as is the case with the 75% percent plus scenario, the negative costs become visible, therefore it is reasonable to see the negative participant costs of $5M and $1M in the ten-year and three-year time periods respectively.

Figure 5-32: Benefits and Costs of Energy Efficiency Savings—2016-2018*



* Present value of benefits and costs over measure lifetimes; nominal discount rate is 2.78 percent, inflation rate is 2.22 percent.

The present value of total avoided cost benefits is $1,402 million under the BAU scenario, $1,561 million under the 25 Percent Plus and $1,784 million under the 75 Percent Plus for the 3-year period. The present value of net avoided cost benefits for the 3-year period is $1,097 million under the BAU scenario, $1,218 million under 25 Percent Plus and $1,374 million under 75 Percent Plus.

Key results of the efficiency scenario forecasts from 2016 to 2018 are summarized in Table 5-41 . Gross cumulative savings include naturally occurring savings, while Net program savings include savings net of naturally occurring savings.

Table 5-41: Summary of Achievable Potential Results—2016-2018*

Result - Programs	Program Scenario:		
	BAU	25% Plus	75% Plus
Gross Cumulative Annual Energy Savings - GWh	720	795	901
Gross Cumulative Annual Peak Demand Savings - MW	133	147	166
Net Cumulative Annual Energy Savings - GWh	686	761	867
Net Cumulative Annual Peak Demand Savings - MW	127	141	160
Program Costs - Real, $ Million (sum 3-year cost, not discounted)			
Administration	$11	$13	$16
Marketing	$45	$45	$45
Incentives	$160	$212	$295
Total	$216	$270	$356
PV 3-year Avoided Costs	$1,402	$1,561	$1,784
PV 3-year Annual Program Costs (Adm/Mkt)	$55	$57	$60
PV 3-year Net Measure Costs	$250	$286	$349
Net Benefits (PV 3-year)	$1,097	$1,218	$1,374
TRC Ratio	4.6	4.5	4.4

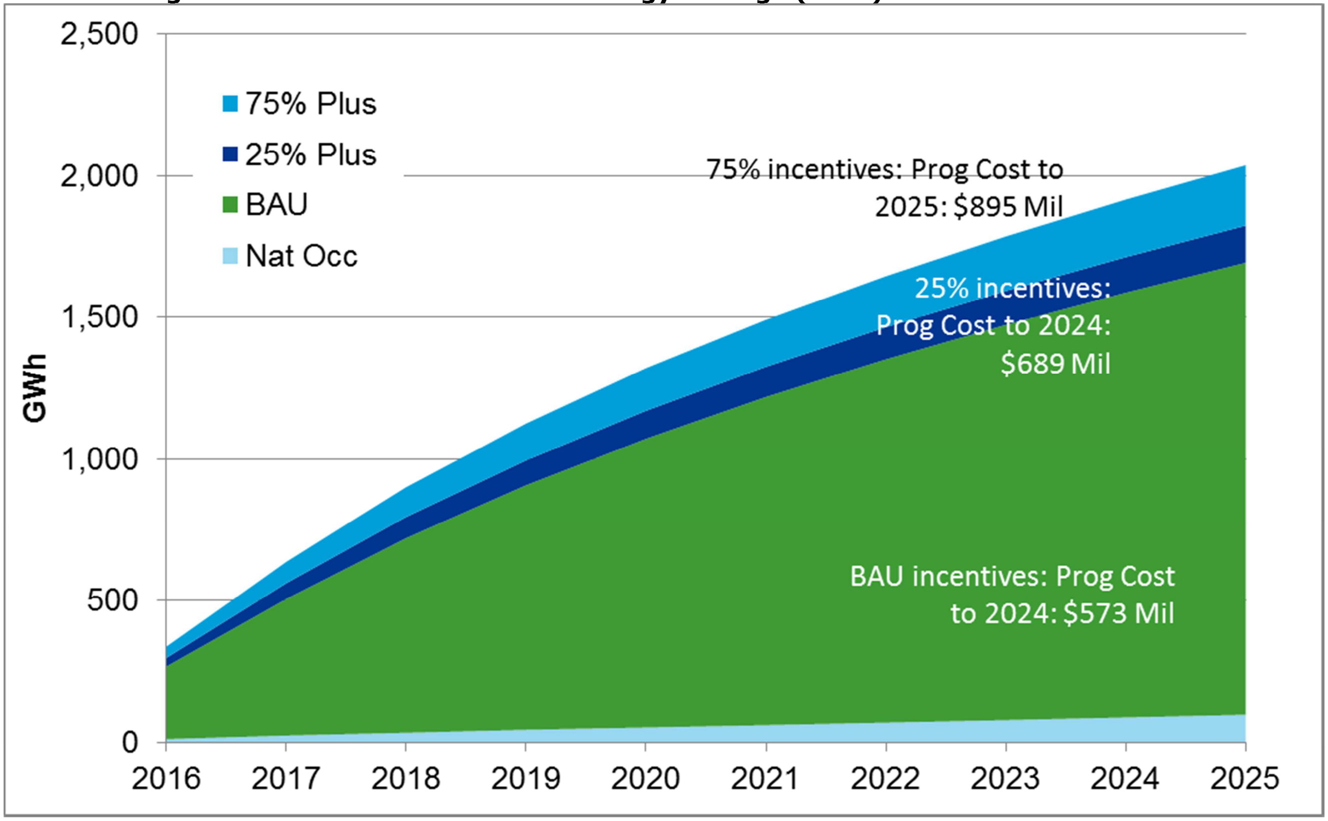
*PV (present value) of benefits and costs is calculated over measure lifetimes for 2016-2018 program years, nominal discount rate = 2.78 percent, inflation rate = 2.22 percent; GWh and MW savings are cumulative through 2018.

5.3.3.2 2016 to 2025 Time Frame

Figure 5-33 shows the estimates of achievable potential savings over time. As shown in this figure, by 2025 cumulative annual net[18] energy savings are projected to be 1,597 GWh under the BAU scenario, 1,728 GWh under the 25 Percent Plus scenario and 1,941 GWh under the 75 Percent Plus scenario. In each scenario, savings increase over time. A breakdown of the program costs can be seen in Figure 5-34 below.

[18] Throughout this section, *net* refers to savings beyond those estimated to be naturally occurring; that is, from customer adoptions that would occur in the absence of any programs or standards.

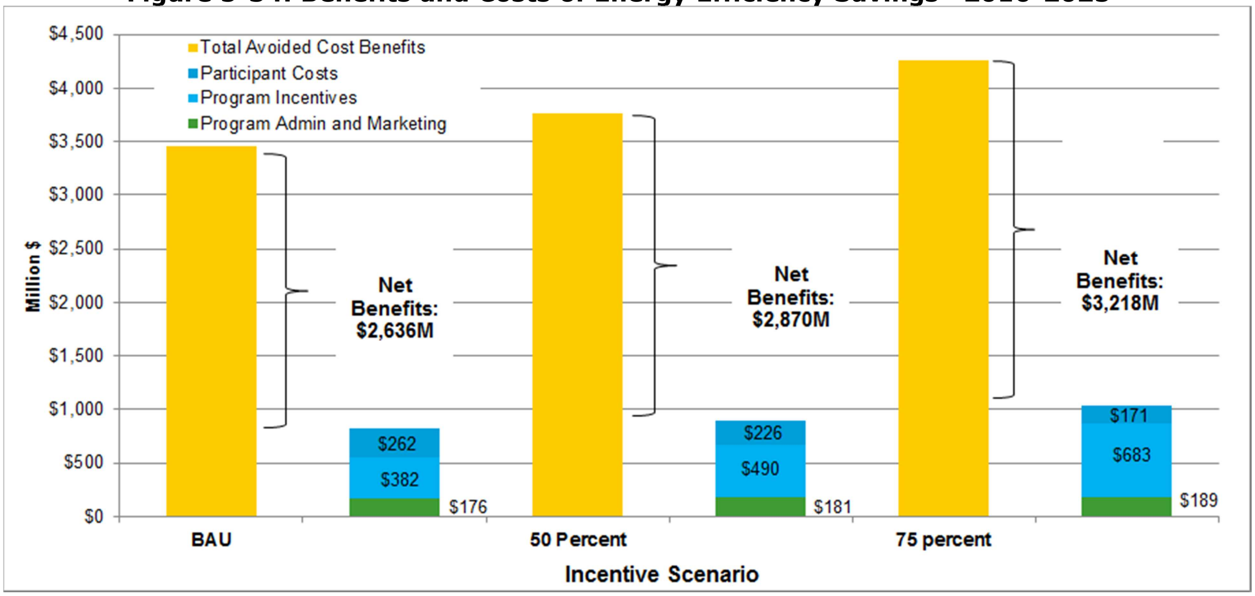
Figure 5-33: Achievable Electric Energy Savings (GWh): All Evaluated Sectors



As incentive levels increase between program scenarios, the costs to administer and market the program also increase from additional programmatic activity. Increased incentives also affect participant costs as the incremental cost participants must pay per measure has decreased as a result of the higher incentives. It is also important to note that although the level of naturally occurring savings does not change between scenarios, program free riders receive the same incentives payments as program participants.

Figure 5-34 depicts the estimated costs and benefits under each funding scenario from 2016 to 2025. The present value of program costs (including program incentives and program administration, marketing) is $558 million under the BAU scenario, $671 million under the 25 Percent Plus scenario and $872 million under the 75 Percent Plus scenario.

Figure 5-34: Benefits and Costs of Energy Efficiency Savings—2016-2025*



* Present value of benefits and costs over measure lives; nominal discount rate is 2.78 percent, inflation rate is 2.22 percent.

The present value of total avoided cost benefits is $3,456 million under the BAU scenario, $3,767 million under the 25 Percent Plus scenario and $4,261 million under the 75 Percent Plus scenario. Finally, all scenarios have positive net benefits: the present value of net avoided cost benefits, i.e., the difference between total avoided cost benefits and total costs (which include participant costs in addition to program costs) for the 10-year period is $2,636 million under the BAU scenario, $2,870 million under the 25 Percent Plus scenario and $3,218 million under the 75 Percent Plus scenario.

Each of the funding scenarios are cost-effective based on the TRC test The TRC benefit-cost ratios for National Grid's service territory are 4.2 for the BAU scenario, 4.2 for the 25 Percent Plus scenario and 4.1 under the 75 Percent Plus scenario.

Key results of the efficiency scenario forecasts from 2016 to 2025 are summarized in Table 5-42. Gross cumulative savings include naturally occurring savings, while Net savings include savings net of naturally occurring savings.

Table 5-42: Summary of Achievable Potential Results—2016-2025*

Result - Programs	Program Scenario:		
	BAU	25% Plus	75% Plus
Gross Cumulative Annual Energy Savings - GWh	1,695	1,825	2,038
Gross Cumulative Annual Peak Demand Savings - MW	325	352	396
Net Cumulative Annual Energy Savings - GWh	1,597	1,728	1,941
Net Cumulative Annual Peak Demand Savings - MW	309	336	380
Program Costs - Real, $ Million (sum 10-year cost, not discounted)			
Administration	$33	$38	$46
Marketing	$149	$149	$149
Incentives	$392	$503	$701
Total	$573	$689	$895
PV 10-year Avoided Costs	$3,456	$3,767	$4,261
PV 10-year Annual Program Costs (Adm/Mkt)	$176	$181	$189
PV 10-year Net Measure Costs	$644	$716	$854
Net Benefits (PV 10-year)	$2,636	$2,870	$3,218
TRC Ratio	4.2	4.2	4.1

*PV (present value) of benefits and costs is calculated over the life of each measure for 2016-2025 program years, nominal discount rate = 2.78 percent, inflation rate = 2.22 percent; GWh and MW savings are per year, but reflect the cumulative effects of program efforts through 2025.

5.3.3.3 Breakdown of Achievable Electric Potential by Sector

Cumulative achievable potential estimates by sector for the period of 2016 to 2025 and the period 2016 to 2018 are presented in Figure 5-36 through Figure 5-37. These figures compare the industrial and commercial sector results for each funding scenario.

Under the program assumptions developed for this study, achievable energy savings under each scenario are highest for the commercial sector during both time periods. Peak demand savings under all scenarios are also highest for the commercial sector.[19]

[19] The estimates of peak demand savings are from the installation of energy efficiency measures and do not include demand savings from demand response technologies such as direct load control or dynamic pricing.

Figure 5-35: Net Achievable Energy Savings (2016-2018) by Sector—GWh per Year

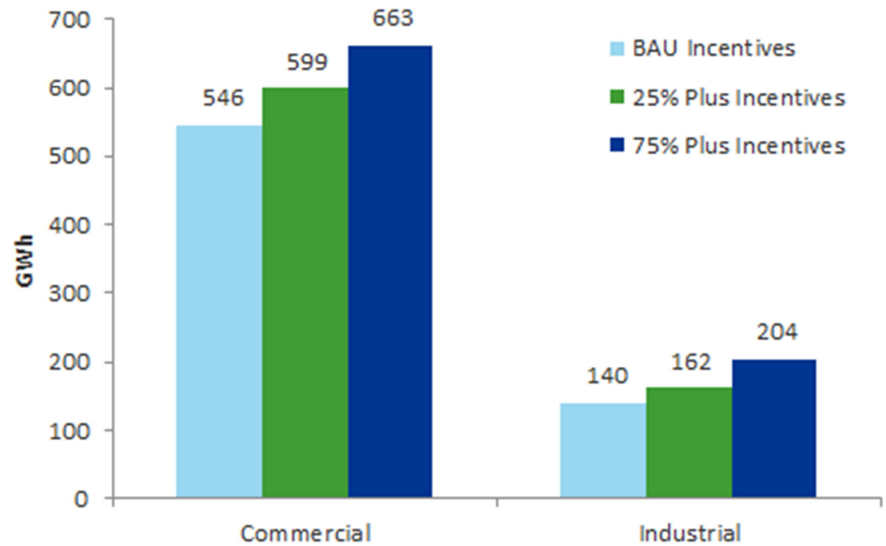


Figure 5-36: Net Achievable Energy Savings (2025) by Sector—GWh per Year

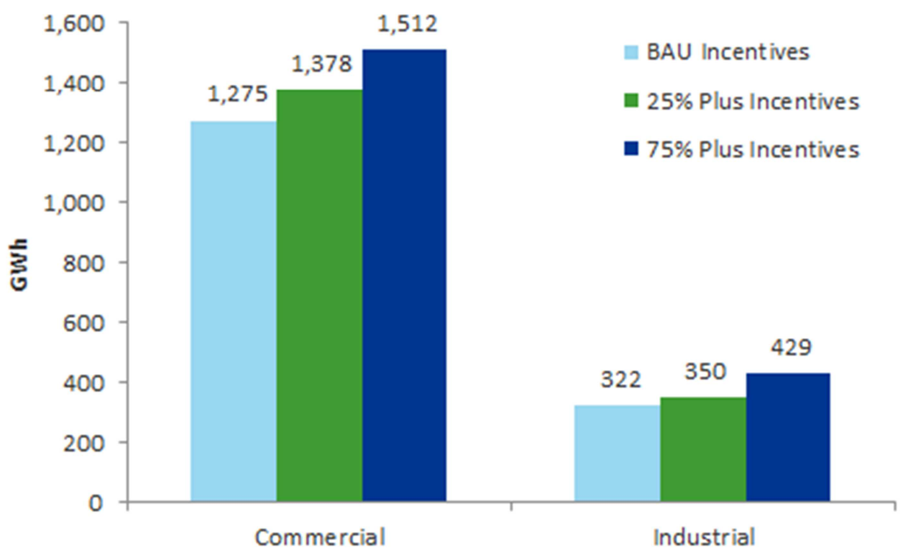


Figure 5-37: Net Achievable Peak-Demand Savings (2016-2018) by Sector—MW

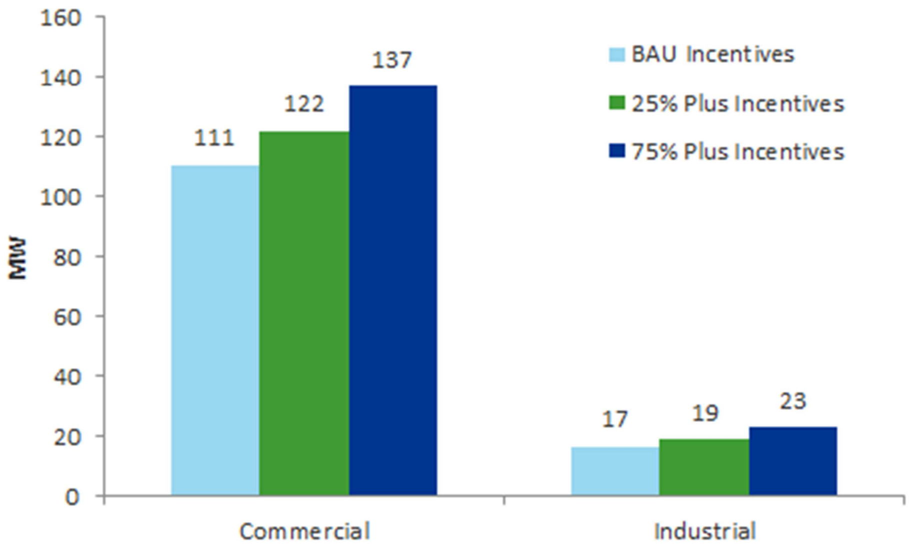
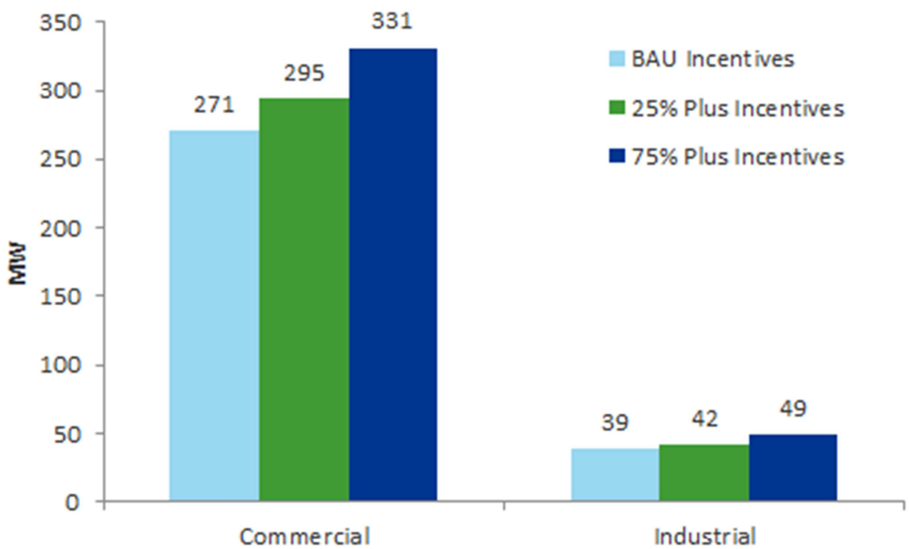


Figure 5-38: Net Achievable Peak-Demand Savings (2025) by Sector—MW

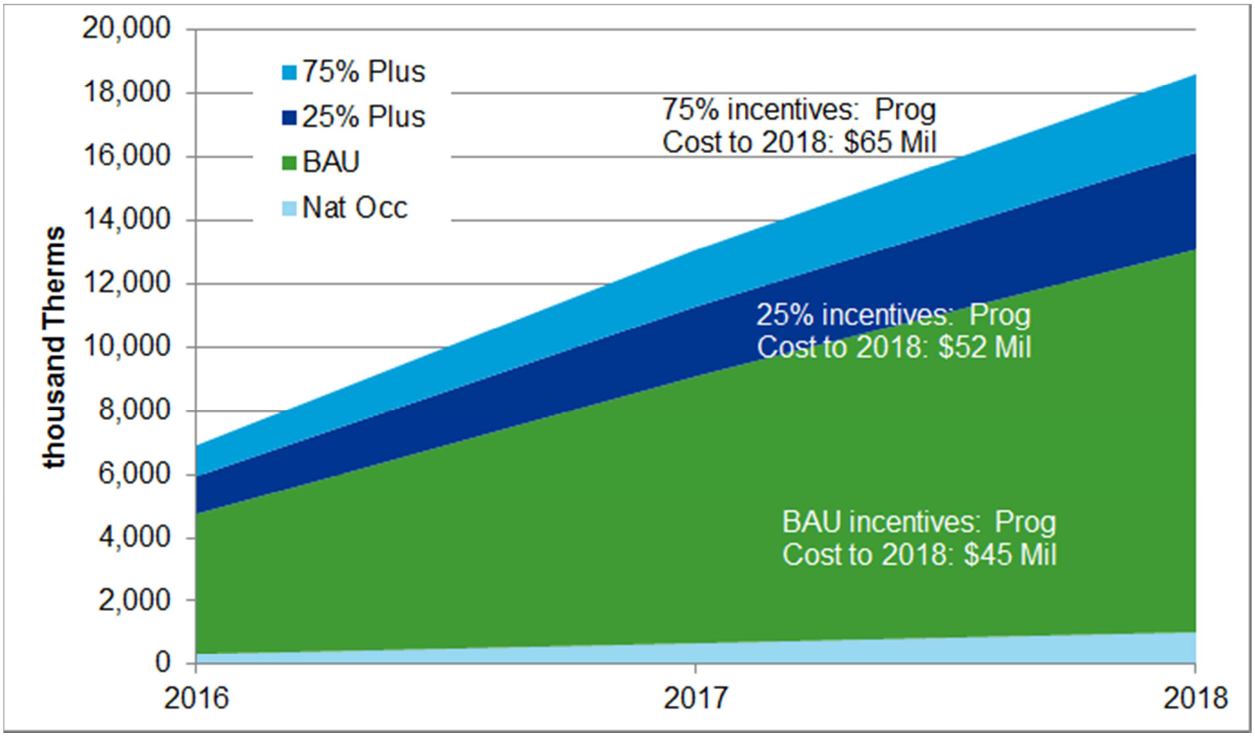


5.3.4 Achievable (Program) Potential – Detailed Results - Natural Gas

5.3.4.1 2016 to 2018 Time Frame

Figure 5-39 shows the estimates of achievable potential savings over the 2016 to 2018 time frame. As shown in this figure, by 2018 cumulative net gas savings are projected to be 24,126 thousand therms under the BAU scenario, 30,249 thousand therms under the 25 Percent Plus scenario, and 35,211 thousand therms under the 75 Percent Plus scenario. In each scenario, savings increase over time. A breakdown of the program costs can be seen below.

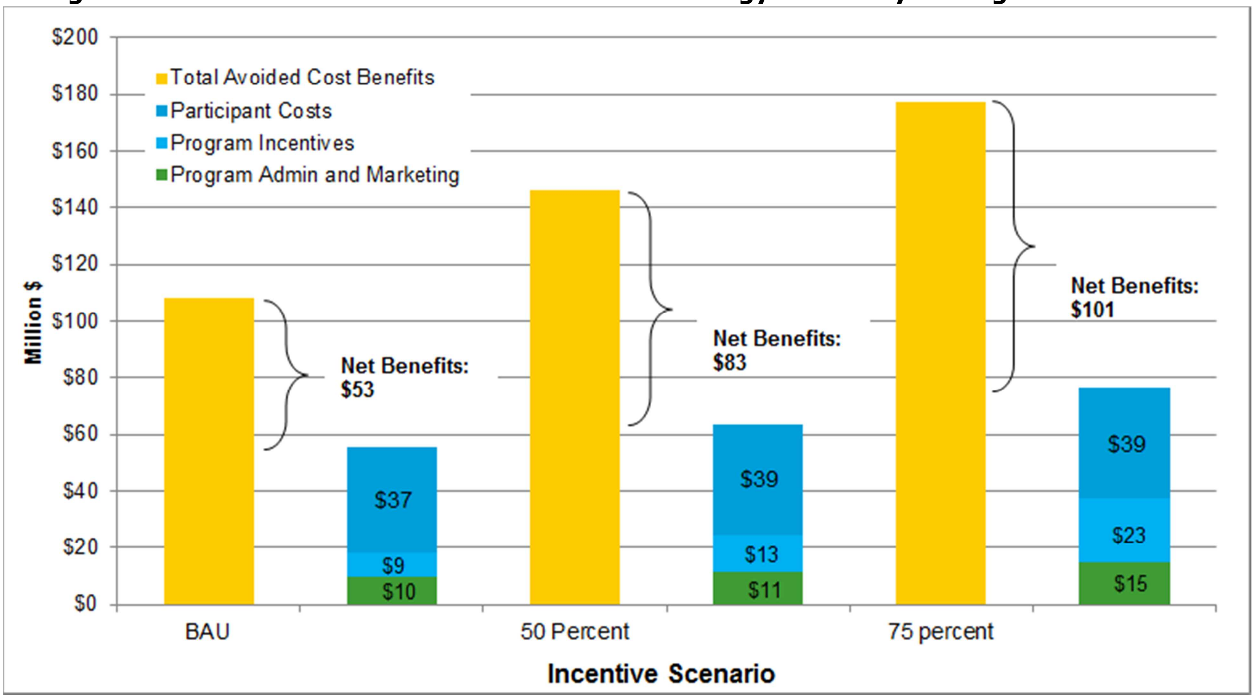
Figure 5-39. Achievable Natural Gas Energy Savings (thousand therms): All Evaluated Sectors



The present value of program costs (including program incentives and program admin and marketing) is $45 million under the BAU scenario, $52 million under the 25 Percent Plus scenario and $65 million under the 75 Percent Plus scenario for the 3-year period.[20]

[20] It should be noted that a portion of all participant costs are negative costs due to free-riders. As the participant cost get closer to zero for all participants, as is the case with the 75% percent plus scenario, the negative costs become visible, therefore it is reasonable to see the negative participant costs of $5M and $1M in the ten-year and three-year time periods respectively.

Figure 5-40. Benefits and Costs of Natural Gas Energy Efficiency Savings—2016-2018*



* Present value of benefits and costs over measure lives; nominal discount rate is 2.78 percent, inflation rate is 2.22 percent.

The present value of total avoided cost benefits is $108 million under the BAU scenario, $146 million under the 25 Percent Plus and $177 million under the 75 Percent Plus for the 3-year period. The present value of net avoided cost benefits for the 3-year period is $53 million under the BAU scenario, $83 million under 25 Percent Plus and $101 million under 75 Percent Plus.

Key results of the efficiency scenario forecasts from 2016 to 2018 are summarized in Table 5-43.

Table 5-43. Summary of Achievable Natural Gas Potential Results—2016-2018*

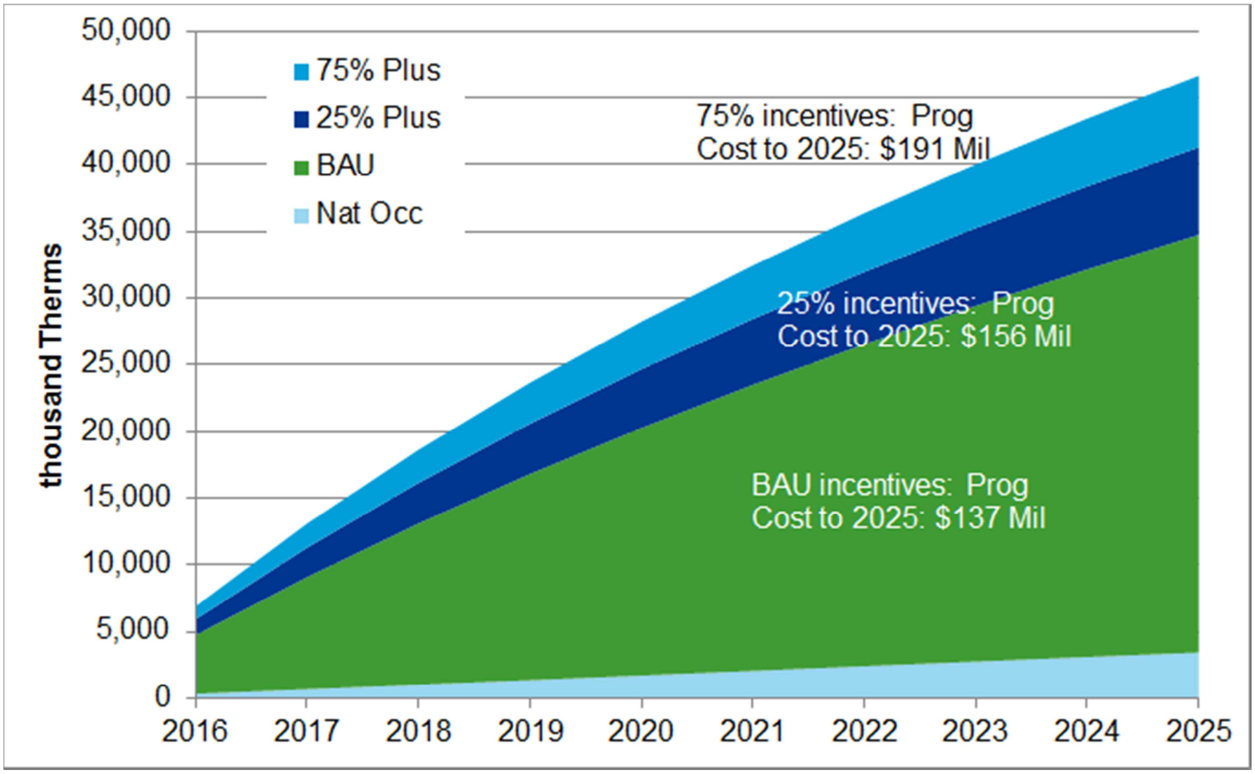
Result – Programs	Program Scenario:		
	BAU	25% Plus	75% Plus
Gross Cumulative Annual Energy Savings – thousand therms	13,087	16,148	18,629
Net Cumulative Annual Energy Savings – thousand therms	12,063	15,125	17,606
Program Costs - Real, $ Million (sum 3-year cost, not discounted)			
Administration	$5	$6	$8
Marketing	$18	$18	$18
Incentives	$22	$28	$39
Total	$45	$52	$65
PV 3-year Avoided Costs	$108	$146	$177
PV 3-year Annual Program Costs (Adm/Mkt)	$10	$11	$15
PV 3-year Net Measure Costs	$46	$52	$61
Net Benefits (PV 3-year)	$53	$83	$101
TRC Ratio	1.9	2.3	2.3

*PV (present value) of benefits and costs is calculated over the life of each measure for 2016-2018 program years, nominal discount rate = 2.78 percent, inflation rate = 2.22 percent; therms savings are cumulative through 2018.

5.3.4.2 2016 to 2025 Time Frame

Figure 5-41 shows the estimates of achievable potential gas savings over time. As shown in this figure, by 2025 cumulative annual net energy savings are projected to be 31,318 thousand therms under the BAU scenario, 37,867 thousand therms under the 25 Percent Plus scenario, and 1,941 GWh under the 75 Percent Plus scenario. In each scenario, savings increase over time. A breakdown of the program costs can be seen in Figure 5 10 below.

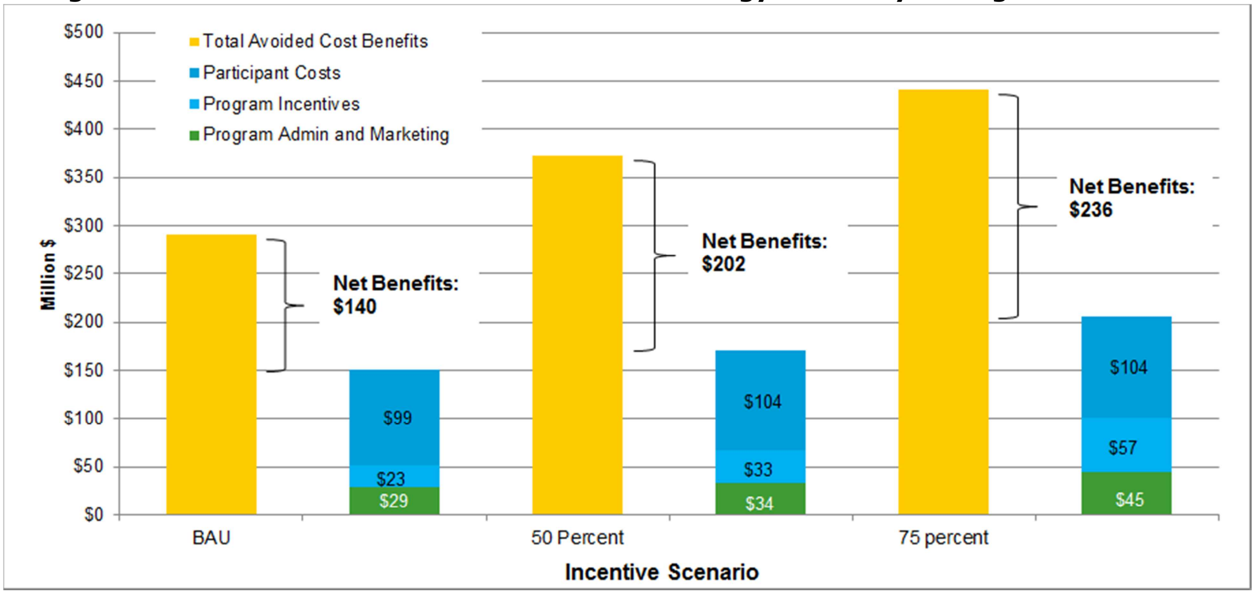
Figure 5-41. Achievable Natural Gas Energy Savings (thousand therms): All Evaluated Sectors



As incentive levels increase between program scenarios, the costs to administer and market the program also increase from additional programmatic activity. Increased incentives also affect participant costs as the incremental cost participants must pay per measure has decreased as a result of the higher incentives. It is also important to note that although the level of naturally occurring savings does not change between scenarios, program free riders receive the same incentives payments as program participants.

Figure 5-42 depicts the estimated costs and benefits under each funding scenario from 2016 to 2025. The present value of program costs (including program incentives and program administration, marketing) is $52 million under the BAU scenario, $67 million under the 25 Percent Plus scenario and $102 million under the 75 Percent Plus scenario.

Figure 5-42. Benefits and Costs of Natural Gas Energy Efficiency Savings—2016-2025*



* Present value of benefits and costs over measure lives; nominal discount rate is 2.78 percent, inflation rate is 2.22 percent.

The present value of total avoided cost benefits is $291 million under the BAU scenario, $373 million under the 25 Percent Plus scenario and $441 million under the 75 Percent Plus scenario. Finally, all scenarios have positive net benefits: the present value of net avoided cost benefits, i.e., the difference between total avoided cost benefits and total costs (which include participant costs in addition to program costs) for the 10-year period is $140 million under the BAU scenario, $202 million under the 25 Percent Plus scenario and $236 million under the 75 Percent Plus scenario.

Each of the funding scenarios are cost-effective based on the TRC test The TRC benefit-cost ratios for National Grid's service territory are 1.9 for the BAU scenario, 2.2 for the 25 Percent Plus scenario and 2.1 under the 75 Percent Plus scenario.

Key results of the efficiency scenario forecasts from 2016 to 2018 are summarized in Table 5-44.

Table 5-44. Summary of Achievable Natural Gas Potential Results—2016-2025*

Result - Programs	Program Scenario: BAU	Program Scenario: 25% Plus	Program Scenario: 75% Plus
Gross Cumulative Annual Energy Savings – thousand therms	34,762	41,312	46,695
Net Cumulative Annual Energy Savings – thousand therms	31,318	37,867	43,250
Program Costs - Real, $ Million (sum 10-year cost, not discounted)			
Administration	$15	$17	$23
Marketing	$61	$61	$61
Incentives	$60	$77	$107
Total	$137	$156	$191
PV 10-year Avoided Costs	$291	$373	$441
PV 10-year Annual Program Costs (Adm/Mkt)	$29	$34	$45
PV 10-year Net Measure Costs	$122	$137	$161
Net Benefits (PV 10-year)	$140	$202	$236
TRC Ratio	1.9	2.2	2.1

*PV (present value) of benefits and costs is calculated over the life of each measure for 2016-2025 program years, nominal discount rate = 2.78 percent, inflation rate = 2.22 percent; therms savings are cumulative through 2025.

5.3.4.3 Breakdown of Achievable Natural Gas Potential by Sector

Cumulative achievable potential estimates by sector for gas for the period of 2016 to 2025 and the period 2016 to 2018 are presented in Figure 5-43 and

Figure 5-44. These figures compare the industrial and commercial sector results for each funding scenario. Under the program assumptions developed for this study, achievable energy savings under each scenario are highest for the commercial sector during both time periods. Peak demand savings under all scenarios are also highest for the commercial sector.

Figure 5-43. Net Achievable Natural Gas Energy Savings (2016-2018) by Sector—thousand Therms per Year

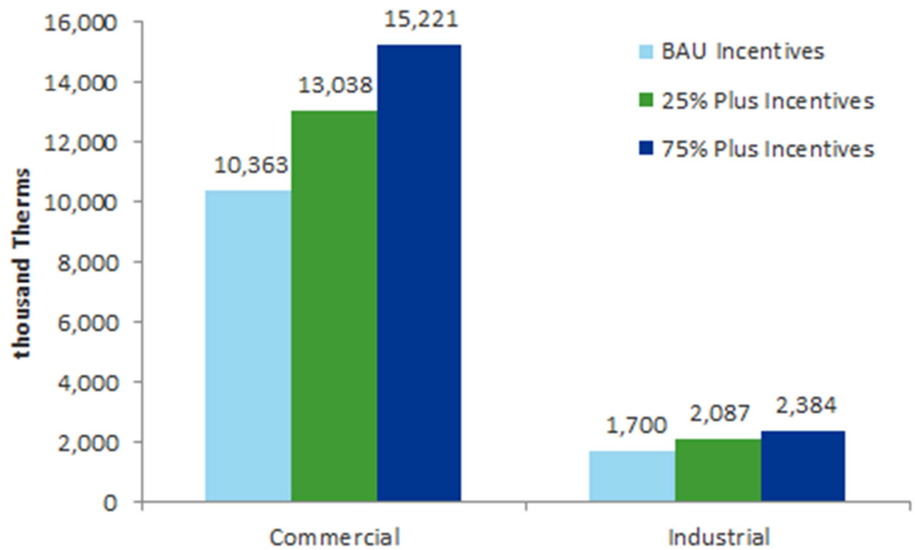
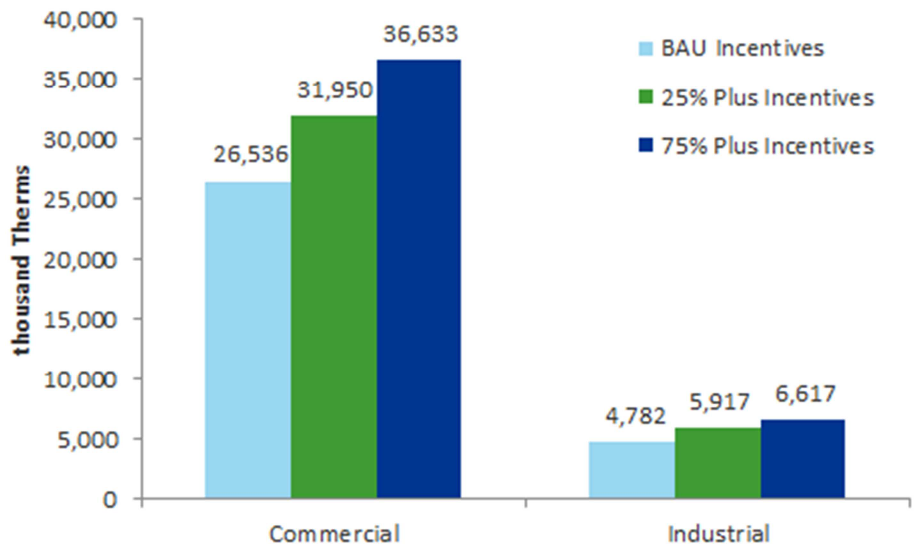


Figure 5-44. Net Achievable Natural Gas Energy Savings (2016-2025) by Sector—thousand therms per year



5.3.5 Top 20 Saving Measures - Electric

Table 5-45 and Table 5-46 show the top 20 electricity measures ranked by net achievable energy savings for the commercial and industrial sectors, respectively. The savings shown are annual savings for 2016, the first year of the forecast period.

Upstream LEDs replacing incandescents have the highest savings in the commercial sector. While incandescents represent only a small share of the screw-based lighting stock, Project 41 found them in many commercial buildings (see saturation in Table 5-1), though in smaller numbers than CFLs. That remaining stock, the high per-unit savings, combined with the short lifetime (and therefore rapid turnover) of incandescents, results in high savings for this measure in the early years of the forecast. Upstream LEDs are followed closely by occupancy sensors.

Table 5-45: Top 20 Commercial Electric Measures for 2016 Net Energy Savings

Rank	Measure	MWh
1	Upstream LEDs (base Incandescent 72W)	42,109
2	Occupancy Sensors	25,092
3	RET 4L4' Low Watt High Performance T8 (83 W)	23,057
4	Retrocommissioning/Building tune up	20,972
5	Custom Lighting	9,912
6	Upstream LEDs (base CFL spiral 23W)	8,413
7	High Bay T5 HO (240W)	8,143
8	Variable Speed Drive Control, 5 HP	7,088
9	RET LED Troffer	6,207
10	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings	6,113
11	Upstream 4L4' LED Tube	5,873
12	Advanced Lighting Controls	5,343
13	High Bay LED Lighting	4,897
14	ROB DX Packaged System, EER=10.8, 30 tons	3,919
15	Commissioning	2,888
16	New Construction 30% better than code	2,621
17	RTU VSD	2,462
18	RET 4L4' LED Tube	2,373
19	New Construction 15% better than code	2,095
20	New Construction 50% better than code	2,089

In the industrial analysis, electric drive injection molders, which have been a large part of National Grid's programs for many years, has the highest savings, followed by variable speed drive control for large (100 HP and larger) motors.

Table 5-46: Top 20 Industrial Electric Measures for 2016 Net Energy Savings

Rank	Measure	MWh
1	Electric Drive Injection Molder (Plastics)	13,901
2	Variable speed drive control (100+ hp)	9,570
3	Occupancy Sensor, 4L4' Fluorescent Fixtures	3,991
4	High Bay T5 HO (240W)	3,691
5	Custom Measures--Drives (100+ hp)	2,643
6	Variable speed drive (pumps)	1,785
7	RET 4L4' Low Watt High Performance T8 (83 W)	1,711
8	Variable speed drive control (51-100 hp)	1,456
9	Upstream 4L4' LED Tube	973
10	Custom Measures--Other Process	929
11	High Bay LED Lighting	811
12	Custom Measures--Process Heating	674
13	Custom Measures--Drives, (6-20 hp)	628
14	Custom Compressed Air	601
15	Custom Measures--Drives (51-100 hp)	514
16	Variable Speed Drive Control, (6-20 hp)	424
17	Motors- System Optimization and sizing (100+ hp)	371
18	Upstream 4L4' Low Watt High Performance T8 (83 W)	369
19	Water/Wastewater Custom Projects	355
20	High Efficiency Air Compressors	331

5.3.6 Top 20 Saving Measures - Natural Gas

Table 5-47 and Table 5-48 show the top 20 natural gas measures ranked by net achievable energy savings for the commercial and industrial sectors, respectively. The savings shown are annual savings for 2016, the first year of the forecast period.

Retrocommissioning has the highest savings in the commercial sector, followed by air side heat recovery systems.

Table 5-47: Top 20 Commercial Natural Gas Measures for 2016 Net Energy Savings

Rank	Measure	1000 therms
1	Retrocommissioning	1,177,049
2	Installation of Air Side Heat Recovery Systems	483,461
3	Installation of Energy Management Systems (EMS)	312,821
4	Steam traps	300,379
5	Boiler Controls	238,357
6	High Efficiency Condensing Boiler 95% efficiency	137,298
7	Custom Boiler	106,627
8	Custom Other Heat	101,208
9	Custom Water Heating-high standby loss	97,449
10	Condensing unit heaters	94,178
11	Programmable communicating thermostat	82,055
12	Refrigeration heat recovery - space conditioning	75,553
13	Energy Star Steamer	71,240
14	Stack Heat Exchanger	68,213
15	Condensing Water Heater (gas, 95% thermal efficiency)	59,342
16	DHW Pipe Insulation - high standby loss (as % of load)	58,776
17	Insulation of Pipes	54,350
18	Energy Star Fryer	45,910
19	Hot water temperature reset	45,281
20	Insulation (ceiling)	39,611

In the industrial analysis, custom process heating has the highest savings, followed by improved furnace combustion efficiency.

Table 5-48: Top 20 Industrial Natural Gas Measures for 2016 Net Energy Savings

Rank	Measure	1000 therms
1	Custom (Base Process Heating)	145,799
2	Improved Furnace Combustion Efficiency/Oxygen enrichment	74,077
3	Boiler reset controls (Base Steam Boiler)	37,671
4	Process heat recovery	36,502
5	Process integration	30,743
6	Upgrading to steam blanchers (Food)	29,472
7	Improve ceiling insulation	25,863
8	Steam trap improvement/maintenance/monitoring	23,857
9	Improved boiler pipe insulation (Base Steam Boiler)	21,420
10	Custom (Base Other Process)	19,711
11	Custom (Base HVAC)	16,671
12	Improved insulation on steam lines	16,238
13	Direct contact water heating (low temperature only)	13,963
14	Resize charging openings or add a movable door on furnace	12,567
15	EMS install	9,836
16	Boiler reset controls (Base Hot Water Boiler)	7,770
17	Efficient drying systems	5,356
18	Blowdown heat recovery (Base Steam Boiler)	5,007
19	Improved boiler pipe insulation (Base Hot Water Boiler)	4,554
20	Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	3,289

5.4 Interpreting the Results

This section presents the DNV GL team's assessment of the drivers behind the results of the model. While the research team recognizes that the results are lower than anticipated, DNV GL does feel that the numbers are reasonable given the landscape of the Massachusetts energy efficiency programs and the assumptions made in the model. In addition, the analysis specifically includes assumptions about the technology, program and market conditions that are intended to best represent the 2016 to 2018 time frame which was of most interest to National Grid.

5.4.1.1 National Grid's Program Landscape

For the last six years, National Grid has faced and achieved aggressive energy savings goals. In addition, National Grid's own energy efficiency programs have existed for decades. Together, this has led to both high program awareness and saturation within National Grid's territory. Put more simply, the availability of wide-spread cost-effective measures in National Grid's territory is diminishing. Without a disruptive change either in new technology or program design on the horizon during the 2016 to 2018 time frame, the results of the modeling effort are not surprising.

5.4.1.2 Market Saturation of Retrofit Measures

When the total BAU achievable results are disaggregated and reviewed year by year across 2016 to 2025, there is a noted decline over time in the annual BAU achievable energy savings as a percentage of base consumption as shown in Figure 5-45 (electric) and Figure 5-46 (gas) below. One of the main drivers for this drop is the treatment of retrofit upgrades over the study period. The decline is the result of front-loading one-time retrofit savings, which saturates the market and reduces opportunities for retrofit savings going into the future. In addition, the modeling effort intentionally uses a conservative approach and does not count on speculative changes in technologies and markets to produce savings that may or may not come to pass. In reality, this decline in savings would be at least partially offset by new technologies not reviewed in this analysis entering the market (or existing technologies becoming more cost effective).

Figure 5-45: Total BAU Achievable Electric Energy Savings as a % of 2025 Base Consumption

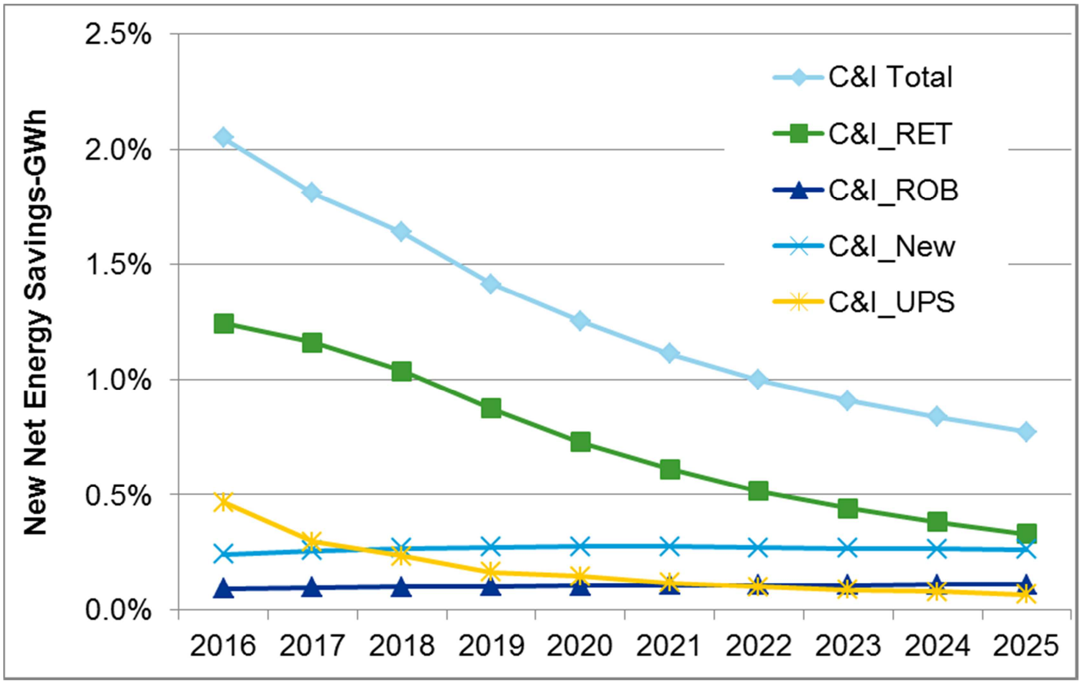
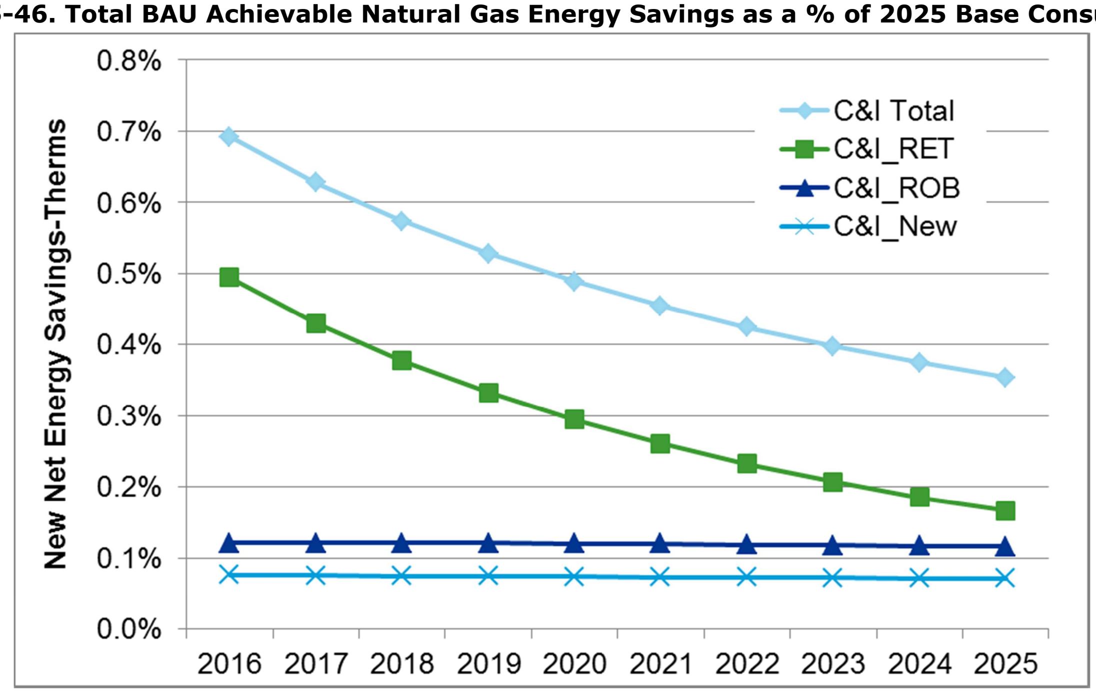


Figure 5-46. Total BAU Achievable Natural Gas Energy Savings as a % of 2025 Base Consumption



It should be noted that retrofit is the largest contributor to savings, as well as the main driver of the slope of the line. Other program measures (e.g. new construction) have a more constant stream of savings, but retrofit measures saturate the market early and decline much faster than other programs, despite the study including a number of measures that are relatively new to the market and have low current saturations. The reason for this early saturation is that retrofit opportunities are available immediately, as installations do not need to wait for the base measure to reach the end of its lifetime before it can be updated. With greater program effort, retrofit savings can be front-loaded, but without additional measures, the total area under the curve will be the same. Because of this, the study assumes that a majority of the retrofit measures are being implemented during the earlier years, while replace on burn-out measures and new construction measures experience a continuous stream over the 10-year period of the model.

5.4.1.3 Conservative Estimates of New Technologies

One way that programs compensate for the decline in annual accomplishments due to rapid saturation of retrofit measures is to support new measures and/or new technologies. The DNV GL team does incorporate several new technologies in the model, including but not limited to:

- Advanced rooftop controls
- Advanced lighting controls
- Comprehensive lighting design
- Rooftop unit automated fault detection (limited applicability)
- Multiple catch-all custom measures that can capture new technologies not explicitly modeled.

In addition to the new technologies that are included in the model, the DNV GL team reviewed a number of additional technologies and program approaches for inclusion in the study (see section 3.1), but did not include them either due to lack of credible costs and savings data or because the technology or program approach was considered to be too nascent to be viable in the near term. Instead, the new technologies that are included in the study are commercially available and most have been included in National Grid's programs, although in relatively small numbers to date. The limited inclusion of emerging technologies is a result of a decision made by the DNV GL and National Grid teams to take a conservative approach, and not include technologies that were not yet commercialized (or near commercialization). There were several reasons for this decision, most importantly to ensure that the estimates for the 2016 to 2018 time frame were based on measures that were likely to be available in the market during the next three-year plan. A more aggressive approach to modeling new technologies would potentially have seen more savings coming from new technologies in future years of the model.

A more complete discussion of the new technologies considered is included in Section 3.1.

5.4.1.4 Lighting Baselines/Lifetimes

The EM&V Project 41 Wave 1 on-sites found a screw-based lamp distribution of 18 percent incandescent, 71 percent CFL, and 11 percent LED. Incandescents last less than a year with typical commercial or industrial usage, so turnover is rapid. While to date, National Grid program evaluations have found that upstream LEDs have mostly replaced incandescents, the small and shrinking share of incandescents suggests that this practice will change in the near future. DNV GL's analysis predicts (and other evidence of LED adoption supports) that incandescent lamps will be rapidly replaced with LEDs over the next couple years, leaving the upstream program with the less fruitful opportunity of replacing CFLs with LEDs (or possibly lower efficiency LEDs with higher efficiency LEDs). Less fruitful, because not only are the savings smaller going from a CFL to an LED, but also because CFLs last longer than incandescents and will turn over more slowly.

5.4.1.5 Exclusion of CHP & Streetlighting

Another reason for lower than expected achievable savings is due to the fact that both CHP and streetlighting measures are not addressed in the study. While the CHP measure accounts for 9.6% of gross C&I Retrofit kWh savings and 6.4% of gross C&I total kWh savings according to the 2013-2015 Electric Screening Model, CHP projects do not follow an easily modeled path, instead showing up in very unpredictable and "lumpy" waves over a 10-year time frame. In addition, the more predictable, smaller scale 1-to-5 kW CHP system projects are still a long way off from being a cost-effective measure. Finally, in early discussions with National Grid, their program implementation team felt that it had a solid understanding of the CHP projects in the pipeline over the next few years. For these reasons, the DNV GL team determined (along with National Grid) that it was not necessary to include CHP in the study. The team followed a similar decision making process when deciding not to include streetlighting as a measure in the study.

5.4.1.6 Comparison to Other Potential Studies

Finally, while the results of the study show a lower than expected achievable potential result, it should be noted that in comparison to other potential studies conducted recently, National Grid is within the "ball park" of findings DNV GL is seeing in other jurisdictions with a similar history of energy efficiency programs as Massachusetts. Table 5-49 provides the results of the achievable scenarios for several of these additional potential studies.

Table 5-49: 10-Year Achievable Scenarios (percent of base) from other recent Potential Studies

Study	BAU	Low-Case	High-Case
Electric Results			
National Grid 2015 Potential Study	13%	14%	16%
CPUC 2015 Potential Study[21]	9%	NA	NA
Vermont Public Service 2013 Potential Study[22]	NA	NA	19%
Xcel Energy 2012 Potential Study[23]	9%	10%	11%
Idaho Power 2012 Potential Study (Comm'l)[24]	9%	NA	NA
Idaho Power 2012 Potential Study (Ind'l)[25]	9%	NA	NA
Natural Gas Results			
National Grid 2015 Potential Study	5%	6%	7%
CPUC 2015 Potential Study[26]	3%	NA	NA
Xcel Colorado DSM Market Potential (Gas results)[27]	NA	3%	7%

It should be noted that the achievable scenarios in Table 5-49 for the other utilities were approached differently than what was done for National Grid. For example, the scenarios for Xcel were for incentives that covered 50% and 75% of the total cost for each measure. Although this difference makes comparing the results not quite apples to apples, it does provide context for the range of achievable energy savings other utilities similar to National Grid have seen for their 10 year potential studies.

[21] *Energy Efficiency Potential and Goals Study for 2015 and Beyond, Stage 1 Public Draft Report.* Navigant Consulting May 2015. http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Energy+Efficiency+Goals+and+Potential+Studies.htm

[22] *2013 Vermont Energy Efficiency Potential Study Update, Final Report.* GDS Associates, Inc., March 2014. http://publicservice.vermont.gov/sites/psd/files/Topics/Energy_Efficiency/2013%20VT%20Energy%20Efficiency%20Potential%20Study%20Update_FINAL_03-28-2014.pdf

[23] *Xcel Energy Minnesota DSM Market Potential Assessment, Final Report.* KEMA, Inc., April 2012. http://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/MN-DSM/MN-DSM-Market-Potential-Assessment-Vol-1.pdf

[24] *Idaho Power Energy Efficiency Potential Study,* EnerNOC, February 2012. https://www.idahopower.com/pdfs/EnergyEfficiency/Reports/2012PotentialStudyReport.pdf

[25] Ibid.

[26] *Energy Efficiency Potential and Goals Study for 2015 and Beyond, Stage 1 Public Draft Report.* Navigant Consulting May 2015. http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Energy+Efficiency+Goals+and+Potential+Studies.htm

[27] *Colorado DSM Market Potential Assessment.* Kema Consulting March 2010. http://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/CODSM-Report.pdf

DNV·GL

National Grid Massachusetts Energy Efficiency Potential Study Appendices

FINAL

Prepared by KEMA, Inc.

October 26, 2015

APPENDICES

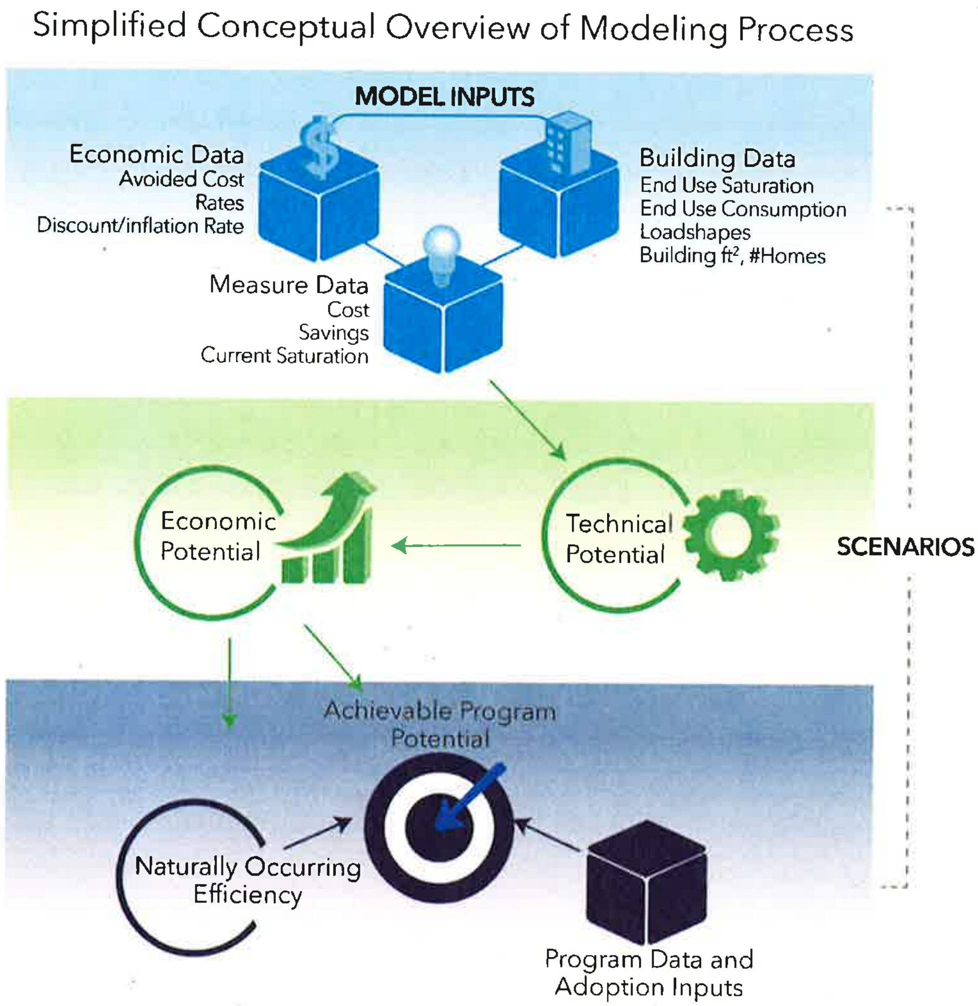
A. DETAILED METHODOLOGY

In this appendix DNV GL presents and discusses our basic methodology for conducting market potential studies.

A.1 Overview of DSM Forecasting Method

The crux of this study involves carrying out a number of basic analytical steps to produce estimates of the energy efficiency potentials introduced above. The basic analytical steps for this study are shown in relation to one another in Figure A-1. The bulk of the analytical process for this study was carried out in a model developed by DNV GL for conducting energy efficiency potential studies. The study integrates technology-specific engineering and customer behavior data with utility market saturation data, load shapes, rate projections, and marginal costs into an easily updated data management system.

Figure A-1: Conceptual Overview of Study Process



The key steps implemented in this study are:

Step 1: Develop Initial Input Data

- Develop a list of energy efficiency measure opportunities to include in scope. In this step, an initial draft measure list was developed and provided to National Grid. The final measure list was developed after incorporating comments.
- Gather and develop technical data (costs and savings) on efficient measure opportunities. Data on measures were gathered from a variety of sources. Detail on measure inputs is provided in Appendix D.
- Gather, analyze, and develop information on building characteristics, including total square footage, energy consumption and intensity by end use, end-use consumption load patterns by time of day and year (i.e., load shapes), market shares of key electric consuming equipment, and market shares of energy efficiency technologies and practices.

- Collect data on economic parameters: avoided costs, electricity rates, discount rates, and inflation rate. These inputs are provided in Appendix C of this report.

Step 2: Estimate Technical Potential and Develop Supply Curves

- Match and integrate data on efficient measures to data on existing building characteristics to produce estimates of technical potential and energy efficiency supply curves.

Step 3: Estimate Economic Potential

- Match and integrate measure and building data with economic assumptions to produce indicators of costs from different viewpoints (e.g., societal and consumer).
- Account for interaction and competition between measures. Measures are assumed to be implemented in order of cost-effectiveness, with the most cost-effective measures implemented first. If subsequent measures are mutually exclusive with previous measures (for example, CFL and LED lamps competing for the same socket), the subsequent measure is evaluated on its marginal costs and marginal savings compared to the more cost-effective measure.
- Estimate total economic potential. Note that at this stage of the analysis, program-related costs are not factored into the cost-effectiveness screening. Thus, the results reflect the theoretical estimate of the measure impacts, while disregarding the mode of delivery. In addition, this step does not take into account natural measure turnover and instead assumes that all available measure installations occur immediately in year one.

Step 4: Estimate Achievable Program and Naturally Occurring Potentials

- Screen initial measures for inclusion in the program analysis. This screening may take into account factors such as natural measure turnover, cost effectiveness, potential market size, non-energy benefits, market barriers, and potentially adverse effects associated with a measure. For this study, measures were screened using the total-resource-cost test, with the exclusion of program marketing and administrative costs.
- Gather and develop estimates of program costs (e.g., for administration and marketing) and historic program savings.
- Develop estimates of customer adoption of energy efficiency measures as a function of the economic attractiveness of the measures, barriers to their adoption, and the effects of program intervention.
- Estimate achievable program and naturally occurring potentials and associated program costs.

Step 5: Scenario Analyses

- Recalculate potentials under alternate program scenarios. These scenarios relate to different levels of incentives offered to participants for energy efficiency measures.

Provided below is additional discussion of DNV GL's modeling approaches for technical, economic, and achievable DSM forecasts.

A.1.1 Estimate Technical Potential and Develop Energy-Efficiency Supply Curves

Technical potential refers to the amount of energy savings or peak demand reduction that would occur with the *complete* penetration of all measures analyzed in applications where they were deemed *technically* feasible from an *engineering* perspective. Total technical potential is developed from estimates of the technical potential of individual measures as they are applied to discrete market segments (commercial building types, residential dwelling types, etc.).

A.1.1.1 Core Equation

The core equation used to calculate the energy technical potential for each individual efficiency measure, by market segment, is shown below (using a commercial example):[1]

$$\text{Technical Potential of Efficient Measure} = \text{Total Square Feet} \times \text{Base Case Equipment EUI} \times \text{Applicability Factor} \times \text{Not Complete Factor} \times \text{Feasibility Factor} \times \text{Savings Factor}$$

where:

Square feet is the total floor space for all buildings in the market segment. For a residential analysis, the **number of dwelling units** is substituted for square feet.

Base-case equipment EUI is the energy used per square foot by each base-case technology in each market segment. This is the consumption of the energy-using equipment that the efficient technology replaces or affects. For example, if the efficient measure were a CFL, the base EUI would be the annual kWh per square foot of an equivalent incandescent lamp. For the residential analysis, unit energy consumption (UECs), energy used per dwelling, are substituted for EUIs.

Applicability factor is the fraction of the floor space (or dwelling units) that is applicable for the efficient technology in a given market segment; for the example above, the percentage of floor space lit by incandescent bulbs.

Not complete factor is the fraction of applicable floor space (or dwelling units) that has not yet been converted to the efficient measure; that is, (1 minus the fraction of floor space that already has the EE measure installed).

Feasibility factor is the fraction of the applicable floor space (or dwelling units) that is technically feasible for conversion to the efficient technology from an *engineering* perspective.

Savings factor is the percent reduction in energy consumption resulting from application of the efficient technology.

Technical potential for peak demand reduction is calculated analogously.

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[1] Note that stock turnover is not accounted for in our estimates of technical and economic potential, stock turnover *is accounted for* in our estimates of achievable potential. Our definition of technical potential assumes instantaneous replacement of standard-efficiency with high-efficiency measures.

An example of the core equation is shown in Table A-1 for the case of a prototypical 4-lamp 4-foot standard T-8 lighting fixture, which is replaced by a 4-lamp 4-foot premium T-8 fixture in the office segment of a large utility service territory.

Table A-1
Example of Technical Potential Calculation—Replace 4-Lamp 4-Foot Standard T-8s with 4-Lamp 4-Foot Premium T-8s in the Office Segment of a Utility Service Territory
(Note: Data are illustrative only)

Technical Potential of Efficient Measure	=	Total square feet	×	Base Case Equipment UEC	×	Applicability Factor	×	Not Complete Factor	×	Feasibility Factor	×	Savings Factor
57 million kWh		195 million		5.74		0.34		0.95		1.00		0.16

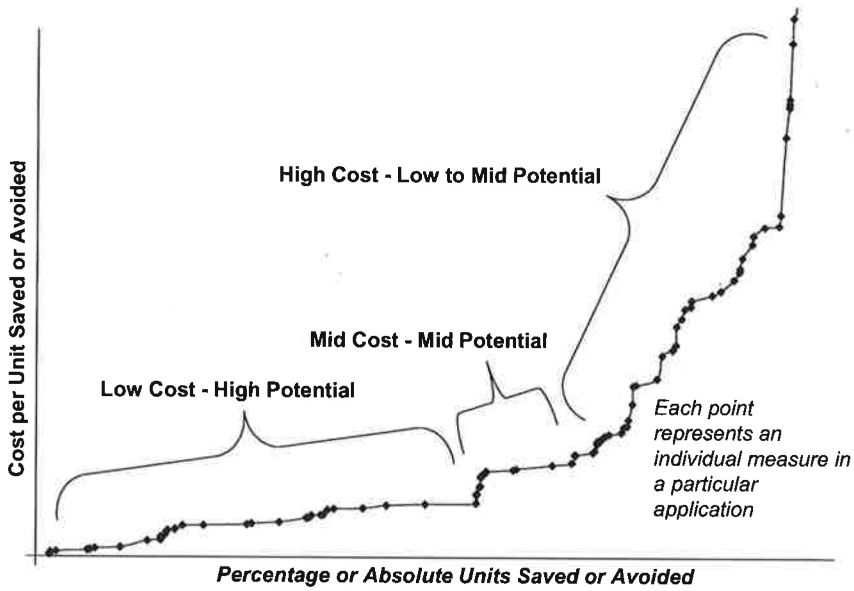
Technical EE potential is calculated in two steps. In the first step, all measures are treated independently; that is, the savings of each measure are not marginalized or otherwise adjusted for overlap between competing or synergistic measures. By treating measures independently, their relative economics are analyzed without making assumptions about the order or combinations in which they might be implemented in customer buildings. However, the total technical potential across measures cannot be estimated by summing the individual measure potentials directly. The cumulative savings cannot be estimated by adding the savings from the individual savings estimates because some savings would be double counted. For example, the savings from a measure that reduces heat gain into a building, such as window film, are partially dependent on other measures that affect the efficiency of the system being used to cool the building, such as a high-efficiency chiller; the more efficient the chiller, the less energy saved from the application of the window film.

A.1.1.2 Use of Supply Curves

In the second step, cumulative technical potential is estimated using an EE supply curve approach.[2] This method eliminates the double-counting problem. In Figure A-2, DNV GL presents a generic example of a supply curve. As shown in the figure, a supply curve typically consists of two axes—one that captures the cost per unit of saving a resource or mitigating an impact (e.g., $/kWh saved or $/ton of carbon avoided) and the other that shows the amount of savings or mitigation that could be achieved at each level of cost. The curve is typically built up across individual measures that are applied to specific base-case practices or technologies by market segment. Savings or mitigation measures are sorted on a least-cost basis, and total savings or impacts mitigated are calculated incrementally with respect to measures that precede them. Supply curves typically, but not always, end up reflecting diminishing returns, i.e., as costs increase rapidly and savings decrease significantly at the end of the curve.

[2] This section describes conservation supply curves as they have been defined and implemented in numerous studies. Readers should note that Stoft 1995 describes several technical errors in the definition and implementation of conservation supply curves in the original and subsequent conservation supply curve studies. Stoft concludes that conservation supply curves are not "true" supply curves in the standard economic sense but can still be useful (albeit with his recommended improvements) for their intended purpose (demonstration of cost-effective conservation opportunities).

Figure A-2: Generic Illustration of EE Supply Curve



As noted above, the cost dimension of most EE supply curves is usually represented in dollars per unit of energy savings. Costs are usually annualized (often referred to as "levelized") in supply curves. For example, EE supply curves usually present levelized costs per kWh or kW saved by multiplying the initial investment in an efficient technology or program by the "capital recovery rate" (CRR):

$$\text{CRR} = \frac{d}{1-(1+d)^{-n}}$$

where *d* is the real discount rate and *n* is the number of years over which the investment is written off (i.e., amortized).

Thus,

Levelized Cost per kWh Saved = Initial Cost x CRR/Annual Energy Savings

Levelized Cost per kW Saved = Initial Cost x CRR/Peak Demand Savings

The levelized cost per kWh and kW saved are useful because they allow simple comparison of the characteristics of EE with the characteristics of energy supply technologies. However, the levelized cost per kW saved is a biased indicator of cost-effectiveness because all of the efficiency measure costs are arbitrarily allocated to peak savings.

Returning to the issue of EE supply curves, Table A-2 shows a simplified numeric example of a supply curve calculation for several EE measures applied to commercial lighting for a hypothetical population of buildings. What is important to note is that in an EE supply curve, the measures are sorted by relative cost—from least to most expensive. In addition, the energy consumption of the system being affected by the efficiency measures goes down as each measure is applied. As a result, the savings attributable to each subsequent measure decrease if the measures are interactive. For example, the occupancy sensor measure shown in Table A-2 would save more at less cost per unit saved if it were applied to the base-case consumption before the T8 lamp and electronic ballast combination. Because the T8 electronic ballast combination is more cost-effective, however, it is applied first, reducing the energy savings potential for the occupancy sensor. Thus, in a typical EE supply curve, the base-case end-use consumption is reduced with each unit of EE that is acquired. Notice in Table A-2 that the total end-use GWh consumption is recalculated after each measure is implemented, thus reducing the base energy available to be saved by the next measure.

Table A-2 shows an example that would represent measures for one base-case technology in one market segment. These calculations are performed for all of the base-case technologies, market segments, and measure combinations in the scope of a study. The results are then ordered by levelized cost and the individual measure savings are summed to produce the EE potential for the entire sector.

In the next subsection, DNV GL discusses how economic potential is estimated as a subset of the technical potential.

Table A-2
Sample Technical Potential Supply Curve Calculation for Commercial Lighting
(Note: Data are illustrative only)

Measure	Total End Use Consumption of Population (GWh)	Applicable, Not Complete and Feasible (1000s of ft^2)	Average kWh/ft^2 of population	Savings %	GWh Savings	Levelized Cost ($/kWh saved)
Base Case: T12 lamps with Magnetic Ballast	425	100,000	4.3	N/A	N/A	N/A
1. T8 w. Elec. Ballast	425	100,000	4.3	21%	89	$0.04
2. Occupancy Sensors	336	40,000	3.4	10%	13	$0.11
3. Perimeter Dimming	322	10,000	3.2	45%	14	$0.25
With all measures	309		3.1	27%	116	

A.1.2 Estimation of Economic Potential

Economic potential is typically used to refer to the technical potential of those energy conservation measures that are cost effective when compared to either supply-side alternatives or the price of energy. Economic potential takes into account the fact that many EE measures cost more to purchase initially than do their standard-efficiency counterparts. The incremental costs of each efficiency measure are compared to the savings delivered by the measure to produce estimates of energy savings per unit of additional cost. These estimates of EE resource costs can then be compared to estimates of other resources such as building and operating new power plants.

A.1.2.1 Cost Effectiveness Tests

To estimate economic potential, it is necessary to develop a method by which it can be determined that a measure or program is economic. There is a large body of literature that debates the merits of different approaches to calculating whether a public purpose investment in EE is cost effective (Chamberlin and Herman 1993, RER 2000, Ruff 1988, Stoft 1995, and Sutherland 2000). DNV GL usually utilizes the total resource cost (TRC) test to assess cost effectiveness and in addition, National Grid's own cost-effectiveness testing utilizes the TRC test. The TRC is a form of societal benefit-cost test. Other tests that have been used in analyses of program cost-effectiveness by EE analysts include the utility cost, ratepayer impact measure (RIM), and participant tests. The California Standard Practice Manual (CASPM) discusses the tests in detail and presents a good primer for a basic understanding. Before discussing the TRC test and how it is typically used in our DSM forecasts, DNV GL presents below a brief introduction to the basic tests as described in the CASPM:[3]

- Total Resource Cost Test—The TRC test measures the net costs of a demand-side management program as a resource option based on the total costs of the program, including both the participants' and the utility's costs. The test is applicable to conservation, load management, and fuel substitution programs. For fuel substitution programs, the test measures the net effect of the impacts from the fuel not chosen versus the impacts from the fuel that is chosen as a result of the program. TRC test results for fuel substitution programs should be viewed as a measure of the economic efficiency implications of the total energy supply system (gas and electric). A variant on the TRC test is the societal test. The societal test differs from the TRC test in that it includes the effects of externalities (e.g. environmental, national security), excludes tax credit benefits, and uses a different (societal) discount rate.
- Participant Test—The participant test is the measure of the quantifiable benefits and costs to the customer due to participation in a program. Since many customers do not base their decision to participate in a program entirely on quantifiable variables, this test cannot be a complete measure of the benefits and costs of a program to a customer.
- Utility (Program Administrator) Test—The program administrator cost test measures the net costs of a demand-side management program as a resource option based on the costs incurred by the program administrator (including incentive costs) and excluding any net costs incurred by the participant. The benefits are similar to the TRC benefits. Costs are defined more narrowly.
- Ratepayer Impact Measure Test—The ratepayer impact measure (RIM) test measures what happens to customer bills or rates due to changes in utility revenues and operating costs caused by the program. Rates will go down if the change in revenues from the program is greater than the change in utility costs. Conversely, rates or bills will go up if revenues collected after program implementation are less than the total costs incurred by the utility in

[3] These definitions are direct excerpts from the California Standard Practice Manual, October 2001.

implementing the program. This test indicates the direction and magnitude of the expected change in customer bills or rate levels.

The key benefits and costs of the various cost-effectiveness tests are summarized in Table A-3.

Table A-3
Summary of Benefits and Costs of California Standard Practice Manual Tests

Test	Benefits	Costs
TRC Test	Generation, transmission and distribution savings Participants avoided equipment costs (fuel switching only)	Generation costs Program costs paid by the administrator Net participant measure costs
Participant Test	Bill reductions Incentives Participants avoided equipment costs (fuel switching only)	Bill increases Participant measure costs
Utility (Program Administrator) Test	Generation, transmission and distribution savings	Generation costs Program costs paid by the administrator Incentives
Ratepayer Impact Measure Test	Generation, transmission and distribution savings Revenue gain	Generation costs Revenue loss Program costs paid by the administrator Incentives

Generation, transmission and distribution savings (hereafter, energy benefits) are defined as the economic value of the energy and demand savings stimulated by the interventions being assessed. These benefits are typically measured as induced changes in energy consumption, valued using some mix of avoided costs. Electricity benefits are valued using three types of avoided electricity costs: avoided distribution costs, avoided transmission costs, and avoided electricity generation costs.

Participant costs are comprised primarily of incremental measure costs. Incremental measure costs are essentially the costs of obtaining EE. In the case of an add-on device (say, an adjustable-speed drive or ceiling insulation), the incremental cost is simply the installed cost of the measure itself. In the case of equipment that is available in various levels of efficiency (e.g., a central air conditioner), the incremental cost is the excess of the cost of the high-efficiency unit over the cost of the base (reference) unit.

Administrative costs encompass the real resource costs of program administration, including the costs of administrative personnel, program promotions, overhead, measurement and evaluation, and shareholder incentives. In this context, administrative costs are not defined to include the costs of various incentives (e.g., customer rebates and salesperson incentives) that may be offered to encourage certain types of behavior. The exclusion of these incentive costs reflects the fact that they are essentially transfer payments. That is, from a societal perspective they involve offsetting costs (to the program administrator) and benefits (to the recipient).

A.1.2.2 Use of the Total Resource Cost to Estimate Economic Potential

We use the TRC test in two ways in our model. First, the team develops an estimate of economic potential by calculating the TRC of individual measures and applying the methodology described below. Second, the team develops estimates of whether different program scenarios are cost effective.

Economic potential can be defined either inclusively or exclusively of the costs of programs that are designed to increase the adoption rate of EE measures. In many of our projects, DNV GL defines economic potential to exclude program costs. DNV GL does so primarily because program costs are dependent on a number of factors that vary significantly as a function of program delivery strategy. There is no single estimate of program costs that would accurately represent such costs across the wide range of program types and funding levels possible. Once an assumption is made about program costs, one must also link those assumptions to expectations about market response to the types of interventions assumed. Because of this, the team believes it is more appropriate to factor program costs into our analysis of program potential. Thus, our definition of economic potential is that portion of the technical potential that passes our economic screening test (described below) exclusive of program costs. Economic potential, like technical potential, is a theoretical quantity that will exceed the amount of potential the team estimates to be achievable through current or more aggressive program activities.

As implied in Table A-3 and defined in the CASPM 2001, the TRC focuses on resource savings and counts benefits as utility-avoided supply costs and costs as participant costs and utility program costs. It ignores any impact on rates. It also treats financial incentives and rebates as transfer payments; i.e., the TRC is not affected by incentives. The somewhat simplified benefit and cost formulas for the TRC are presented in Equations A-1 and A-2 below.

Equation A-1

$$\text{Benefits} = \sum_{t=1}^{N} \frac{\text{Avoided Costs of Supply}_{p,t}}{(1+d)^{t-1}}$$

Equation A-2

$$\text{Costs} = \sum_{t=1}^{N} \frac{\text{Program Cost}_t + \text{Participant Cost}_t}{(1+d)^{t-1}}$$

Where:

d = the discount rate
p = the costing period
t = time (in years)
n = 20 years

A nominal discount rate is typically used in the analysis, as inflation is taken into account separately.

The avoided costs of supply are calculated by multiplying measure energy savings and peak demand impacts by per-unit avoided costs by costing period. Energy savings are allocated to costing periods and peak impacts estimated using load shape factors.

As noted previously, in the measure-level TRC calculation used to estimate economic potential, program costs are excluded from Equation A-2. Using the supply curve methodology discussed previously, measures are ordered by TRC (highest to lowest) and then the economic potential is calculated by summing the energy savings for all of the technologies for which the marginal TRC test is greater than 1.0. In the example in Table A-4, the economic potential would include the savings for measures 1 and 2, but exclude saving for measure 3 because the TRC is less than 1.0 for measure 3. The supply curve methodology, when combined with estimates of the TRC for individual measures, produces estimates of the economic potential of efficiency improvements. By definition and intent, this estimate of economic potential is a theoretical quantity that will exceed the amount of potential the team estimates to be achievable through program activities in the final steps of our analyses.

Table A-4: Sample Use of Supply Curve Framework to Estimate Economic Potential (Note: Data are illustrative only)

Measure	**Total End Use Consumption of Population (GWh)**	**Applicable, Not Complete and Feasible Sq.Feet (000s)**	**Average kWh/ft^2 of population**	**Savings %**	**GWh Savings**	**Total Resource Cost Test**	**Savings Included in Economic Potential?**
Base Case: T12 lamps with Magnetic Ballast	425	100,000	4.3	N/A	N/A	N/A	N/A
1. T8 w. Elec. Ballast	425	100,000	4.3	21%	89	2.5	Yes
2. Occupancy Sensors	336	40,000	3.4	10%	13	1.3	Yes
3. Perimeter Dimming	322	10,000	3.2	45%	14	0.8	No
Technical Potential with all measures				27%	116		
Economic Potential with measures for which TRC Ratio > 1.0				24%	102		

A.1.3 Estimation of Program and Naturally Occurring Potentials

In this section DNV GL presents the method we employ to estimate the fraction of the market that adopts each EE measure in the presence and absence of EE programs. DNV GL defines:

- Program potential as the amount of savings that would occur in response to one or more specific market interventions
- Naturally occurring potential as the amount of savings estimated to occur as a result of normal market forces, that is, in the absence of any utility or governmental intervention.

Our estimates of program potential are typically the most important results of the modeling process. Estimating technical and economic potentials are necessary steps in the process from which important information can be obtained; however, the end goal of the process is better understanding how much of the remaining potential can be captured in programs, whether it would be cost-effective to increase program spending, and how program costs may be expected to change in response to measure adoption over time.

A.1.3.1 Adoption Method Overview

We use a method of estimating adoption of EE measures that applies equally to be our program and naturally occurring analyses. Whether as a result of natural market forces or aided by a program intervention, the rate at which measures are adopted is modeled in our method as a function of the following factors:

- The availability of the adoption opportunity as a function of capital equipment turnover rates and changes in building stock over time
- Customer awareness of the efficiency measure
- The cost-effectiveness of the efficiency measure
- Market barriers associated with the efficiency measure.

In many of our projects, only measures that pass the measure-level TRC test are put into the penetration module for estimation of customer adoption.

A.1.3.2 Availability

A crucial part of the model is a stock accounting algorithm that handles capital turnover and stock decay over a period of up to 20 years. In the first step of our achievable potential method, the team calculates the number of customers for whom each measure will apply. The input to this calculation is the total floor space available for the measure from the technical potential analysis, i.e., the total floor space multiplied by the applicability, not complete, and feasibility factors described previously. DNV GL calls this the eligible stock. The stock algorithm keeps track of the amount of floor space available for each efficiency measure in each year based on the total eligible stock and whether the application is new construction, retrofit, or replace-on-burnout.[4]

Retrofit measures are available for implementation by the entire eligible stock. The eligible stock is reduced over time as a function of adoptions[5] and building decay.[6] Replace-on-burnout measures are

[4] Replace-on-burnout measures are defined as the efficiency opportunities that are available only when the base equipment turns over at the end of its service life. For example, a high-efficiency chiller measure is usually only considered at the end of the life of an existing chiller. By contrast, retrofit measures are defined to be constantly available, for example, application of a window film to existing glazing.

[5] That is, each square foot that adopts the retrofit measure is removed from the eligible stock for retrofit in the subsequent year, and remains out of the eligible stock until the end of the measure's useful life.

[6] Buildings do not last forever. An input to the model is the rate of decay of the existing floor space. Floor space typically decays at a very slow rate.

available only on an annual basis, approximated as equal to the inverse of the service life.[7] The annual portion of the eligible market that does not accept the replace-on-burnout measure does not have an opportunity again until the end of the service life.

New construction applications are available for implementation in the first year. Those customers that do not accept the measure are given subsequent opportunities corresponding to whether the measure is a replacement or retrofit-type measure.

A.1.3.3 Awareness

In our modeling framework, customers cannot adopt an efficient measure merely because there is stock available for conversion. Before they can make the adoption choice, they must be aware and informed about the efficiency measure. Thus, in the second stage of the process, the model calculates the portion of the available market that is informed. An initial user-specified parameter sets the initial level of awareness for all measures. Incremental awareness occurs in the model as a function of the amount of money spent on awareness/information building and how costly it is to reach each customer.

The model also controls for information retention. An information decay parameter in the model is used to control for the percentage of customers that will retain program information from one year to the next. Information retention is based on the characteristics of the target audience and the temporal effectiveness of the marketing techniques employed.

A.1.3.4 Adoption

The portion of the total market this is available and informed can now face the choice of whether or not to adopt a particular measure. Only those customers for whom a measure is available for implementation (stage 1) and, of those customers, only those who have been informed about the program/measure (stage 2), are in a position to make the implementation decision.

In the third stage of our penetration process, the model calculates the fraction of the market that adopts each efficiency measure as a function of the participant test. The participant test is a benefit-cost ratio that is generally calculated as follows:

Equation A-3

$$\text{Benefits} = \sum_{t=1}^{N} \frac{\text{Customer Bill Savings (\$)}_t}{(1+d)^{t-1}}$$

Equation A-4

$$\text{Costs} = \sum_{t=1}^{N} \frac{\text{Participant Costs (\$)}_t}{(1+d)^{t-1}}$$

Where:

[7] For example, a base-case technology with a service life of 15 years is only available for replacement to a high-efficiency alternative each year at the rate of 1/15 times the total eligible stock. For example, the fraction of the market that does not adopt the high-efficiency measure in year *t* will not be available to adopt the efficient alternative again until year *t* + 15.

d = the discount rate
t = time (in years)
N = measure lifetime

The bill reductions are calculated by multiplying measure energy savings and customer peak demand impacts by retail energy and demand rates.

The model uses measure implementation curves to estimate the percentage of the informed market that will accept each measure based on the participant's benefit-cost ratio. The model provides enough flexibility so that each measure in each market segment can have a separate implementation rate curve. The functional form used for the implementation curves is:

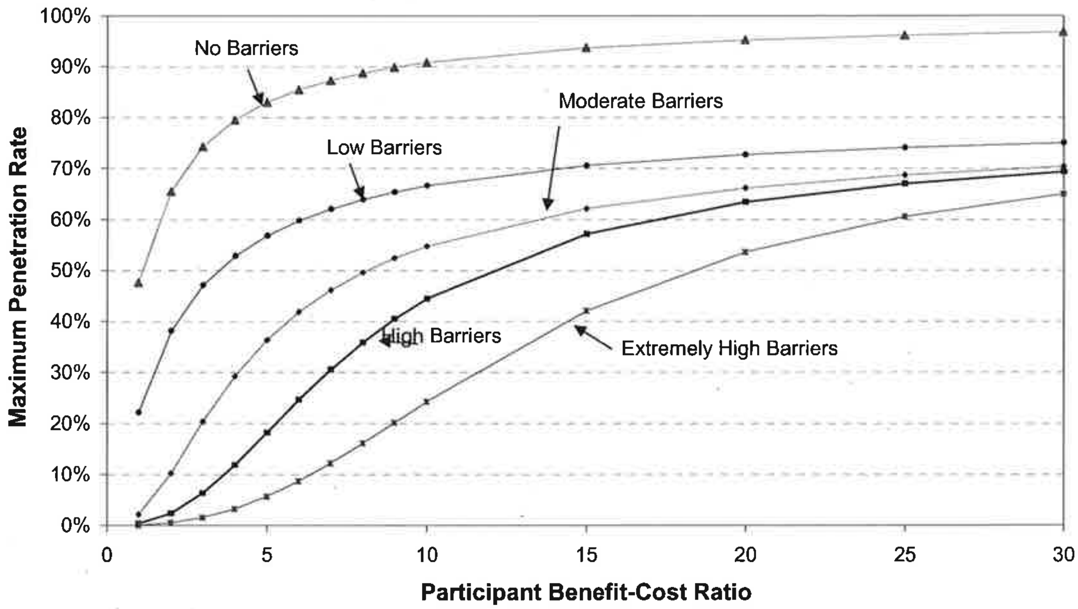
$$y = \frac{a}{\left(1 + e^{-\ln\frac{x}{4}}\right) \times \left(1 + e^{-c\ln(bx)}\right)}$$

where:

y = the fraction of the market that installs a measure in a given year from the pool of informed applicable customers;
x = the customer's benefit-cost ratio for the measure;
a = the maximum annual acceptance rate for the technology;
b = the inflection point of the curve. It is generally 1 over the benefit-cost ratio that will give a value of 1/2 the maximum value; and
c = the parameter that determines the general shape (slope) of the curve.

The primary curves utilized in our model are shown in Figure A-3. These curves produce base year program results that are calibrated to actual measure implementation results associated with major IOU commercial efficiency programs over the past several years. Different curves are used to reflect different levels of market barriers for different efficiency measures. A list of market barriers is shown in Table A-5. It is the existence of these barriers that necessitates program interventions to increase the adoption of EE measures.

Figure A-3: Primary Measure Implementation Curves Used in Adoption Model



Note that for the moderate, high barrier, and extremely high curves, the participant benefit-cost ratios have to be very high before significant adoption occurs. This is because the participant benefit-cost ratios are based on a 15-percent discount rate. This discount rate reflects likely adoption if there were no market barriers or market failures, as reflected in the no-barriers curve in the figure. Experience has shown, however, that actual adoption behavior correlates with implicit discount rates several times those that would be expected in a perfect market.[8]

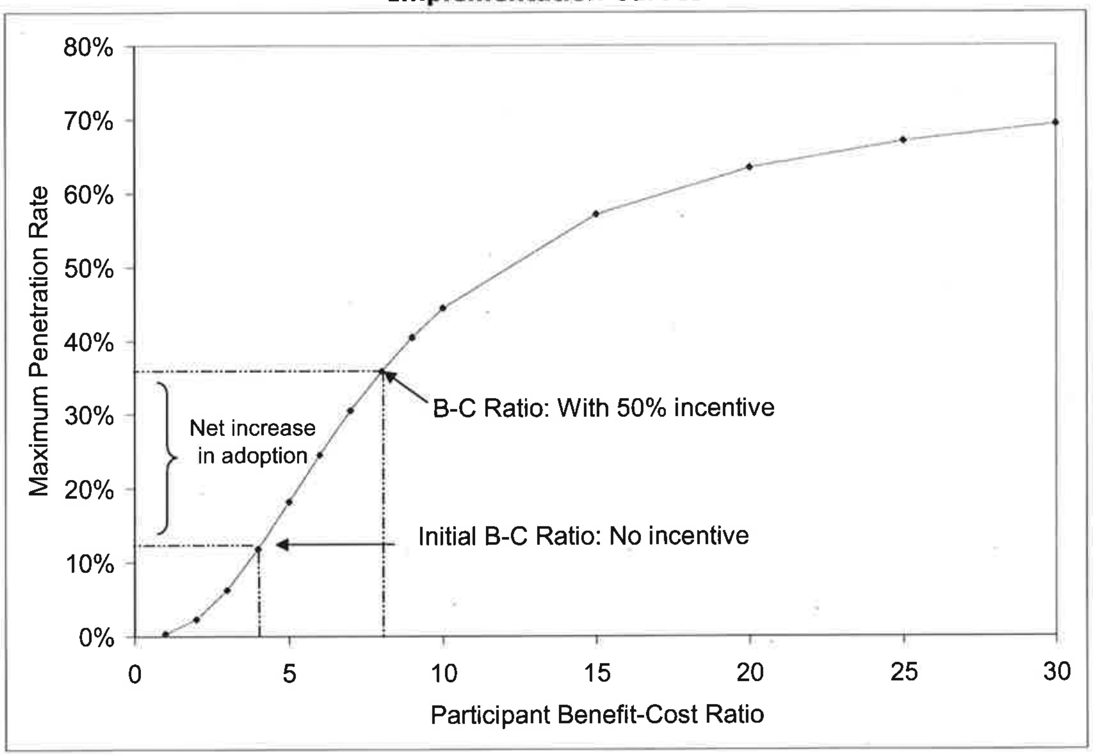
[8] For some, it is easier to consider adoption as a function of simple payback. However, the relationship between payback and the participant benefit-cost ratio varies depending on measure life and discount rate. For a long-lived measure of 15 years with a 15-percent discount rate, the equivalent payback at which half of the market would adopt a measure is roughly 6 months, based on the high barrier curve in Figure 2-3. At a 1-year payback, one-quarter of the market would adopt the measure. Adoption reaches near its maximum at a 3-month payback. The curves reflect the real-world observation that implicit discount rates can average up to 100 percent.

Table A-5: Summary Description of Market Barriers from Eto, Prahl, Schlegel 1997

Barrier	Description
Information or Search Costs	The costs of identifying energy-efficient products or services or of learning about energy-efficient practices, including the value of time spent finding out about or locating a product or service or hiring someone else to do so.
Performance Uncertainties	The difficulties consumers face in evaluating claims about future benefits. Closely related to high search costs, in that acquiring the information needed to evaluate claims regarding future performance is rarely costless.
Asymmetric Information and Opportunism	The tendency of sellers of energy-efficient products or services to have more and better information about their offerings than do consumers, which, combined with potential incentives to mislead, can lead to sub-optimal purchasing behavior.
Hassle or Transaction Costs	The indirect costs of acquiring EE, including the time, materials and labor involved in obtaining or contracting for an energy-efficient product or service. (Distinct from search costs in that it refers to what happens once a product has been located.)
Hidden Costs	Unexpected costs associated with reliance on or operation of energy-efficient products or services - for example, extra operating and maintenance costs.
Access to Financing	The difficulties associated with the lending industry's historic inability to account for the unique features of loans for energy savings products (i.e., that future reductions in utility bills increase the borrower's ability to repay a loan) in underwriting procedures.
Bounded Rationality	The behavior of an individual during the decision-making process that either seems or actually is inconsistent with the individual's goals.
Organization Practices or Customs	Organizational behavior or systems of practice that discourage or inhibit cost-effective EE decisions, for example, procurement rules that make it difficult to act on EE decisions based on economic merit.
Misplaced or Split incentives	Cases in which the incentives of an agent charged with purchasing EE are not aligned with those of the persons who would benefit from the purchase.
Product or Service Unavailability	The failure of manufacturers, distributors or vendors to make a product or service available in a given area or market. May result from collusion, bounded rationality, or supply constraints.
Externalities	Costs that are associated with transactions, but which are not reflected in the price paid in the transaction.
Non-externality Pricing	Factors other than externalities that move prices away from marginal cost. An example arises when utility commodity prices are set using ratemaking practices based on average (rather than marginal) costs.
Inseparability of Product Features	The difficulties consumers sometimes face in acquiring desirable EE features in products without also acquiring (and paying for) additional undesired features that increase the total cost of the product beyond what the consumer is willing to pay.
Irreversibility	The difficulty of reversing a purchase decision in light of new information that may become available, which may deter the initial purchase, for example, if energy prices decline, one cannot resell insulation that has been blown into a wall.

The model estimates adoption under both naturally occurring and program intervention situations. There are only two differences between the naturally occurring and program analyses. First, in any program intervention case in which measure incentives are provided, the participant benefit-cost ratios are adjusted based on the incentives. Thus, if an incentive that pays 50 percent of the incremental measure cost is applied in the program analysis, the participant benefit-cost ratio for that measure will double (since the costs have been halved). The effect on the amount of adoption estimated will depend on where the pre- and post-incentive benefit-cost ratios fall on the curve. This effect is illustrated in Figure A-4.

Figure A-4: Illustration of Effect of Incentives on Adoption Level as Characterized in Implementation Curves



In many of our projects achievable potential EE forecasts are developed for several scenarios, ranging from base levels of program intervention, through moderate levels, up to an aggressive EE acquisition scenario. Uncertainty in rates and avoided costs are often characterized in alternate scenarios. The final results produced are annual streams of achievable program impacts (energy and demand by time-of-use period) and all societal and participant costs (program costs plus end-user costs).

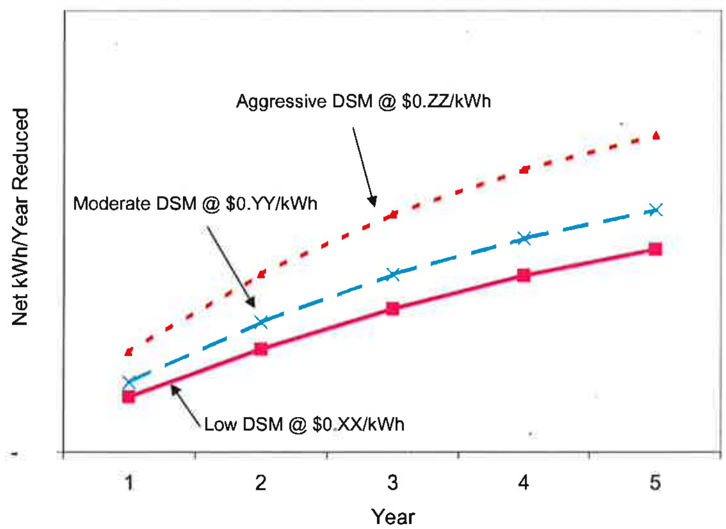
A.1.4 Scenario Analyses

Achievable potential forecasts can be developed for multiple scenarios. For example, program savings can be modeled under low levels of program intervention, through moderate levels, up to an aggressive DSM acquisition scenario. Uncertainty in rates and avoided costs can be characterized in alternate scenarios as well. The final results produced will be annual streams of achievable DSM program impacts (energy and demand by time-of-use period) and all societal and participant costs. An example of the types of outputs that have been produced for similar studies in the past is shown in Table A-6 and Figure A-5.

Table A-6: Example Format of Achievable Potential Outputs

DSM Program Output	2015	20016	20017	etc.
Annual Energy Savings (kWh)				
Net Annual Energy Savings (kWh)				
Peak Demand Savings (kW)				
Net Peak Demand Savings (kW)				
Annual Program Costs				
Supplemental Customer Costs				

Figure A-5: Example of DSM Scenario Outputs



A.1.5 Measure "Bundles" for Complex End Uses

Although potential can be estimated through measure-specific analyses for many sectors and end uses, there are some cases where the measure-specific approach becomes problematic because of the complexity or heterogeneity of the base-case energy systems being addressed. Two key examples are industrial processes and some aspects of residential and commercial new construction.

In the industrial case, there may be dozens or even hundreds of individual measures that can be applied to industrial processes throughout the population of industrial facilities in a service territory; however, analyzing each of these opportunities, though possible, is impractical within a resource and time-constrained study such as this one.

In the case of new construction, the problem is sometimes that an equipment substitution paradigm does not fit the real-world circumstances in which efficiency levels are improved. For example, in commercial lighting, virtually all new buildings tend to have electronic ballasts and T-8 lamps, as well as CFLs or LEDs, and other high-efficiency components. However, the overall lighting system efficiency can often be increased by using these same components in smarter designs configurations or by combining with other features such as daylighting.

For both of these situations, our approach on recent related work has been to bundle multiple individual efficiency measures into somewhat simplified efficiency levels. For example, lighting levels for commercial new construction might be set at 10- and 20-percent improvement over those required by building codes. Similarly, for industrial compressed air systems, the team has bundled savings opportunities into three levels where both savings and costs increase with each level. The team then estimates an incremental cost for achieving each of the efficiency levels.

Once the levels efficiency are specified in terms of costs and savings, they are run through the modeling system as if they were individual measures. Thus, cost-effectiveness indicators are calculated for each level, those that pass the TRC are included in the achievable potential forecasting, and adoption is modeled using the same process as described above. Although the team recommends using this approach for complex end uses because it creates a manageable forecasting process, care must be taken in developing the levels and recognizing that this approach results in some aggregation bias.

B. GLOSSARY

Achievable potential: The amount of savings that would occur in response to specific marketing levels and measure incentive levels. Savings associated with program potential are savings that are projected beyond those that would occur naturally in the absence of any market intervention.

Applicability factor: The percentage of the building stock that has a particular type of equipment or for which an efficiency measure applies. For example, the applicability factor for a tankless electric water heater (compared to a base standard electric water heater) is the percentage of homes with electric water heaters. The applicability factor for high-efficiency clothes washers as an electric water heating measure is the percentage of homes with electric water heating that also have a clothes washer. For base measures, this is sometimes referred to as the equipment saturation.

Business-as-usual (BAU): Represents a continuation of current activities or trends. For utility programs, it denotes a scenario in which program marketing and administrative budgets are kept constant in real terms, and incentive levels are kept constant.

Baseline analysis: Characterizes how baseline energy consumption breaks down by sector, building type, and end use.

Base measure: The equipment against which an efficiency measure is compared.

C&I: commercial and industrial.

CBECS: EIA Commercial Buildings Energy Consumption Survey

CFL: compact fluorescent lamp.

Coincidence factor: Utility coincidence factors are the ratio of actual demand reduction at utility peak to the gross of maximum demand reduction. These factors vary by market segment or building type, end use, measure and by time-of-use period.

Cumulative annual: Savings occurring in a particular year that are due to cumulative program activities up to that year. For example, if a program installs one high-efficiency widget in year 1 of the program, two in year 2, and five in year 3, the cumulative annual savings in year three would be the savings accruing on all eight surviving units in place in year 3, regardless of what year they were installed. Cumulative annual savings does account for equipment retirement. In the example above, widgets are assumed to have an effective useful life of more than three years. If the equipment in the above example were measures that only have a two-year effective useful life, the year 1 measures would have retired at the end of year 2, so only the units sold in years 2 and 3 would contribute to year 3 cumulative annual savings.

Demand-side management (DSM): An electric system must balance the supply of electricity with the demand for electricity. Demand-side management (DSM) programs focus on managing the demand side of this balance through energy-efficiency and load management to reduce the need for supply.

DOE: Department of Energy.

Economic potential: The technical potential of those energy conservation measures that are cost effective when compared to supply-side alternatives. This scenario counts the savings of all cost effective energy conservation measures regardless of the predicted time of installation, i.e. all potential savings are counted in year one.

Effective useful life (EUL): A measure of the typical lifetime of an efficiency measure. Technically, it is the age at which half of the units have failed and half survive. In DNV GL's National Grid model, all measures are assumed to remain in place until the end of their effective useful lives and then retire.

Energy-use intensity (EUI): Energy use per unit of building stock for a specific end use. For example, the EUI for commercial electric heating is the amount of electricity used for heating divided by the number of square feet of floor space that are electrically heated. EUI differs from EI in that it accounts for the equipment type's saturation. If the saturation of the equipment type is low, the EI will be much lower than the EUI.

Energy intensity (EI): Energy use per unit of building stock. For example, the EI for commercial electric heating is the amount of electricity used for heating divided by the total square feet. EI differs from EUI in that it does not account for the saturation of the equipment. If the saturation for the equipment type is low, EI will be much lower than the EUI.

EUI adjustment factor: Because equipment efficiencies can change over time independent of program activities, due to either naturally occurring technological changes or external intervention, such as appliance standards, the efficiency of new equipment may differ from the typical efficiency of the equipment stock. The EUI adjustment factor is the ratio of new standard efficiency equipment's energy use to the average energy use of units in the equipment stock.

Feasibility factor: The fraction of the applicable floor space, or households, that is technically feasible to convert to a DSM technology, from an engineering perspective.

Free rider: A program participant who would have invested in an energy efficiency measure even without the intervention of the program. Free riders add to program costs but do not contribute to net energy savings.

Free-rider energy savings: The subset of naturally occurring energy savings for which the utility pays incentives or provides other program benefits. These savings are included in gross program savings but not in net program savings.

Gross program savings: The total savings for all measures installed under the program, including those that would have been installed even without program intervention (free riders). Gross program savings equals net program savings minus free ridership savings.

Horsepower (HP): A metric for the rated work a motor can perform.

HVAC: heating, ventilation and air conditioning. These space-conditioning measures are often discussed as a group and are referred to by the abbreviation HVAC.

Incomplete factor: The fraction of the applicable floor space which has not yet been converted to the particular energy-efficiency technology.

Incremental cost: The additional cost required to purchase an efficiency measure compared to base equipment.

kW: kilowatts, 1,000 watts. A measure of electric power or electricity demand.

kWh: kilowatt-hour. A measure of electrical energy.

LED: light-emitting diode. LEDs are semiconductor light sources. They have been in use for decades as indicator lights; they are increasingly being used for general-purpose lighting. They are highly efficient compared to incandescent lamps.

MW: megawatt, one million watts. A measure of electric power or electricity demand.

MWh: megawatt-hour, equal to 1,000 kWh. A measure of electrical energy.

NAICS: The North American Industry Classification System is the standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy.

Naturally occurring energy savings: The amount of savings estimated to occur as a result of normal market forces, that is, in the absence of any utility or governmental intervention.

Net program savings: Program savings above and beyond naturally occurring levels. Net savings exclude free-rider energy savings.

Net-to-gross: The ratio of net program savings to gross program savings.

Program potential: This term is used interchangeably with achievable potential.

Replace on burnout (ROB): A measure that is installed when the previous equipment reaches the end of its useful life. ROB measures penetrate the market gradually as the existing stock of equipment turns over due to equipment age and eventual failure.

Retrofit: A measure that is installed to achieve energy savings independent of the condition of the existing equipment. This includes measures that affect the energy use of other equipment, such as insulation to reduce heating costs. It also includes replacing equipment with higher efficiency equipment before the end of existing equipment's useful life, for example replacing T12 fluorescent lighting in an office with higher efficiency T8s. Retrofits can be done at any time and therefore have the potential to penetrate the market more quickly than ROB measures.

Technical potential: The savings that would result from complete penetration of all analyzed measures in applications where they were deemed technically feasible, from an engineering perspective.

Technology saturation: A factor that relates the cost units used in the model for a measure to its savings units. For example, the cost of a chiller may be expressed in dollars per ton, though the savings are in kWh per square foot. The technology saturation then represents the number of tons of cooling per square foot.

Time-of-use (TOU) period: The study can analyze energy use by up to six time-of-use periods. These periods are used to characterize the relationship between energy and peak demand, which varies over both season and time of day, and to capture differences in avoided costs and rates over different time periods. TOU periods usually capture differences between summer/winter and peak/off-peak but can also capture shoulder season, mid-peak, or super peak demand, depending on the needs of a utility.

Total resource cost test (TRC): A benefit-cost test that compares the value of avoided energy production and power plant construction to the costs of energy efficiency measures and the program activities necessary to deliver them. The values of both energy savings and peak-demand reductions are incorporated in the TRC test.

UEC: unit energy consumption.

C. ECONOMIC INPUTS

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APPENDIX C - ECONOMIC INPUTS

Commercial
Electricity and Gas

UTILITY NAME	National Grid
SECTOR	Com
BATCH #	1
UTILITY DISCOUNT RATE (Nominal)	2.78%
CUSTOMER DISCOUNT RATE (Nominal)	2.78%
GENERAL INFLATION RATE (Measure)	2.22%
BASE YEAR	2015
START YEAR	2015
UTILITY LINE LOSS RATE	0.00%

	AVOIDED ENERGY COSTS BY TIME PERIOD				COMMERCIAL ENERGY RATES			
Year	Average $/kWh	Peak $/kW	Average $/Therm	Average $/Therm/day	Average $/kWh	Peak $/kW	Average $/Therm	Average $/Therm/Peak
2015	0.068	140.968	0.478	0.000	0.141	0.000	0.842	0.000
2016	0.101	165.151	0.514	0.000	0.142	0.000	0.851	0.000
2017	0.089	211.862	0.611	0.000	0.144	0.000	0.895	0.000
2018	0.090	227.241	0.673	0.000	0.146	0.000	1.000	0.000
2019	0.088	226.604	0.684	0.000	0.148	0.000	1.070	0.000
2020	0.075	345.788	0.658	0.000	0.149	0.000	1.091	0.000
2021	0.072	357.449	0.707	0.000	0.151	0.000	1.073	0.000
2022	0.077	367.242	0.732	0.000	0.153	0.000	1.132	0.000
2023	0.082	372.169	0.759	0.000	0.155	0.000	1.166	0.000
2024	0.087	384.687	0.799	0.000	0.157	0.000	1.203	0.000
2025	0.093	397.826	0.831	0.000	0.158	0.000	1.252	0.000
2026	0.098	407.540	0.863	0.000	0.160	0.000	1.295	0.000
2027	0.102	414.366	0.892	0.000	0.161	0.000	1.337	0.000
2028	0.109	429.275	0.927	0.000	0.162	0.000	1.377	0.000
2029	0.117	448.448	0.974	0.000	0.164	0.000	1.422	0.000
2030	0.129	461.312	1.035	0.000	0.165	0.000	1.480	0.000
2031	0.136	459.895	1.077	0.000	0.165	0.000	1.552	0.000
2032	0.144	470.094	1.121	0.000	0.166	0.000	1.606	0.000
2033	0.153	480.520	1.167	0.000	0.167	0.000	1.662	0.000
2034	0.162	491.177	1.215	0.000	0.167	0.000	1.720	0.000
2035	0.171	502.071	1.265	0.000	0.167	0.000	1.780	0.000
2036	0.182	513.205	1.317	0.000	0.167	0.000	1.842	0.000
2037	0.192	524.587	1.371	0.000	0.167	0.000	1.907	0.000
2038	0.204	536.222	1.428	0.000	0.166	0.000	1.974	0.000
2039	0.216	548.114	1.486	0.000	0.165	0.000	2.044	0.000
2040	0.219	560.270	1.519	0.000	0.164	0.000	2.116	0.000
2041	0.224	572.696	1.553	0.000	0.163	0.000	2.163	0.000
2042	0.229	585.397	1.587	0.000	0.162	0.000	2.211	0.000
2043	0.234	598.380	1.623	0.000	0.165	0.000	2.260	0.000
2044	0.239	611.651	1.659	0.000	0.169	0.000	2.310	0.000
2045	0.244	625.216	1.695	0.000	0.173	0.000	2.362	0.000
2046	0.250	639.082	1.733	0.000	0.177	0.000	2.414	0.000
2047	0.255	653.256	1.771	0.000	0.181	0.000	2.468	0.000
2048	0.261	667.744	1.811	0.000	0.185	0.000	2.522	0.000
2049	0.267	682.553	1.851	0.000	0.189	0.000	2.578	0.000
2050	0.272	697.691	1.892	0.000	0.193	0.000	2.635	0.000
2051	0.278	713.164	1.934	0.000	0.197	0.000	2.694	0.000
2052	0.285	728.980	1.977	0.000	0.202	0.000	2.754	0.000
2053	0.291	745.148	2.021	0.000	0.206	0.000	2.815	0.000
2054	0.297	761.674	2.065	0.000	0.211	0.000	2.877	0.000

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APPENDIX C - ECONOMIC INPUTS

Industrial
Electricity and Gas

UTILITY NAME	National Grid
SECTOR	Ind
BATCH #	1
UTILITY DISCOUNT RATE (Nominal)	2.78%
CUSTOMER DISCOUNT RATE (Nominal)	2.78%
GENERAL INFLATION RATE (Measure)	2.22%
BASE YEAR	2015
START YEAR	2015
UTILITY LINE LOSS RATE	0.00%

	AVOIDED ENERGY COSTS BY TIME PERIOD				INDUSTRIAL ENERGY RATES			
Year	Average $/kWh	Peak $/kW	Average $/Therm	Average $/Therm/day	Average $/kWh	Peak $/kW	Average $/Therm	Average $/Therm/Peak
2015	0.068	140.968	0.478	0.000	0.123	0.000	0.743	0.000
2016	0.101	165.151	0.514	0.000	0.124	0.000	0.749	0.000
2017	0.089	211.862	0.611	0.000	0.126	0.000	0.791	0.000
2018	0.090	227.241	0.673	0.000	0.127	0.000	0.893	0.000
2019	0.088	226.604	0.684	0.000	0.128	0.000	0.961	0.000
2020	0.075	345.788	0.658	0.000	0.129	0.000	0.979	0.000
2021	0.072	357.449	0.707	0.000	0.130	0.000	0.959	0.000
2022	0.077	367.242	0.732	0.000	0.131	0.000	1.016	0.000
2023	0.082	372.169	0.759	0.000	0.132	0.000	1.047	0.000
2024	0.087	384.687	0.799	0.000	0.133	0.000	1.081	0.000
2025	0.093	397.826	0.831	0.000	0.134	0.000	1.128	0.000
2026	0.098	407.540	0.863	0.000	0.135	0.000	1.168	0.000
2027	0.102	414.366	0.892	0.000	0.136	0.000	1.207	0.000
2028	0.109	429.275	0.927	0.000	0.137	0.000	1.244	0.000
2029	0.117	448.448	0.974	0.000	0.138	0.000	1.287	0.000
2030	0.129	461.312	1.035	0.000	0.139	0.000	1.342	0.000
2031	0.136	459.895	1.077	0.000	0.140	0.000	1.410	0.000
2032	0.144	470.094	1.121	0.000	0.141	0.000	1.461	0.000
2033	0.153	480.520	1.167	0.000	0.141	0.000	1.514	0.000
2034	0.162	491.177	1.215	0.000	0.142	0.000	1.569	0.000
2035	0.171	502.071	1.265	0.000	0.143	0.000	1.625	0.000
2036	0.182	513.205	1.317	0.000	0.143	0.000	1.684	0.000
2037	0.192	524.587	1.371	0.000	0.144	0.000	1.746	0.000
2038	0.204	536.222	1.428	0.000	0.144	0.000	1.809	0.000
2039	0.216	548.114	1.486	0.000	0.145	0.000	1.875	0.000
2040	0.219	560.270	1.519	0.000	0.145	0.000	1.944	0.000
2041	0.224	572.696	1.553	0.000	0.146	0.000	1.987	0.000
2042	0.229	585.397	1.587	0.000	0.146	0.000	2.031	0.000
2043	0.234	598.380	1.623	0.000	0.150	0.000	2.076	0.000
2044	0.239	611.651	1.659	0.000	0.153	0.000	2.122	0.000
2045	0.244	625.216	1.695	0.000	0.156	0.000	2.169	0.000
2046	0.250	639.082	1.733	0.000	0.160	0.000	2.217	0.000
2047	0.255	653.256	1.771	0.000	0.163	0.000	2.266	0.000
2048	0.261	667.744	1.811	0.000	0.167	0.000	2.317	0.000
2049	0.267	682.553	1.851	0.000	0.171	0.000	2.368	0.000
2050	0.272	697.691	1.892	0.000	0.175	0.000	2.420	0.000
2051	0.278	713.164	1.934	0.000	0.178	0.000	2.474	0.000
2052	0.285	728.980	1.977	0.000	0.182	0.000	2.529	0.000
2053	0.291	745.148	2.021	0.000	0.186	0.000	2.585	0.000
2054	0.297	761.674	2.065	0.000	0.191	0.000	2.642	0.000

D. MEASURE INPUTS

The following tables present the measure inputs to the model, including base technology end-use energy and demand intensities, measure costs and lifetimes, applicability factors, incomplete factors, feasibility factors, and technology saturations.

The applicabilities for whole building new construction measures are designed to segment the market in a way that avoids double counting of savings. In new construction, we have both individual measures paralleling the approach to existing buildings (for example, a low wattage high performance T8 fixture). We also have whole building measures that could encompass many individual measures, including low wattage high performance T8s. We first segment the market into the portion getting whole building treatment and that getting individual measure treatment. Then, within the whole building segment, we divide the floor space into that getting 15 percent savings, 30 percent savings, 50 percent savings, and 70 percent savings, with progressively smaller shares going to the more aggressive savings levels. The way these measures are modelled applies a single costs that applies to all buildings of a given type (e.g. offices), and this segmentation recognizes that different buildings will face different costs in achieving the various levels of savings, and that as a result not all building will find it equally cost effective to pursue a 50 or 70 percent saving.

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Commercial Electric Measure Inputs — **BASE TECHNOLOGY EUIs (kWh/square foot)**

Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--RET	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--ROB	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1020	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--RET	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--ROB	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1070	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1080	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--RET	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--ROB	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1120	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--RET	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--ROB	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1200	Base Other Fluorescent Fixture--RET	0.2	0.1	0.0	1.1	0.2	0.2	0.5	1.1	0.0	0.6	4.4	0.0
1210	Base Other Fluorescent Fixture--ROB	0.2	0.1	0.0	1.1	0.2	0.2	0.5	1.1	0.0	0.6	4.4	0.0
1220	Base Other Fluorescent Fixture--Upstream	0.2	0.1	0.0	1.1	0.2	0.2	0.5	1.1	0.0	0.6	4.4	0.0
1300	Base Incandescent Lamp, 72W 2015--Hardwired	0.3	0.1	0.8	7.0	1.2	0.4	1.0	0.5	0.8	1.9	4.8	0.3
1310	Base Incandescent Lamp, 72W 2015--Upstream	0.3	0.1	0.8	7.0	1.2	0.4	1.0	0.5	0.8	1.9	4.8	0.3
1320	Base Incandescent Lamp, 72W 2016-2017--Hardwired	0.3	0.1	0.8	7.0	1.2	0.4	1.0	0.5	0.8	1.9	4.8	0.3
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream	0.3	0.1	0.8	7.0	1.2	0.4	1.0	0.5	0.8	1.9	4.8	0.3
1340	Base Incandescent Lamp, 72W 2018-2019--Hardwired	0.3	0.1	0.8	7.0	1.2	0.4	1.0	0.5	0.8	1.9	4.8	0.3
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream	0.3	0.1	0.8	7.0	1.2	0.4	1.0	0.5	0.8	1.9	4.8	0.3
1360	Base Incandescent Lamp, 72W 2020--Hardwired	0.3	0.1	0.8	7.0	1.2	0.4	1.0	0.5	0.8	1.9	4.8	0.3
1370	Base Incandescent Lamp, 72W 2020--Upstream	0.3	0.1	0.8	7.0	1.2	0.4	1.0	0.5	0.8	1.9	4.8	0.3
1400	Base CFL Lamp, 23W 2015--Hardwired	4.0	0.0	0.3	0.5	1.0	0.5	0.4	0.3	0.9	0.4	1.3	0.3
1410	Base CFL Lamp, 23W 2015--Upstream	4.0	0.0	0.3	0.5	1.0	0.5	0.4	0.3	0.9	0.4	1.3	0.3
1420	Base CFL Lamp, 23W 2016-2017--Hardwired	4.0	0.0	0.3	0.5	1.0	0.5	0.4	0.3	0.9	0.4	1.3	0.3
1430	Base CFL Lamp, 23W 2016-2017--Upstream	4.0	0.0	0.3	0.5	1.0	0.5	0.4	0.3	0.9	0.4	1.3	0.3
1440	Base CFL Lamp, 23W 2018-2019--Hardwired	4.0	0.0	0.3	0.5	1.0	0.5	0.4	0.3	0.9	0.4	1.3	0.3
1450	Base CFL Lamp, 23W 2018-2019--Upstream	4.0	0.0	0.3	0.5	1.0	0.5	0.4	0.3	0.9	0.4	1.3	0.3
1460	Base CFL Lamp, 23W 2020--Hardwired	4.0	0.0	0.3	0.5	1.0	0.5	0.4	0.3	0.9	0.4	1.3	0.3
1470	Base CFL Lamp, 23W 2020--Upstream	4.0	0.0	0.3	0.5	1.0	0.5	0.4	0.3	0.9	0.4	1.3	0.3
1500	Base Metal Halide, 400W	13.5	1.0	0.3	4.1	0.1	10.1	2.1	2.7	2.0	0.3	7.4	2.5
1600	Base HID Parking Garage Lighting	0.2				0.8	0.8	2.1	2.0	4.0	2.0		
1700	Base CFL Exit Sign	0.0	0.0	0.0	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
1800	Base Outdoor High Pressure Sodium 250W Lamp	0.7	0.5	1.6	4.6	0.9	0.9	1.0	0.5	0.4	0.4	1.8	0.9
2000	Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	0.6	0.4			2.9	3.0	0.2	0.8	0.3	0.6	0.8	
2100	Base DX Packaged System, EER=10.3, 10 tons	1.7	0.6	2.3	2.9	2.2	2.7	2.0	2.4	0.3	0.6	2.1	0.3
2200	Base Other Cooling	1.1	1.2	0.3	3.4	0.1	0.9	0.0	0.6	0.1	1.0	0.1	1.8
2300	Base PTAC, EER=8.3, 1 ton	0.2	0.3	0.1	0.1	1.2	1.2	4.6	0.8	0.3	2.3	0.3	0.8
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	2.3	2.6	0.8	1.5	2.4	2.8	1.6	3.1	1.5	2.2	0.7	0.7
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	2.3	2.6	0.8	1.5	2.4	2.8	1.6	3.1	1.5	2.2	0.7	0.7
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	2.3	2.6	0.8	1.5	2.4	2.8	1.6	3.1	1.5	2.2	0.7	0.7
4000	Base Built-Up Refrigeration System	0.3	0.2	10.0	3.0	0.3	0.4	0.2	0.1	0.3	0.3	0.2	6.2
4500	Base Self-Contained Refrigeration	0.3	0.2	10.0	3.0	0.3	0.4	0.2	0.1	0.3	0.3	0.2	0.2
6000	Base Water Heating	0.5	0.0	0.0	0.4	0.7	0.7	0.6	0.3	1.0	1.0	1.0	0.5
7000	Base Refrigerated Vending Machines	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
7500	Base Non-Refrigerated Vending Machines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8000	Base Oven	0.1	0.3	0.5	8.3	0.3		1.1	0.9	0.1	0.2	0.3	
8100	Base Fryer		0.1	1.6	23.9			0.2	0.0		0.1		
8200	Base Steamer		0.2	0.1	18.9	0.1		0.6	0.0	0.4	0.0	0.2	
8300	Base Hot Food Holding Cabinet		0.1	0.1	3.9	0.0	0.0	0.2	0.0	0.0	0.1	0.1	
8500	Base Air Compressor	0.2	0.1	0.5	0.6	0.4	0.4	0.1	0.2	0.7	0.7	0.4	0.2
8700	Base Heating	1.0	0.2	0.6	0.3	1.0	1.0	0.5	0.6	0.4	0.4	0.1	0.4
9000	Base Miscellaneous	2.5	1.4	1.1	2.0	3.1	5.9	1.2	2.9	21.2	1.3	1.0	0.7
9500	Base Whole Building	10.3	10.6	27.5	28.2	12.2	24.1	11.4	12.7	24.4	7.3	12.4	6.5
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015 (New)	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream New	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017 (New)	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6

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Commercial Electric Measure Inputs

BASE TECHNOLOGY EUIs (kWh/square foot)

Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream New	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019 (New)	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream New	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020 (New)	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream New	8.0	5.2	9.1	2.7	3.8	5.0	6.3	2.3	5.8	1.9	7.1	0.6
1200	Base Other Fluorescent Fixture (New)	0.2	0.1	0.0	1.1	0.2	0.2	0.5	1.1	0.0	0.6	4.4	0.0
1210	Base Other Fluorescent Fixture--Upstream New	0.2	0.1	0.0	1.1	0.2	0.2	0.5	1.1	0.0	0.6	4.4	0.0
1300	Base Incandescent Lamp, 72W 2015--New	0.3	0.1	0.8	7.0	1.2	0.4	1.0	0.5	0.8	1.9	4.8	0.3
1310	Base Incandescent Lamp, 72W 2015--Upstream New	0.3	0.1	0.8	7.0	1.2	0.4	1.0	0.5	0.8	1.9	4.8	0.3
1320	Base Incandescent Lamp, 72W 2016-2017--New	0.3	0.1	0.8	7.0	1.2	0.4	1.0	0.5	0.8	1.9	4.8	0.3
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream New	0.3	0.1	0.8	7.0	1.2	0.4	1.0	0.5	0.8	1.9	4.8	0.3
1340	Base Incandescent Lamp, 72W 2018-2019--New	0.3	0.1	0.8	7.0	1.2	0.4	1.0	0.5	0.8	1.9	4.8	0.3
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream New	0.3	0.1	0.8	7.0	1.2	0.4	1.0	0.5	0.8	1.9	4.8	0.3
1360	Base Incandescent Lamp, 72W 2020--New	0.3	0.1	0.8	7.0	1.2	0.4	1.0	0.5	0.8	1.9	4.8	0.3
1370	Base Incandescent Lamp, 72W 2020--Upstream New	0.3	0.1	0.8	7.0	1.2	0.4	1.0	0.5	0.8	1.9	4.8	0.3
1400	Base CFL Lamp, 23W 2015--New	4.0	0.0	0.3	0.5	1.0	0.5	0.4	0.3	0.9	0.4	1.3	0.3
1410	Base CFL Lamp, 23W 2015--Upstream New	4.0	0.0	0.3	0.5	1.0	0.5	0.4	0.3	0.9	0.4	1.3	0.3
1420	Base CFL Lamp, 23W 2016-2017--New	4.0	0.0	0.3	0.5	1.0	0.5	0.4	0.3	0.9	0.4	1.3	0.3
1430	Base CFL Lamp, 23W 2016-2017--Upstream New	4.0	0.0	0.3	0.5	1.0	0.5	0.4	0.3	0.9	0.4	1.3	0.3
1440	Base CFL Lamp, 23W 2018-2019--New	4.0	0.0	0.3	0.5	1.0	0.5	0.4	0.3	0.9	0.4	1.3	0.3
1450	Base CFL Lamp, 23W 2018-2019--Upstream New	4.0	0.0	0.3	0.5	1.0	0.5	0.4	0.3	0.9	0.4	1.3	0.3
1460	Base CFL Lamp, 23W 2020--New	4.0	0.0	0.3	0.5	1.0	0.5	0.4	0.3	0.9	0.4	1.3	0.3
1470	Base CFL Lamp, 23W 2020--Upstream New	4.0	0.0	0.3	0.5	1.0	0.5	0.4	0.3	0.9	0.4	1.3	0.3
1500	Base Metal Halide, 400W	13.5	1.0	0.3	4.1	0.1	10.1	2.1	2.7	2.0	0.3	7.4	2.5
1600	Base HID Parking Garage Lighting	0.2				0.8	0.8	2.1	2.0	4.0	2.0		
1700	Base CFL Exit Sign	0.0	0.0	0.0	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
1800	Base Outdoor High Pressure Sodium 250W Lamp	0.7	0.5	1.6	4.6	0.9	0.9	1.0	0.5	0.4	0.4	1.8	0.9
2000	Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	0.6	0.3			2.8	2.9	0.2	0.8	0.3	0.6	0.8	
2100	Base DX Packaged System, EER=10.3, 10 tons	1.6	0.6	2.2	2.8	2.1	2.6	2.0	2.3	0.3	0.6	2.1	0.3
2200	Base Other Cooling	1.1	1.2	0.3	3.4	0.1	0.9	0.0	0.6	0.1	1.0	0.1	1.8
2300	Base PTAC, EER=8.3, 1 ton	0.2	0.3	0.1	0.1	1.2	1.2	4.6	0.8	0.3	2.3	0.3	0.8
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	2.3	2.6	0.8	1.5	2.4	2.8	1.6	3.1	1.5	2.2	0.7	0.7
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	2.3	2.6	0.8	1.5	2.4	2.8	1.6	3.1	1.5	2.2	0.7	0.7
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	2.3	2.6	0.8	1.5	2.4	2.8	1.6	3.1	1.5	2.2	0.7	0.7
4000	Base Built-Up Refrigeration System	0.3	0.2	10.0	3.0	0.3	0.4	0.2	0.1	0.3	0.3	0.2	6.2
4500	Base Self-Contained Refrigeration	0.3	0.2	10.0	3.0	0.3	0.4	0.2	0.1	0.3	0.3	0.2	0.2
6000	Base Water Heating	0.5	0.0	0.0	0.4	0.7	0.7	0.6	0.3	1.0	1.0	1.0	0.5
7000	Base Refrigerated Vending Machines	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
7500	Base Non-Refrigerated Vending Machines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8000	Base Oven	0.1	0.3	0.5	8.3	0.3		1.1	0.9	0.1	0.2	0.3	
8100	Base Fryer		0.1	1.6	23.9			0.2	0.0		0.1		
8200	Base Steamer		0.2	0.1	18.9	0.1		0.6	0.0	0.4	0.0	0.2	
8300	Base Hot Food Holding Cabinet		0.1	0.1	3.9	0.0	0.0	0.2	0.0	0.0	0.1	0.1	
8500	Base Air Compressor	0.2	0.1	0.5	0.6	0.4	0.4	0.1	0.2	0.7	0.7	0.4	0.2
8700	Base Heating	1.0	0.2	0.6	0.3	1.0	1.0	0.5	0.6	0.4	0.4	0.1	0.4
9000	Base Miscellaneous	2.5	1.4	1.1	2.0	3.1	5.9	1.2	2.9	21.2	1.3	1.0	0.7
9500	Base Building Design - Standard Code	10.3	10.6	27.5	28.2	12.2	24.1	11.4	12.7	24.4	7.3	12.4	6.5
9600	Base Building Design - Standard Code	10.3	10.6	27.5	28.2	12.2	24.1	11.4	12.7	24.4	7.3	12.4	6.5
9700	Base Building Design - Standard Code	10.3	10.6	27.5	28.2	12.2	24.1	11.4	12.7	24.4	7.3	12.4	6.5
9800	Base Building Design - Standard Code	10.3	10.6	27.5	28.2	12.2	24.1	11.4	12.7	24.4	7.3	12.4	6.5

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Commercial Electric Measure Inputs		BASE TECHNOLOGY EUIs / DEMAND (kW/square foot)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--RET	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--ROB	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1020	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--RET	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--ROB	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1070	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1080	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--RET	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--ROB	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1120	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--RET	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--ROB	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1200	Base Other Fluorescent Fixture--RET	0.00004	0.00002	0.00000	0.00022	0.00002	0.00003	0.00006	0.00023	0.00000	0.00012	0.00088	0.00001
1210	Base Other Fluorescent Fixture--ROB	0.00004	0.00002	0.00000	0.00022	0.00002	0.00003	0.00006	0.00023	0.00000	0.00012	0.00088	0.00001
1220	Base Other Fluorescent Fixture--Upstream	0.00004	0.00002	0.00000	0.00022	0.00002	0.00003	0.00006	0.00023	0.00000	0.00012	0.00088	0.00001
1300	Base Incandescent Lamp, 72W 2015--Hardwired	0.00006	0.00002	0.00012	0.00136	0.00018	0.00006	0.00012	0.00010	0.00013	0.00038	0.00094	0.00005
1310	Base Incandescent Lamp, 72W 2015--Upstream	0.00006	0.00002	0.00012	0.00136	0.00018	0.00006	0.00012	0.00010	0.00013	0.00038	0.00094	0.00005
1320	Base Incandescent Lamp, 72W 2016-2017--Hardwired	0.00006	0.00002	0.00012	0.00136	0.00018	0.00006	0.00012	0.00010	0.00013	0.00038	0.00094	0.00005
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream	0.00006	0.00002	0.00012	0.00136	0.00018	0.00006	0.00012	0.00010	0.00013	0.00038	0.00094	0.00005
1340	Base Incandescent Lamp, 72W 2018-2019--Hardwired	0.00006	0.00002	0.00012	0.00136	0.00018	0.00006	0.00012	0.00010	0.00013	0.00038	0.00094	0.00005
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream	0.00006	0.00002	0.00012	0.00136	0.00018	0.00006	0.00012	0.00010	0.00013	0.00038	0.00094	0.00005
1360	Base Incandescent Lamp, 72W 2020--Hardwired	0.00006	0.00002	0.00012	0.00136	0.00018	0.00006	0.00012	0.00010	0.00013	0.00038	0.00094	0.00005
1370	Base Incandescent Lamp, 72W 2020--Upstream	0.00006	0.00002	0.00012	0.00136	0.00018	0.00006	0.00012	0.00010	0.00013	0.00038	0.00094	0.00005
1400	Base CFL Lamp, 23W 2015--Hardwired	0.00074	0.00001	0.00005	0.00010	0.00014	0.00008	0.00005	0.00005	0.00015	0.00009	0.00026	0.00006
1410	Base CFL Lamp, 23W 2015--Upstream	0.00074	0.00001	0.00005	0.00010	0.00014	0.00008	0.00005	0.00005	0.00015	0.00009	0.00026	0.00006
1420	Base CFL Lamp, 23W 2016-2017--Hardwired	0.00074	0.00001	0.00005	0.00010	0.00014	0.00008	0.00005	0.00005	0.00015	0.00009	0.00026	0.00006
1430	Base CFL Lamp, 23W 2016-2017--Upstream	0.00074	0.00001	0.00005	0.00010	0.00014	0.00008	0.00005	0.00005	0.00015	0.00009	0.00026	0.00006
1440	Base CFL Lamp, 23W 2018-2019--Hardwired	0.00074	0.00001	0.00005	0.00010	0.00014	0.00008	0.00005	0.00005	0.00015	0.00009	0.00026	0.00006
1450	Base CFL Lamp, 23W 2018-2019--Upstream	0.00074	0.00001	0.00005	0.00010	0.00014	0.00008	0.00005	0.00005	0.00015	0.00009	0.00026	0.00006
1460	Base CFL Lamp, 23W 2020--Hardwired	0.00074	0.00001	0.00005	0.00010	0.00014	0.00008	0.00005	0.00005	0.00015	0.00009	0.00026	0.00006
1470	Base CFL Lamp, 23W 2020--Upstream	0.00074	0.00001	0.00005	0.00010	0.00014	0.00008	0.00005	0.00005	0.00015	0.00009	0.00026	0.00006
1500	Base Metal Halide, 400W	0.00251	0.00023	0.00004	0.00080	0.00001	0.00150	0.00026	0.00055	0.00033	0.00007	0.00146	0.00045
1600	Base HID Parking Garage Lighting	0.00004				0.00011	0.00011	0.00026	0.00040	0.00065	0.00040		
1700	Base CFL Exit Sign	0.00001	0.00001	0.00001	0.00003	0.00002	0.00001	0.00001	0.00002	0.00001	0.00003	0.00001	0.00000
1800	Base Outdoor High Pressure Sodium 250W Lamp	0.00000	0.00001	0.00003	0.00011	0.00001	0.00001	0.00001	0.00000	0.00001	0.00000	0.00004	0.00001
2000	Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	0.00048	0.00026			0.00183	0.00190	0.00009	0.00062	0.00014	0.00052	0.00060	
2100	Base DX Packaged System, EER=10.3, 10 tons	0.00128	0.00041	0.00117	0.00141	0.00141	0.00171	0.00106	0.00181	0.00015	0.00051	0.00162	0.00021
2200	Base Other Cooling	0.00088	0.00087	0.00013	0.00166	0.00004	0.00056	0.00000	0.00049	0.00004	0.00082	0.00005	0.00136
2300	Base PTAC, EER=8.3, 1 ton	0.00016	0.00020	0.00003	0.00004	0.00076	0.00075	0.00240	0.00063	0.00016	0.00192	0.00024	0.00058
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	0.00025	0.00029	0.00011	0.00023	0.00031	0.00036	0.00020	0.00061	0.00027	0.00045	0.00012	0.00015
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	0.00025	0.00029			0.00031	0.00036	0.00020	0.00061	0.00027	0.00045	0.00012	
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	0.00025	0.00029	0.00011			0.00036		0.00061	0.00027		0.00012	0.00015
4000	Base Built-Up Refrigeration System		0.00002	0.00134	0.00038	0.00004	0.00006	0.00002	0.00001	0.00004	0.00003	0.00003	0.00101
4500	Base Self-Contained Refrigeration	0.00004	0.00002	0.00134	0.00038	0.00004	0.00006	0.00002	0.00001	0.00004	0.00003	0.00003	0.00003
6000	Base Water Heating	0.00009	0.00000	0.00000	0.00007	0.00010	0.00010	0.00007	0.00004	0.00014	0.00017	0.00017	0.00008
7000	Base Refrigerated Vending Machines	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00003
7500	Base Non-Refrigerated Vending Machines	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8000	Base Oven	0.00001	0.00005	0.00007	0.00142	0.00005		0.00018	0.00021	0.00002	0.00003	0.00005	
8100	Base Fryer		0.00002	0.00025	0.00411			0.00003	0.00001		0.00002		
8200	Base Steamer		0.00004	0.00002	0.00325	0.00002		0.00009	0.00000	0.00007	0.00001	0.00004	
8300	Base Hot Food Holding Cabinet		0.00002	0.00001	0.00067	0.00000	0.00000	0.00003	0.00000	0.00000	0.00002	0.00001	
8500	Base Air Compressor		0.00001			0.00006						0.00009	
8700	Base Heating	0.00000	0.00000	0.00000	0.00000	0.00000		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9000	Base Miscellaneous	0.00036	0.00021	0.00016	0.00030	0.00048	0.00091	0.00016	0.00046	0.00354	0.00018	0.00018	0.00014
9500	Base Whole Building	0.00199	0.00225	0.00437	0.00527	0.00254	0.00573	0.00223	0.00347	0.00405	0.00182	0.00321	0.00108
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015 (New)	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream New	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017 (New)	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010

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Commercial Electric Measure Inputs	BASE TECHNOLOGY EUIs / DEMAND (kW/square foot)											
Measure # Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1060 Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream New	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1100 Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019 (New)	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1110 Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream New	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1150 Base Fluorescent Fixture, 4L4'T8, 1EB, 2020 (New)	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1160 Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream New	0.00148	0.00128	0.00138	0.00053	0.00057	0.00074	0.00078	0.00047	0.00093	0.00038	0.00140	0.00010
1200 Base Other Fluorescent Fixture (New)	0.00004	0.00002	0.00000	0.00022	0.00002	0.00003	0.00006	0.00023	0.00000	0.00012	0.00088	0.00001
1210 Base Other Fluorescent Fixture--Upstream New	0.00004	0.00002	0.00000	0.00022	0.00002	0.00003	0.00006	0.00023	0.00000	0.00012	0.00088	0.00001
1300 Base Incandescent Lamp, 72W 2015--New	0.00006	0.00002	0.00012	0.00136	0.00018	0.00006	0.00012	0.00010	0.00013	0.00038	0.00094	0.00005
1310 Base Incandescent Lamp, 72W 2015--Upstream New	0.00006	0.00002	0.00012	0.00136	0.00018	0.00006	0.00012	0.00010	0.00013	0.00038	0.00094	0.00005
1320 Base Incandescent Lamp, 72W 2016-2017--New	0.00006	0.00002	0.00012	0.00136	0.00018	0.00006	0.00012	0.00010	0.00013	0.00038	0.00094	0.00005
1330 Base Incandescent Lamp, 72W 2016-2017--Upstream New	0.00006	0.00002	0.00012	0.00136	0.00018	0.00006	0.00012	0.00010	0.00013	0.00038	0.00094	0.00005
1340 Base Incandescent Lamp, 72W 2018-2019--New	0.00006	0.00002	0.00012	0.00136	0.00018	0.00006	0.00012	0.00010	0.00013	0.00038	0.00094	0.00005
1350 Base Incandescent Lamp, 72W 2018-2019--Upstream New	0.00006	0.00002	0.00012	0.00136	0.00018	0.00006	0.00012	0.00010	0.00013	0.00038	0.00094	0.00005
1360 Base Incandescent Lamp, 72W 2020--New	0.00006	0.00002	0.00012	0.00136	0.00018	0.00006	0.00012	0.00010	0.00013	0.00038	0.00094	0.00005
1370 Base Incandescent Lamp, 72W 2020--Upstream New	0.00006	0.00002	0.00012	0.00136	0.00018	0.00006	0.00012	0.00010	0.00013	0.00038	0.00094	0.00005
1400 Base CFL Lamp, 23W 2015--New	0.00074	0.00001	0.00005	0.00010	0.00014	0.00008	0.00005	0.00005	0.00015	0.00009	0.00026	0.00006
1410 Base CFL Lamp, 23W 2015--Upstream New	0.00074	0.00001	0.00005	0.00010	0.00014	0.00008	0.00005	0.00005	0.00015	0.00009	0.00026	0.00006
1420 Base CFL Lamp, 23W 2016-2017--New	0.00074	0.00001	0.00005	0.00010	0.00014	0.00008	0.00005	0.00005	0.00015	0.00009	0.00026	0.00006
1430 Base CFL Lamp, 23W 2016-2017--Upstream New	0.00074	0.00001	0.00005	0.00010	0.00014	0.00008	0.00005	0.00005	0.00015	0.00009	0.00026	0.00006
1440 Base CFL Lamp, 23W 2018-2019--New	0.00074	0.00001	0.00005	0.00010	0.00014	0.00008	0.00005	0.00005	0.00015	0.00009	0.00026	0.00006
1450 Base CFL Lamp, 23W 2018-2019--Upstream New	0.00006	0.00002	0.00012	0.00136	0.00018	0.00006	0.00012	0.00010	0.00013	0.00038	0.00094	0.00005
1460 Base CFL Lamp, 23W 2020--New	0.00074	0.00001	0.00005	0.00010	0.00014	0.00008	0.00005	0.00005	0.00015	0.00009	0.00026	0.00006
1470 Base CFL Lamp, 23W 2020--Upstream New	0.00074	0.00001	0.00005	0.00010	0.00014	0.00008	0.00005	0.00005	0.00015	0.00009	0.00026	0.00006
1500 Base Metal Halide, 400W	0.00251	0.00023	0.00004	0.00080	0.00001	0.00150	0.00026	0.00055	0.00033	0.00007	0.00146	0.00045
1600 Base HID Parking Garage Lighting	0.00004				0.00011	0.00011	0.00026	0.00040	0.00065	0.00040		
1700 Base CFL Exit Sign	0.00001	0.00001	0.00001	0.00003	0.00002	0.00001	0.00001	0.00002	0.00001	0.00003	0.00001	0.00000
1800 Base Outdoor High Pressure Sodium 250W Lamp	0.00000	0.00001	0.00003	0.00011	0.00001	0.00001	0.00001	0.00000	0.00001	0.00000	0.00004	0.00001
2000 Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	0.00048	0.00026			0.00183	0.00190	0.00009	0.00062	0.00014	0.00052	0.00060	
2100 Base DX Packaged System, EER=10.3, 10 tons	0.00128	0.00041	0.00117	0.00141	0.00141	0.00171	0.00106	0.00181	0.00015	0.00051	0.00162	0.00021
2200 Base Other Cooling	0.00088	0.00087	0.00013	0.00166	0.00004	0.00056	0.00000	0.00049	0.00004	0.00082	0.00005	0.00136
2300 Base PTAC, EER=8.3, 1 ton	0.00016	0.00020	0.00003	0.00004	0.00076	0.00075	0.00240	0.00063	0.00016	0.00192	0.00024	0.00058
3000 Base Fan Motor, 5hp, 1800rpm, 87.5%	0.00025	0.00029	0.00011	0.00023	0.00031	0.00036	0.00020	0.00061	0.00027	0.00045	0.00012	0.00015
3100 Base Fan Motor, 15hp, 1800rpm, 91.0%	0.00025	0.00029			0.00031	0.00036	0.00020	0.00061	0.00027	0.00045	0.00012	
3200 Base Fan Motor, 40hp, 1800rpm, 93.0%	0.00025	0.00029	0.00011			0.00036		0.00061	0.00027		0.00012	0.00015
4000 Base Built-Up Refrigeration System		0.00002	0.00134	0.00038	0.00004	0.00006	0.00002	0.00001	0.00004	0.00003	0.00003	0.00101
4500 Base Self-Contained Refrigeration	0.00004	0.00002	0.00134	0.00038	0.00004	0.00006	0.00002	0.00001	0.00004	0.00003	0.00003	0.00003
6000 Base Water Heating	0.00009	0.00000	0.00000	0.00007	0.00010	0.00010	0.00007	0.00004	0.00014	0.00017	0.00017	0.00008
7000 Base Refrigerated Vending Machines	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00003
7500 Base Non-Refrigerated Vending Machines	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8000 Base Oven	0.00001	0.00005	0.00007	0.00142	0.00005		0.00018	0.00021	0.00002	0.00003	0.00005	
8100 Base Fryer		0.00002	0.00025	0.00411			0.00003	0.00001		0.00002		
8200 Base Steamer		0.00004	0.00002	0.00325	0.00002		0.00009	0.00000	0.00007	0.00001	0.00004	
8300 Base Hot Food Holding Cabinet		0.00002	0.00001	0.00067	0.00000	0.00000	0.00003	0.00000	0.00000	0.00002	0.00001	
8500 Base Air Compressor		0.00001			0.00006						0.00009	
8700 Base Heating	0.00000	0.00000	0.00000	0.00000	0.00000		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9000 Base Miscellaneous	0.00036	0.00021	0.00016	0.00030	0.00048	0.00091	0.00016	0.00046	0.00354	0.00018	0.00018	0.00014
9500 Base Building Design - Standard Code	0.00199	0.00225	0.00437	0.00527	0.00254	0.00573	0.00223	0.00347	0.00405	0.00182	0.00321	0.00108
9600 Base Building Design - Standard Code	0.00199	0.00225	0.00437	0.00527	0.00254	0.00573	0.00223	0.00347	0.00405	0.00182	0.00321	0.00108
9700 Base Building Design - Standard Code	0.00199	0.00225	0.00437	0.00527	0.00254	0.00573	0.00223	0.00347	0.00405	0.00182	0.00321	0.00108
9800 Base Building Design - Standard Code	0.00199	0.00225	0.00437	0.00527	0.00254	0.00573	0.00223	0.00347	0.00405	0.00182	0.00321	0.00108

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Commercial Electric Measure Costs

Measure #	Measure Description	First Year	End Year	Savings Units	Cost Units	Unit Equipment Cost	Unit Labor Costs	NPV of Lifetime O&M Cost	Implementation Cost Factor	Implementation Type (RET/ROB)	Initial Cost	Replacement Cost	Measure File Service Life (Yrs)	Full Per Unit Cost
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--RET	2015	2015	sqft	fixture	$0.00	$0.00		$0.00	RET	1	1	18.00	$0.00
1001	RET 4L4' Low Watt High Performance T8 (83 W), 2015	2015	2015	sqft	fixture	$60.00			$60.00	RET	1	1	13.00	$60.00
1002	RET 4L4' LED Tube, 2015	2015	2015	sqft	fixture	$95.92			$95.92	RET	1	1	13.00	$95.92
1003	RET LED Troffer (base 4L4'T8), 2015	2015	2015	sqft	fixture	$125.00			$125.00	RET	1	1	13.00	$125.00
1004	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base RET)	2015	2015	sqft	fixture	$45.00			$45.00	RET	1	1	9.00	$45.00
1005	Advanced Lighting Controls (2015 Base RET)	2015	2015	sqft	sq ft	$0.75			$0.75	RET	1	1	9.00	$0.75
1006	Daylight Dimming Controls (2015 Base RET)	2015	2015	sqft	Ballast controlled	$100.00			$100.00	RET	1	1	9.00	$100.00
1007	Custom Lighting, Base 4L4'T8, 2015	2015	2015	sqft	kWh saved	$0.63			$0.63	RET	1	1	13.00	$0.63
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--ROB	2015	2015	sqft	fixture	$0.00	$0.00		$0.00	ROB	1	1	18.00	$0.00
1011	ROB 4L4' Low Watt High Performance T8 (83 W), 2015	2015	2015	sqft	fixture	$25.00			$25.00	ROB	1	1	15.00	$25.00
1012	ROB 4L4' LED Tube, 2015	2015	2015	sqft	fixture	$60.92			$60.92	ROB	1	1	10.00	$60.92
1013	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base ROB)	2015	2015	sqft	fixture	$45.00			$45.00	RET	1	1	9.00	$45.00
1014	Advanced Lighting Controls (2015 Base ROB)	2015	2015	sqft	sq ft	$0.75			$0.75	RET	1	1	9.00	$0.75
1015	Daylight Dimming Controls (2015 Base ROB)	2015	2015	sqft	Ballast controlled	$100.00			$100.00	RET	1	1	9.00	$100.00
1020	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream	2015	2015	sqft	fixture	$0.00	$0.00		$0.00	ROB	1	1	18.00	$0.00
1021	Upstream 4L4' Low Watt High Performance T8 (83 W), 2015	2015	2015	sqft	fixture	$25.00			$25.00	ROB	1	1	24,000.00	$25.00
1022	Upstream 4L4' LED Tube, 2015	2015	2015	sqft	fixture	$60.92			$60.92	ROB	1	1	10.00	$60.92
1023	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base Upstream)	2015	2015	sqft	fixture	$45.00			$45.00	RET	1	1	9.00	$45.00
1024	Advanced Lighting Controls (2015 Base Up)	2015	2015	sqft	sq ft	$0.75			$0.75	RET	1	1	9.00	$0.75
1025	Daylight Dimming Controls (2015 Base Up)	2015	2015	sqft	Ballast controlled	$100.00			$100.00	RET	1	1	9.00	$100.00
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--RET	2016	2017	sqft	fixture	$0.00	$0.00		$0.00	RET	1	1	18.00	$0.00
1051	RET 4L4' Low Watt High Performance T8 (83 W), 2016-2017	2016	2017	sqft	fixture	$60.00			$60.00	RET	1	1	13.00	$60.00
1052	RET 4L4' LED Tube, 2016-2017	2016	2017	sqft	fixture	$67.14			$67.14	RET	1	1	13.00	$67.14
1053	RET LED Troffer (base 4L4'T8), 2016-2017	2016	2017	sqft	fixture	$87.50			$87.50	RET	1	1	13.00	$87.50
1054	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base RET)	2016	2017	sqft	fixture	$45.00			$45.00	RET	1	1	9.00	$45.00
1055	Advanced Lighting Controls (2016-2017 Base RET)	2016	2017	sqft	sq ft	$0.75			$0.75	RET	1	1	9.00	$0.75
1056	Daylight Dimming Controls (2016-2017 Base RET)	2016	2017	sqft	Ballast controlled	$100.00			$100.00	RET	1	1	9.00	$100.00
1057	Custom Lighting, Base 4L4'T8, 2016-2017	2016	2017	sqft	kWh saved	$0.63			$0.63	RET	1	1	13.00	$0.63
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--ROB	2016	2017	sqft	fixture	$0.00	$0.00		$0.00	ROB	1	1	18.00	$0.00
1061	ROB 4L4' Low Watt High Performance T8 (83 W), 2016-2017	2016	2017	sqft	fixture	$25.00			$25.00	ROB	1	1	15.00	$25.00
1062	ROB 4L4' LED Tube, 2016-2017	2016	2017	sqft	fixture	$32.14			$32.14	ROB	1	1	10.00	$32.14
1063	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base ROB)	2016	2017	sqft	fixture	$45.00			$45.00	RET	1	1	9.00	$45.00
1064	Advanced Lighting Controls (2016-2017 Base ROB)	2016	2017	sqft	sq ft	$0.75			$0.75	RET	1	1	9.00	$0.75
1065	Daylight Dimming Controls (2016-2017 Base ROB)	2016	2017	sqft	Ballast controlled	$100.00			$100.00	RET	1	1	9.00	$100.00
1070	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream	2016	2017	sqft	fixture	$0.00	$0.00		$0.00	ROB	1	1	18.00	$0.00
1071	Upstream 4L4' Low Watt High Performance T8 (83 W), 2016-2017	2016	2017	sqft	fixture	$25.00			$25.00	ROB	1	1	24,000.00	$25.00
1072	Upstream 4L4' LED Tube, 2016-2017	2016	2017	sqft	fixture	$32.14			$32.14	ROB	1	1	10.00	$32.14
1073	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base Upstream)	2016	2017	sqft	fixture	$45.00			$45.00	RET	1	1	9.00	$45.00
1074	Advanced Lighting Controls (2016-2017 Base Up)	2016	2017	sqft	sq ft	$0.75			$0.75	RET	1	1	9.00	$0.75
1075	Daylight Dimming Controls (2016-2017 Base Up)	2016	2017	sqft	Ballast controlled	$100.00			$100.00	RET	1	1	9.00	$100.00
1080	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--RET	2018	2019	sqft	fixture	$0.00	$0.00		$0.00	RET	1	1	18.00	$0.00
1081	RET 4L4' Low Watt High Performance T8 (83 W), 2018-2019	2018	2019	sqft	fixture	$60.00			$60.00	RET	1	1	13.00	$60.00
1082	RET 4L4' LED Tube, 2018-2019	2018	2019	sqft	fixture	$60.81			$60.81	RET	1	1	13.00	$60.81
1083	RET LED Troffer (base 4L4'T8), 2018-2019	2018	2019	sqft	fixture	$79.25			$79.25	RET	1	1	13.00	$79.25
1084	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base RET)	2018	2019	sqft	fixture	$45.00			$45.00	RET	1	1	9.00	$45.00
1085	Advanced Lighting Controls (2018-2019 Base RET)	2018	2019	sqft	sq ft	$0.75			$0.75	RET	1	1	9.00	$0.75
1086	Daylight Dimming Controls (2018-2019 Base RET)	2018	2019	sqft	Ballast controlled	$100.00			$100.00	RET	1	1	9.00	$100.00
1087	Custom Lighting, Base 4L4'T8, 2018-2019	2018	2019	sqft	kWh saved	$0.63			$0.63	RET	1	1	13.00	$0.63
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--ROB	2018	2019	sqft	fixture	$0.00	$0.00		$0.00	ROB	1	1	18.00	$0.00
1101	ROB 4L4' Low Watt High Performance T8 (83 W), 2018-2019	2018	2019	sqft	fixture	$25.00			$25.00	ROB	1	1	15.00	$25.00
1102	ROB 4L4' LED Tube, 2018-2019	2018	2019	sqft	fixture	$25.81			$25.81	ROB	1	1	10.00	$25.81
1103	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base ROB)	2018	2019	sqft	fixture	$45.00			$45.00	RET	1	1	9.00	$45.00
1104	Advanced Lighting Controls (2018-2019 Base ROB)	2018	2019	sqft	sq ft	$0.75			$0.75	RET	1	1	9.00	$0.75
1105	Daylight Dimming Controls (2018-2019 Base ROB)	2018	2019	sqft	Ballast controlled	$100.00			$100.00	RET	1	1	9.00	$100.00
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream	2018	2019	sqft	fixture	$0.00	$0.00		$0.00	ROB	1	1	18.00	$0.00
1111	Upstream 4L4' Low Watt High Performance T8 (83 W), 2018-2019	2018	2019	sqft	fixture	$25.00			$25.00	ROB	1	1	24,000.00	$25.00
1112	Upstream 4L4' LED Tube, 2018-2019	2018	2019	sqft	fixture	$25.81			$25.81	ROB	1	1	10.00	$25.81
1113	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base Upstream)	2018	2019	sqft	fixture	$45.00			$45.00	RET	1	1	9.00	$45.00
1114	Advanced Lighting Controls (2018-2019 Base Up)	2018	2019	sqft	sq ft	$0.75			$0.75	RET	1	1	9.00	$0.75
1115	Daylight Dimming Controls (2018-2019 Base Up)	2018	2019	sqft	Ballast controlled	$100.00			$100.00	RET	1	1	9.00	$100.00
1120	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--RET	2020	2054	sqft	fixture	$0.00	$0.00		$0.00	RET	1	1	18.00	$0.00
1121	RET 4L4' Low Watt High Performance T8 (83 W), 2020	2020	2054	sqft	fixture	$60.00			$60.00	RET	1	1	13.00	$60.00
1122	RET 4L4' LED Tube, 2020	2020	2054	sqft	fixture	$57.55			$57.55	RET	1	1	13.00	$57.55

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1123	RET LED Troffer (base 4L4'T8), 2020	2020	2054	sqft	fixture	$75.00			$75.00	RET	1	1	13.00	$75.00
1124	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base RET)	2020	2054	sqft	fixture	$45.00			$45.00	RET	1	1	9.00	$45.00
1125	Advanced Lighting Controls (2020 Base RET)	2020	2054	sqft	sq ft	$0.75			$0.75	RET	1	1	9.00	$0.75
1126	Daylight Dimming Controls (2020 Base RET)	2020	2054	sqft	Ballast controlled	$100.00			$100.00	RET	1	1	9.00	$100.00
1127	Custom Lighting, Base 4L4'T8, 2020	2020	2054	sqft	kWh saved	$0.63			$0.63	RET	1	1	13.00	$0.63
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--ROB	2020	2054	sqft	fixture	$0.00	$0.00		$0.00	ROB	1	1	18.00	$0.00
1151	ROB 4L4' Low Watt High Performance T8 (83 W), 2020	2020	2054	sqft	fixture	$25.00			$25.00	ROB	1	1	15.00	$25.00
1152	ROB 4L4' LED Tube, 2020	2020	2054	sqft	fixture	$22.55			$22.55	ROB	1	1	10.00	$22.55
1153	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base ROB)	2020	2054	sqft	fixture	$45.00			$45.00	RET	1	1	9.00	$45.00
1154	Advanced Lighting Controls (2020 Base ROB)	2020	2054	sqft	sq ft	$0.75			$0.75	RET	1	1	9.00	$0.75
1155	Daylight Dimming Controls (2020 Base ROB)	2020	2054	sqft	Ballast controlled	$100.00			$100.00	RET	1	1	9.00	$100.00
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream	2020	2054	sqft	fixture	$0.00	$0.00		$0.00	ROB	1	1	18.00	$0.00
1161	Upstream 4L4' Low Watt High Performance T8 (83 W), 2020	2020	2054	sqft	fixture	$25.00			$25.00	ROB	1	1	24,000.00	$25.00
1162	Upstream 4L4' LED Tube, 2020	2020	2054	sqft	fixture	$22.55			$22.55	ROB	1	1	10.00	$22.55
1163	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base Upstream)	2020	2054	sqft	fixture	$45.00			$45.00	RET	1	1	9.00	$45.00
1164	Advanced Lighting Controls (2020 Base Up)	2020	2054	sqft	sq ft	$0.75			$0.75	RET	1	1	9.00	$0.75
1165	Daylight Dimming Controls (2020 Base Up)	2020	2054	sqft	Ballast controlled	$100.00			$100.00	RET	1	1	9.00	$100.00
1200	Base Other Fluorescent Fixture--RET	2015	2054	sqft	fixture	$0.00	$0.00		$0.00	RET	1	1	18.00	$0.00
1201	RET Low Watt High Performance T8	2015	2054	sqft	fixture	$60.00			$60.00	RET	1	1	13.00	$60.00
1202	RET LED Tube	2015	2054	sqft	fixture	$67.14			$67.14	RET	1	1	13.00	$67.14
1203	RET LED Troffer	2015	2054	sqft	fixture	$87.50			$87.50	RET	1	1	13.00	$87.50
1204	Occupancy Sensor (Base Other Fluor RET)	2015	2054	sqft	fixture	$45.00			$45.00	RET	1	1	9.00	$45.00
1205	Advanced Lighting Controls (Base Other Fluor RET)	2015	2054	sqft	sq ft	$0.75			$0.75	RET	1	1	9.00	$0.75
1206	Daylight Dimming Controls (Base Other Fluor RET)	2015	2054	sqft	Ballast controlled	$100.00			$100.00	RET	1	1	9.00	$100.00
1207	Custom Lighting, Base Other Fluorescent	2015	2054	sqft	kWh saved	$0.63			$0.63	RET	1	1	13.00	$0.63
1210	Base Other Fluorescent Fixture--ROB	2015	2054	sqft	fixture	$0.00	$0.00		$0.00	ROB	1	1	18.00	$0.00
1211	ROB Low Watt High Performance T8	2015	2054	sqft	fixture	$25.00			$25.00	ROB	1	1	15.00	$25.00
1212	ROB LED Tube	2015	2054	sqft	fixture	$42.64			$42.64	ROB	1	1	10.00	$42.64
1213	Occupancy Sensor (Base Other Fluor ROB)	2015	2054	sqft	fixture	$45.00			$45.00	RET	1	1	9.00	$45.00
1214	Advanced Lighting Controls (Base Other Fluor ROB)	2015	2054	sqft	sq ft	$0.75			$0.75	RET	1	1	9.00	$0.75
1215	Daylight Dimming Controls (Base Other Fluor ROB)	2015	2054	sqft	Ballast controlled	$100.00			$100.00	RET	1	1	9.00	$100.00
1220	Base Other Fluorescent Fixture--Upstream	2015	2054	sqft	fixture	$0.00	$0.00		$0.00	ROB	1	1	18.00	$0.00
1221	Upstream Low Watt High Performance T8	2015	2054	sqft	fixture	$25.00			$25.00	ROB	1	1	24,000.00	$25.00
1222	Upstream LED Tube	2015	2054	sqft	fixture	$42.64			$42.64	ROB	1	1	10.00	$42.64
1223	Occupancy Sensor (Base Other Fluor Upstream)	2015	2054	sqft	fixture	$45.00			$45.00	RET	1	1	9.00	$45.00
1224	Advanced Lighting (Base Other Fluor Upstream)	2015	2054	sqft	sq ft	$0.75			$0.75	RET	1	1	9.00	$0.75
1225	Daylight Dimming Controls (Base Other Fluor Upstream)	2015	2054	sqft	Ballast controlled	$100.00			$100.00	RET	1	1	9.00	$100.00
1300	Base Incandescent Lamp, 72W 2015--Hardwired	2015	2015	sqft	lamp	$0.00	$0.00		$0.00	ROB	1	1	1,200.00	$0.00
1301	LED Track Lighting (base Incandescent 72W) 2015	2015	2015	sqft	lamp	$100.00			$100.00	RET	1	1	50,000.00	$100.00
1310	Base Incandescent Lamp, 72W 2015--Upstream	2015	2015	sqft	lamp	$0.00	$0.00		$0.00	ROB	1	1	1,200.00	$0.00
1311	Upstream LEDs (base Incandescent 72W) 2015	2015	2015	sqft	lamp	$18.34			$18.34	ROB	1	1	25,000.00	$18.34
1320	Base Incandescent Lamp, 72W 2016-2017--Hardwired	2016	2017	sqft	lamp	$0.00	$0.00		$0.00	ROB	1	1	1,200.00	$0.00
1321	LED Track Lighting (base Incandescent 72W) 2016-2017	2016	2017	sqft	lamp	$70.00			$70.00	RET	1	1	50,000.00	$70.00
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream	2016	2017	sqft	lamp	$0.00	$0.00		$0.00	ROB	1	1	1,200.00	$0.00
1331	Upstream LEDs (base Incandescent 72W) 2016-2017	2016	2017	sqft	lamp	$12.83			$12.83	ROB	1	1	25,000.00	$12.83
1340	Base Incandescent Lamp, 72W 2018-2019--Hardwired	2018	2019	sqft	lamp	$0.00	$0.00		$0.00	ROB	1	1	1,200.00	$0.00
1341	LED Track Lighting (base Incandescent 72W) 2018-2019	2018	2019	sqft	lamp	$50.00			$50.00	RET	1	1	50,000.00	$50.00
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream	2018	2019	sqft	lamp	$0.00	$0.00		$0.00	ROB	1	1	1,200.00	$0.00
1351	Upstream LEDs (base Incandescent 72W) 2018-2019	2018	2019	sqft	lamp	$6.42			$6.42	ROB	1	1	25,000.00	$6.42
1360	Base Incandescent Lamp, 72W 2020--Hardwired	2020	2054	sqft	lamp	$0.00	$0.00		$0.00	ROB	1	1	1,200.00	$0.00
1361	LED Track Lighting (base Incandescent 72W) 2020	2020	2054	sqft	lamp	$40.00			$40.00	RET	1	1	50,000.00	$40.00
1370	Base Incandescent Lamp, 72W 2020--Upstream	2020	2054	sqft	lamp	$0.00	$0.00		$0.00	ROB	1	1	1,200.00	$0.00
1371	Upstream LEDs (base Incandescent 72W) 2020	2020	2054	sqft	lamp	$2.57			$2.57	ROB	1	1	25,000.00	$2.57
1400	Base CFL Lamp, 23W 2015--Hardwired	2015	2015	sqft	lamp	$0.00	$0.00		$0.00	ROB	1	1	8,000.00	$0.00
1401	LED Track Lighting (base CFL spiral 23W) 2015	2015	2015	sqft	lamp	$100.00			$100.00	RET	1	1	50,000.00	$100.00
1410	Base CFL Lamp, 23W 2015--Upstream	2015	2015	sqft	lamp	$0.00	$0.00		$0.00	ROB	1	1	8,000.00	$0.00
1411	Upstream LEDs (base CFL spiral 23W) 2015	2015	2015	sqft	lamp	$18.34		($10.91)	$18.34	ROB	1	1	25,000.00	$7.42
1420	Base CFL Lamp, 23W 2016-2017--Hardwired	2016	2017	sqft	lamp	$0.00	$0.00		$0.00	ROB	1	1	8,000.00	$0.00
1421	LED Track Lighting (base CFL spiral 23W) 2016-2017	2016	2017	sqft	lamp	$70.00			$70.00	RET	1	1	50,000.00	$70.00
1430	Base CFL Lamp, 23W 2016-2017--Upstream	2016	2017	sqft	lamp	$0.00	$0.00		$0.00	ROB	1	1	8,000.00	$0.00
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	2016	2017	sqft	lamp	$12.83		($10.91)	$12.83	ROB	1	1	25,000.00	$1.92
1440	Base CFL Lamp, 23W 2018-2019--Hardwired	2018	2019	sqft	lamp	$0.00	$0.00		$0.00	ROB	1	1	8,000.00	$0.00
1441	LED Track Lighting (base CFL spiral 23W) 2018-2019	2018	2019	sqft	lamp	$50.00			$50.00	RET	1	1	50,000.00	$50.00

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1450	Base CFL Lamp, 23W 2018-2019--Upstream	2018	2019	sqft	lamp	$0.00	$0.00		$0.00	ROB	1	1	8,000.00	$0.00
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	2018	2019	sqft	lamp	$6.42		($5.42)	$6.42	ROB	1	1	25,000.00	$1.00
1460	Base CFL Lamp, 23W 2020--Hardwired	2020	2054	sqft	lamp	$0.00	$0.00		$0.00	ROB	1	1	8,000.00	$0.00
1461	LED Track Lighting (base CFL spiral 23W) 2020	2020	2054	sqft	lamp	$40.00			$40.00	RET	1	1	50,000.00	$40.00
1470	Base CFL Lamp, 23W 2020--Upstream	2020	2054	sqft	lamp	$0.00	$0.00		$0.00	ROB	1	1	8,000.00	$0.00
1471	Upstream LEDs (base CFL spiral 23W) 2020	2020	2054	sqft	lamp	$2.57		($1.57)	$2.57	ROB	1	1	25,000.00	$1.00
1500	Base Metal Halide, 400W	2015	2054	sqft	fixture	$200.00	$60.00		$260.00	ROB	1	1	18.00	$260.00
1501	High Bay T5 HO (240W)	2015	2054	sqft	fixture	$100.00	$0.00		$100.00	RET	1	1	13.00	$100.00
1502	High Bay Induction Lighting	2015	2054	sqft	fixture	$480.00	$60.00		$540.00	RET	1	1	20.00	$540.00
1503	PSMH with electronic ballast	2015	2054	sqft	fixture	$144.00	$60.00		$204.00	RET	1	1	16.00	$204.00
1504	High Bay LED Lighting	2015	2054	sqft	fixture	$200.00			$200.00	RET	1	1	35,000.00	$200.00
1600	Base HPS (high pressure sodium) Parking Garage Lighting	2015	2054	sqft	fixture	$28.50	$0.00		$28.50	ROB	1	1	15.00	$28.50
1601	High-efficiency fluorescent parking garage fixture	2015	2054	sqft	fixture	$92.00			$92.00	RET	1	1	18.00	$92.00
1602	LED Parking Garage Fixtures	2015	2054	sqft	fixture	343			343	RET	1	1	8.00	$343.00
1603	Bi-Level LED Parking Garage Fixtures	2015	2054	sqft	fixture	343			343	RET	1	1	8.00	$343.00
1700	Base CFL Exit Sign	2015	2054	sqft	unit	0	0		0	RET	1	1	18.00	$0.00
1701	LED Exit Sign	2015	2054	sqft	unit	35			35	RET	1	1	7.00	$35.00
1800	Base Outdoor High Pressure Sodium 250W Lamp	2015	2054	sqft	fixture	0	0		0	ROB	1	1	15.00	$0.00
1801	LED Outdoor Area Lighting (other than pole-mounted)	2015	2054	sqft	fixture	120			120	RET	1	1	18.00	$120.00
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	2015	2054	sqft	ton	240			240	ROB	1	1	23.00	$240.00
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	2015	2054	sqft	ton	122			122	ROB	1	1	23.00	$122.00
2002	Chiller VSD	2015	2054	sqft	ton	50	15		65	RET	1	1	15.00	$65.00
2003	EMS - Chiller	2015	2054	sqft	point	800			800	RET	1	1	10.00	$800.00
2004	Cool Roof - Chiller	2015	2054	sqft	sf-roof	8.45			8.45	ROB	1	1	15.00	$8.45
2006	VSD for Chiller Pumps and Towers	2015	2054	sqft	HP	175.44			175.44	RET	1	1	15.00	$175.44
2008	Ceiling/roof Insulation - Chiller	2015	2054	sqft	sf-ceiling	1.36			1.36	RET	1	1	20.00	$1.36
2009	Custom HVAC--Base Chiller	2015	2054	sqft	kWh saved	0.69			0.69	ROB	1	1	14.00	$0.69
2010	Custom Shell--Base Chiller	2015	2054	sqft	kWh saved	0.69			0.69	RET	1	1	17.00	$0.69
2100	Base DX Packaged System, EER=10.0, 30 tons	2015	2054	sqft	ton	672.4			672.4	ROB	1	1	15.00	$672.40
2101	ROB DX Packaged System, EER=10.8, 30 tons	2015	2054	sqft	ton	37.83			37.83	ROB	1	1	15.00	$37.83
2102	ROB DX Packaged System, EER=11.7, 30 tons	2015	2054	sqft	ton	93.42			93.42	ROB	1	1	15.00	$93.42
2104	Automated Fault Detection	2015	2054	sqft	unit	300			300	RET	1	1	15.00	$300.00
2106	Advanced Controllers for RTUs	2015	2054	sqft	unit	2600	750		3350	RET	1	1	10.00	$3,350.00
2107	Programmable Communicating Thermostat	2015	2054	sqft	ton	150			150	RET	1	1	10.00	$150.00
2108	Prog. Thermostat - DX	2015	2054	sqft	unit	37.5	100		137.5	RET	1	1	8.00	$137.50
2109	Cool Roof - DX	2015	2054	sqft	sf-roof	8.45			8.45	RET	1	1	15.00	$8.45
2110	RTU VSD	2015	2054	sqft	unit	2125			2125	RET	1	1	15.00	$2,125.00
2111	Dual Enthalpy Economizer Controls	2015	2054	sqft	unit	800			800	RET	1	1	7.00	$800.00
2113	Aerosol Duct Sealing	2015	2054	sqft	ton	338			338	RET	1	1	18.00	$338.00
2114	Ceiling/roof Insulation - DX	2015	2054	sqft	sf-ceiling	2.398			2.398	RET	1	1	20.00	$2.40
2115	Duct/Pipe Insulation - DX	2015	2054	sqft	sqft-insulation	17.585			17.585	RET	1	1	15.00	$17.59
2116	Custom HVAC--DX	2015	2054	sqft	kWh saved	0.69			0.69	ROB	1	1	14.00	$0.69
2117	Custom Shell--DX	2015	2054	sqft	kWh saved	0.69			0.69	RET	1	1	17.00	$0.69
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	2015	2054	sqft	unit	1559.966667	0		1559.966667	RET	1	1	15.00	$1,559.97
2201	Air Source Heat Pump, EER=11.3, 10 tons	2015	2054	sqft	unit	5946.666667	5703.333		11650	RET	1	1	15.00	$11,650.00
2300	Base PTAC, EER=8.3, 1 ton	2015	2054	sqft	ton	0	0		0	ROB	1	1	15.00	$0.00
2301	Occupancy Sensor (hotels)	2015	2054	sqft	ton	280			280	RET	1	1	10.00	$280.00
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	2015	2054	sqft	HP	52			52	ROB	1	1	20.00	$52.00
3001	Variable Speed Drive Control, 5 HP	2015	2054	sqft	unit	730.88			730.88	RET	1	1	15.00	$730.88
3002	Custom HVAC--Base Fan Motor, 5hp	2015	2054	sqft	kWh saved	0.69			0.69	ROB	1	1	14.00	$0.69
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	2015	2054	sqft	HP	43			43	ROB	1	1	20.00	$43.00
3101	Variable Speed Drive Control, 15 HP	2015	2054	sqft	unit	2183	1135		3318	RET	1	1	15.00	$3,318.00
3102	Air Handler Optimization, 15 HP	2015	2054	sqft	sqft	0		0.03	0	RET	1	1	8.00	$0.03
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	2015	2054	sqft	ton	27.76			27.76	ROB	1	1	15.00	$27.76
3104	Separate Makeup Air / Exhaust Hoods AC	2015	2054	sqft	CFM	3			3	RET	1	1	15.00	$3.00
3105	Custom HVAC--Base Fan Motor, 15hp	2015	2054	sqft	kWh saved	0.69			0.69	ROB	1	1	14.00	$0.69
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	2015	2054	sqft	HP	37			37	ROB	1	1	20.00	$37.00
3201	Variable Speed Drive Control, 40 HP	2015	2054	sqft	unit	4666.29			4666.29	RET	1	1	15.00	$4,666.29
3202	Air Handler Optimization, 40 HP	2015	2054	sqft	sqft	0		0.03	0	RET	1	1	8.00	$0.03
3203	Demand Controlled Ventilation (40 HP fan motor)	2015	2054	sqft	unit	2100			2100	RET	1	1	10.00	$2,100.00
3204	Custom HVAC--Base Fan Motor, 40hp	2015	2054	sqft	kWh saved	0.69			0.69	ROB	1	1	14.00	$0.69
4000	Base Built-Up Refrigeration System	2015	2054	sqft	40,000 sqft store	0	0		0	ROB	1	1	10.00	$0.00
4001	Strip curtains for walk-ins (built-up)	2015	2054	sqft	sq. ft. doorway	9.86	0		9.86	RET	1	1	4.00	$9.86

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4002	Auto-closer on main door to walk-in freezer (built-up)	2015	2054	sqft	unit	536.43			536.43	RET	1	1	8.00	$536.43
4003	Night covers for display cases	2015	2054	sqft	linear ft. display	42	0		42	RET	1	1	10.00	$42.00
4004	Evaporator fan controller for MT walk-ins	2015	2054	sqft	controller	816.475	0		816.475	RET	1	1	16.00	$816.48
4005	Electronically commutated evaporator fan motor	2015	2054	sqft	motor	226.2			226.2	RET	1	1	15.00	$226.20
4006	Efficient compressor motor	2015	2054	sqft	40,000 sqft store	3510	0		3510	ROB	1	1	10.00	$3,510.00
4007	Floating head pressure controls	2015	2054	sqft	discharge group	5127	0		5127	RET	1	1	15.00	$5,127.00
4008	Refrigeration Commissioning	2015	2054	sqft	Ton of Load	113	0		113	RET	1	1	3.00	$113.00
4009	Demand Hot Gas Defrost	2015	2054	sqft	HP	25	0		25	RET	1	1	10.00	$25.00
4010	Demand Defrost Electric	2015	2054	sqft	HP	25	0		25	RET	1	1	10.00	$25.00
4011	Anti-sweat (humidistat) controls	2015	2054	sqft	linear ft.	70	0		70	RET	1	1	12.00	$70.00
4012	Freezer-Cooler Replacement Gaskets	2015	2054	sqft	lin ft doors	8	0		8	RET	1	1	4.00	$8.00
4013	High R-Value Glass Doors	2015	2054	sqft	lin ft glass doors	400	0		400	RET	1	1	10.00	$400.00
4014	LED Display Lighting (Base T8 Lighting)	2015	2054	sqft	unit	136.1	33.75		169.85	RET	1	1	8.00	$169.85
4016	Multiplex Compressor System	2015	2054	sqft	tons	1750	0		1750	RET	1	1	14.00	$1,750.00
4017	Oversized Air Cooled Condenser	2015	2054	sqft	tons	350	0		350	RET	1	1	16.00	$350.00
4018	Custom Refrigeration	2015	2054	sqft	kWh saved	0.3			0.3	ROB	1	1	12.00	$0.30
4500	Base Self-Contained Refrigeration	2015	2054	sqft	refrigerator	0	0		0	ROB	1	1	10.00	$0.00
4501	Strip curtains for walk-ins (self-contained)	2015	2054	sqft	sq. ft. doorway	9.86			9.86	RET	1	1	4.00	$9.86
4502	Auto-closer on main door to walk-in freezer (self-contained)	2015	2054	sqft	unit	536.43			536.43	RET	1	1	8.00	$536.43
4503	Night covers for display cases (self-contained)	2015	2054	sqft	lin. ft. cover	42			42	RET	1	1	10.00	$42.00
4504	LED Display Lighting (Base T8 Lighting)	2015	2054	sqft	unit	136.1	33.75		169.85	RET	1	1	8.00	$169.85
4506	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	2015	2054	sqft	unit	158	0		158	ROB	1	1	12.00	$158.00
4507	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	2015	2054	sqft	unit	166	0		166	ROB	1	1	12.00	$166.00
4508	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	2015	2054	sqft	unit	158	0		158	ROB	1	1	12.00	$158.00
4509	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	2015	2054	sqft	unit	166	0		166	ROB	1	1	12.00	$166.00
4510	ENERGY STAR Ice Machines	2015	2054	sqft	unit	312	0		312	ROB	1	1	9.00	$312.00
4511	Hydraulic-type door closer on reach-in cooler glass doors	2015	2054	sqft	unit	85	36.82		121.82	RET	1	1	8.00	$121.82
4512	Doors for open cases	2015	2054	sqft	lin. ft. refrigerator	534			534	RET	1	1	12.00	$534.00
6000	Base Water Heating	2015	2054	sqft	kBtu/hr	0	0		0	RET	1	1	15.00	$0.00
6001	Demand controlled circulating systems	2015	2054	sqft	unit	59	165		224	RET	1	1	15.00	$224.00
6003	Hot Water Pipe Insulation	2015	2054	sqft	Lin Ft Pipe	0.37	2.44		2.81	RET	1	1	15.00	$2.81
6004	Tankless Water Heater	2015	2054	sqft	kBtu/hr	6.73	4.54		11.27	ROB	1	1	20.00	$11.27
6005	Heat Pump Water Heater (air source)	2015	2054	sqft	kBtu/hr	925	0		925	ROB	1	1	10.00	$925.00
6006	Heat Recovery Unit	2015	2054	sqft	sqft	0.08	0		0.08	RET	1	1	10.00	$0.08
6007	Heat Trap	2015	2054	sqft	kBtu/hr	0.363636364	2		2.363636364	RET	1	1	10.00	$2.36
6008	Solar Water Heater	2015	2054	sqft	kBtu/hr	85.19	0		85.19	ROB	1	1	20.00	$85.19
6009	High Temperature Dishwasher	2015	2054	sqft	unit	770			770	RET	1	1	15.00	$770.00
7000	Base Refrigerated Vending Machines	2015	2054	sqft	machine	0	0		0	RET	1	1	10.00	$0.00
7001	Vending Misers (Refrigerated units)	2015	2054	sqft	machine	180	0		180	RET	1	1	5.00	$180.00
7002	Vending Misers (Refrigerated glass-front units)	2015	2054	sqft	machine	180	0		180	RET	1	1	5.00	$180.00
7003	Refrigerated Vending Low Watt High Performance T8	2015	2054	sqft	machine	50			50	RET	1	1	24,000.00	$50.00
7500	Base Non-Refrigerated Vending Machines	2015	2054	sqft	machine	0	0		0	RET	1	1	10.00	$0.00
7501	Vending Misers (Non-Refrigerated)	2015	2054	sqft	machine	80	0		80	RET	1	1	5.00	$80.00
7502	Non-refrigerated Vending Low Watt High Performance T8	2015	2054	sqft	machine	50			50	RET	1	1	24,000.00	$50.00
8000	Base Oven	2015	2054	sqft	unit	0	0		0	ROB	1	1	10.00	$0.00
8001	Convection Oven	2015	2054	sqft	unit	590	0		590	ROB	1	1	12.00	$590.00
8100	Base Fryer	2015	2054	sqft	unit	0	0		0	ROB	1	1	10.00	$0.00
8101	Efficient Fryer	2015	2054	sqft	unit	1771.25	0		1771.25	ROB	1	1	12.00	$1,771.25
8200	Base Steamer	2015	2054	sqft	steamer	0	0		0	ROB	1	1	10.00	$0.00
8201	Efficient Steamer	2015	2054	sqft	steamer	5000	0		5000	ROB	1	1	12.00	$5,000.00
8300	Base Hot Food Holding Cabinet	2015	2054	sqft	unit	0	0		0	ROB	1	1	10.00	$0.00
8301	ENERGY STAR Hot Food Holding Cabinets	2015	2054	sqft	unit	50	0		50	ROB	1	1	12.00	$50.00
8500	Base Compressed Air	2015	2054	sqft	sqft	0	0		0	RET	1	1	10.00	$0.00
8700	Base Heating	2015	2054	sqft	sqft	0	0		0	RET	1	1	10.00	$0.00
9000	Base Miscellaneous	2015	2054	sqft	sqft	0	0		0	RET	1	1	10.00	$0.00
9500	Base Whole Building	2015	2054	sqft	sqft	1.25	0		1.25	RET	1	1	10.00	$1.25
9501	NEMA Premium Efficiency Transformer	2015	2054	sqft	kWh saved	1.08			1.08	ROB	1	1	28.00	$1.08
9502	Retrocommissioning/Building tune up	2015	2054	sqft	sqft	0.3			0.3	RET	1	1	5.00	$0.30
9503	Custom O&M	2015	2054	sqft	kWh saved	0.2	0	0	0.2	RET	1	1	15.00	$0.20
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015 (New)	2015	2015	sqft	fixture	0	0		0	NEW	1	1	18.00	$0.00
1001	NEW 3L4'T5, 2015	2015	2015	sqft	fixture	45			45	NEW	1	1	13.00	$45.00
1002	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015	2015	2015	sqft	sqft	0.2			0.2	NEW	1	1	15.00	$0.20
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream New	2015	2015	sqft	fixture	0	0		0	NEW	1	1	18.00	$0.00

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Measure #	Measure Description	First Year	End Year	Savings Units	Cost Units	Unit Equipment Cost	Unit Labor Costs	NPV of Lifetime O&M Cost	Implementation Cost Factor	Implementation Type (RET/ROB)	Initial Cost	Replacement Cost	Measure File Service Life (Yrs)	Full Per Unit Cost
1012	Upstream 4L4' LED Tube, 2015	2015	2015	sqft	fixture	125			125	NEW	1	1	10.00	$125.00
1013	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015 (Base Upstream)	2015	2015	sqft	sqft	0.2			0.2	NEW	1	1	15.00	$0.20
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017 (New)	2016	2017	sqft	fixture	0	0		0	NEW	1	1	18.00	$0.00
1051	NEW 3L4'T5, 2016-2017	2016	2017	sqft	fixture	45			45	NEW	1	1	13.00	$45.00
1052	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017	2016	2017	sqft	sqft	0.2			0.2	NEW	1	1	15.00	$0.20
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream New	2016	2017	sqft	fixture	0	0		0	NEW	1	1	18.00	$0.00
1062	Upstream 4L4' LED Tube, 2016-2017	2016	2017	sqft	fixture	125			125	NEW	1	1	10.00	$125.00
1063	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017 (Base Upstream)	2016	2017	sqft	sqft	0.2			0.2	NEW	1	1	15.00	$0.20
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019 (New)	2018	2019	sqft	fixture	0	0		0	NEW	1	1	18.00	$0.00
1101	NEW 3L4'T5, 2018-2019	2018	2019	sqft	fixture	45			45	NEW	1	1	13.00	$45.00
1102	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019	2018	2019	sqft	sqft	0.2			0.2	NEW	1	1	15.00	$0.20
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream New	2018	2019	sqft	fixture	0	0		0	NEW	1	1	18.00	$0.00
1112	Upstream 4L4' LED Tube, 2018-2019	2018	2019	sqft	fixture	125			125	NEW	1	1	10.00	$125.00
1113	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019 (Base Upstream)	2018	2019	sqft	sqft	0.2			0.2	NEW	1	1	15.00	$0.20
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020 (New)	2020	2054	sqft	fixture	0	0		0	NEW	1	1	18.00	$0.00
1151	NEW 3L4'T5, 2020	2020	2054	sqft	fixture	45			45	NEW	1	1	13.00	$45.00
1152	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020	2020	2054	sqft	sqft	0.2			0.2	NEW	1	1	15.00	$0.20
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream New	2020	2054	sqft	fixture	0	0		0	NEW	1	1	18.00	$0.00
1162	Upstream 4L4' LED Tube, 2020	2020	2054	sqft	fixture	125			125	NEW	1	1	10.00	$125.00
1163	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020 (Base Upstream)	2020	2054	sqft	sqft	0.2			0.2	NEW	1	1	15.00	$0.20
1200	Base Other Fluorescent Fixture (New)	2015	2054	sqft	fixture	0	0		0	NEW	1	1	18.00	$0.00
1201	NEW T5	2015	2054	sqft	fixture	45			45	NEW	1	1	13.00	$45.00
1202	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings	2015	2054	sqft	sqft	0.2			0.2	NEW	1	1	15.00	$0.20
1210	Base Other Fluorescent Fixture--Upstream New	2015	2054	sqft	fixture	0	0		0	NEW	1	1	18.00	$0.00
1211	Upstream Low Watt High Performance T8	2015	2054	sqft	fixture	25			25	NEW	1	1	24,000.00	$25.00
1212	Upstream LED Tube	2015	2054	sqft	fixture	125			125	NEW	1	1	10.00	$125.00
1213	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings (Base Upstream)	2015	2054	sqft	sqft	0.2			0.2	NEW	1	1	15.00	$0.20
1300	Base Incandescent Lamp, 72W 2015--New	2015	2015	sqft	lamp	0	0	0	0	NEW	1	1	1,200.00	$0.00
1301	New LEDs (base incandescent 72W) 2015	2015	2015	sqft	lamp	18.335	0	0	18.335	NEW	1	1	25,000.00	$18.34
1310	Base Incandescent Lamp, 72W 2015--Upstream New	2015	2015	sqft	lamp	0	0	0	0	NEW	1	1	1,200.00	$0.00
1311	Upstream LEDs (base incandescent 72W) 2015	2015	2015	sqft	lamp	18.335	0	0	18.335	NEW	1	1	25,000.00	$18.34
1320	Base Incandescent Lamp, 72W 2016-2017--New	2016	2017	sqft	lamp	0	0	0	0	NEW	1	1	1,200.00	$0.00
1321	New LEDs (base incandescent 72W) 2016-2017	2016	2017	sqft	lamp	12.8345	0	0	12.8345	NEW	1	1	25,000.00	$12.83
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream New	2016	2017	sqft	lamp	0	0	0	0	NEW	1	1	1,200.00	$0.00
1331	Upstream LEDs (base incandescent 72W) 2016-2017	2016	2017	sqft	lamp	12.8345	0	0	12.8345	NEW	1	1	25,000.00	$12.83
1340	Base Incandescent Lamp, 72W 2018-2019--New	2018	2019	sqft	lamp	0	0	0	0	NEW	1	1	1,200.00	$0.00
1341	New LEDs (base incandescent 72W) 2018-2019	2018	2019	sqft	lamp	6.41725	0	0	6.41725	NEW	1	1	25,000.00	$6.42
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream New	2018	2019	sqft	lamp	0	0	0	0	NEW	1	1	1,200.00	$0.00
1351	Upstream LEDs (base incandescent 72W) 2018-2019	2018	2019	sqft	lamp	6.41725	0	0	6.41725	NEW	1	1	25,000.00	$6.42
1360	Base Incandescent Lamp, 72W 2020--New	2020	2054	sqft	lamp	0	0	0	0	NEW	1	1	1,200.00	$0.00
1361	New LEDs (base incandescent 72W) 2020	2020	2054	sqft	lamp	2.5669	0	0	2.5669	NEW	1	1	25,000.00	$2.57
1370	Base Incandescent Lamp, 72W 2020--Upstream New	2020	2054	sqft	lamp	0	0	0	0	NEW	1	1	1,200.00	$0.00
1371	Upstream LEDs (base incandescent 72W) 2020	2020	2054	sqft	lamp	2.5669	0	0	2.5669	NEW	1	1	25,000.00	$2.57
1400	Base CFL Lamp, 23W 2015--New	2015	2015	sqft	lamp	0	0	0	0	NEW	1	1	8,000.00	$0.00
1401	New LEDs (base CFL spiral 23W) 2015	2015	2015	sqft	lamp	18.335	0	-10.91383	18.335	NEW	1	1	25,000.00	$7.42
1410	Base CFL Lamp, 23W 2015--Upstream New	2015	2015	sqft	lamp	0	0	0	0	NEW	1	1	8,000.00	$0.00
1411	Upstream LEDs (base CFL spiral 23W) 2015	2015	2015	sqft	lamp	18.335	0	-10.91383	18.335	NEW	1	1	25,000.00	$7.42
1420	Base CFL Lamp, 23W 2016-2017--New	2016	2017	sqft	lamp	0	0	0	0	NEW	1	1	8,000.00	$0.00
1421	New LEDs (base CFL spiral 23W) 2016-2017	2016	2017	sqft	lamp	12.8345	0	-10.91383	12.8345	NEW	1	1	25,000.00	$1.92
1430	Base CFL Lamp, 23W 2016-2017--Upstream New	2016	2017	sqft	lamp	0	0	0	0	NEW	1	1	8,000.00	$0.00
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	2016	2017	sqft	lamp	12.8345	0	-10.91383	12.8345	NEW	1	1	25,000.00	$1.92
1440	Base CFL Lamp, 23W 2018-2019--New	2018	2019	sqft	lamp	0	0	0	0	NEW	1	1	8,000.00	$0.00
1441	New LEDs (base CFL spiral 23W) 2018-2019	2018	2019	sqft	lamp	6.41725	0	-5.41725	6.41725	NEW	1	1	25,000.00	$1.00
1450	Base CFL Lamp, 23W 2018-2019--Upstream New	2018	2019	sqft	lamp	0	0	0	0	NEW	1	1	8,000.00	$0.00
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	2018	2019	sqft	lamp	6.41725	0	-5.41725	6.41725	NEW	1	1	25,000.00	$1.00
1460	Base CFL Lamp, 23W 2020--New	2020	2054	sqft	lamp	0	0	0	0	NEW	1	1	8,000.00	$0.00
1461	New LEDs (base CFL spiral 23W) 2020	2020	2054	sqft	lamp	2.5669	0	-1.5669	2.5669	NEW	1	1	25,000.00	$1.00
1470	Base CFL Lamp, 23W 2020--Upstream New	2020	2054	sqft	lamp	0	0	0	0	NEW	1	1	8,000.00	$0.00
1471	Upstream LEDs (base CFL spiral 23W) 2020	2020	2054	sqft	lamp	2.5669	0	-1.5669	2.5669	NEW	1	1	25,000.00	$1.00
1500	Base Metal Halide, 400W	2015	2054	sqft	fixture	200	60	0	260	NEW	1	1	18.00	$260.00
1501	High Bay T5 HO (240W)	2015	2054	sqft	fixture	100	0	0	100	NEW	1	1	13.00	$100.00
1502	High Bay Induction Lighting	2015	2054	sqft	fixture	280	60	0	340	NEW	1	1	20.00	$340.00
1600	Base HID Parking Garage Lighting	2015	2054	sqft	fixture	200	60	0	260	NEW	1	1	18.00	$260.00

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1601	LED Parking Garage Fixtures	2015	2054	sqft	fixture	143	0	0	143	NEW	1	1	8.00	$143.00
1602	Bi-Level LED Parking Garage Fixtures	2015	2054	sqft	fixture	143	0	0	143	NEW	1	1	8.00	$143.00
1700	Base CFL Exit Sign	2015	2054	sqft	unit	0	0	0	0	NEW	1	1	18.00	$0.00
1800	Base Outdoor High Pressure Sodium 250W Lamp	2015	2054	sqft	fixture	0	0	0	0	NEW	1	1	15.00	$0.00
1801	LED Outdoor Area Lighting (other than pole-mounted)	2015	2054	sqft	fixture	120	0	0	120	NEW	1	1	18.00	$120.00
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	2015	2054	sqft	ton	220	0	0	220	NEW	1	1	23.00	$220.00
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	2015	2054	sqft	ton	48	0	0	48	NEW	1	1	23.00	$48.00
2002	Chilled Beams	2015	2054	sqft	unit	1089415	0	0	1089415	NEW	1	1	10.00	$1,089,415.00
2003	Cool Roof - Chiller	2015	2054	sqft	sf-roof	8.45	0	0	8.45	NEW	1	1	15.00	$8.45
2005	VSD for Chiller Pumps and Towers	2015	2054	sqft	HP	2055.47	0	0	2055.47	NEW	1	1	15.00	$2,055.47
2100	Base DX Packaged System, EER=10.0, 30 tons	2015	2054	sqft	ton	672.4	0	0	672.4	NEW	1	1	15.00	$672.40
2101	ROB DX Packaged System, EER=10.8, 30 tons	2015	2054	sqft	ton	37.83	0	0	37.83	NEW	1	1	15.00	$37.83
2102	ROB DX Packaged System, EER=11.7, 30 tons	2015	2054	sqft	ton	93.42	0	0	93.42	NEW	1	1	15.00	$93.42
2103	Automated Fault Detection	2015	2054	sqft	unit	300			300	NEW	1	1	15.00	$300.00
2104	RTU VSD	2015	2054	sqft	ton	730.88	0	0	730.88	NEW	1	1	15.00	$730.88
2106	Aerosol Duct Sealing	2015	2054	sqft	ton	338	0	0	338	NEW	1	1	18.00	$338.00
2107	VRF Conditioning Systems	2015	2054	sqft	sqft	24.2			24.2	NEW	1	1	15.00	$24.20
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	2015	2054	sqft	unit	0	0	0	0	NEW	1	1	15.00	$0.00
2201	Air Source Heat Pump, EER=11.3, 10 tons	2015	2054	sqft	unit	5946.666667			5946.666667	NEW	1	1	15.00	$5,946.67
2202	Geothermal Heat Pump, EER=18, 10 tons	2015	2054	sqft	unit	33623.33333			33623.33333	NEW	1	1	15.00	$33,623.33
2203	VRF Conditioning Systems	2015	2054	sqft	sqft	0.5648			0.5648	NEW	1	1	20.00	$0.56
2300	Base PTAC, EER=8.3, 1 ton	2015	2054	sqft	ton	0	0	0	0	NEW	1	1	15.00	$0.00
2301	Occupancy Sensor (hotels)	2015	2054	sqft	ton	280	0	0	280	NEW	1	1	10.00	$280.00
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	2015	2054	sqft	HP	52	0	0	52	NEW	1	1	20.00	$52.00
3001	Variable Speed Drive Control, 5 HP	2015	2054	sqft	unit	730.88	0	0	730.88	NEW	1	1	15.00	$730.88
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	2015	2054	sqft	HP	43	0	0	43	NEW	1	1	20.00	$43.00
3101	Variable Speed Drive Control, 15 HP	2015	2054	sqft	HP	2183	1135	0	3318	NEW	1	1	15.00	$3,318.00
3102	Air Handler Optimization, 15 HP	2015	2054	sqft	sqft	0	0	0.03	0	NEW	1	1	8.00	$0.03
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	2015	2054	sqft	ton	27.76	0	0	27.76	NEW	1	1	15.00	$27.76
3104	Separate Makeup Air / Exhaust Hoods AC	2015	2054	sqft	CFM	3	0	0	3	NEW	1	1	15.00	$3.00
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	2015	2054	sqft	HP	37	0	0	37	NEW	1	1	20.00	$37.00
3201	Variable Speed Drive Control, 40 HP	2015	2054	sqft	unit	4666.29	0	0	4666.29	NEW	1	1	15.00	$4,666.29
3202	Air Handler Optimization, 40 HP	2015	2054	sqft	sqft	0	0	0.03	0	NEW	1	1	8.00	$0.03
3203	Demand Controlled Ventilation (40 HP fan motor)	2015	2054	sqft	unit	2100	0	0	2100	NEW	1	1	10.00	$2,100.00
4000	Base Built-Up Refrigeration System	2015	2054	sqft	40,000 sqft store	0	0	0	0	NEW	1	1	10.00	$0.00
4001	Auto-closer on main door to walk-in freezer (built-up)	2015	2054	sqft	unit	536.43	0	0	536.43	NEW	1	1	8.00	$536.43
4002	Evaporator fan controller for MT walk-ins	2015	2054	sqft	controller	816.475	0	0	816.475	NEW	1	1	16.00	$816.48
4003	Efficient compressor motor	2015	2054	sqft	40,000 sqft store	3510	0	0	3510	NEW	1	1	10.00	$3,510.00
4004	Refrigeration Commissioning	2015	2054	sqft	Ton of Load	113	0	0	113	NEW	1	1	3.00	$113.00
4500	Base Self-Contained Refrigeration	2015	2054	sqft	refrigerator	0	0	0	0	NEW	1	1	10.00	$0.00
4501	Auto-closer on main door to walk-in freezer (self-contained)	2015	2054	sqft	unit	536.43	0	0	536.43	NEW	1	1	8.00	$536.43
4502	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	2015	2054	sqft	unit	158	0	0	158	NEW	1	1	12.00	$158.00
4503	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	2015	2054	sqft	unit	166	0	0	166	NEW	1	1	12.00	$166.00
4504	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	2015	2054	sqft	unit	158	0	0	158	NEW	1	1	12.00	$158.00
4505	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	2015	2054	sqft	unit	166	0	0	166	NEW	1	1	12.00	$166.00
4506	ENERGY STAR Ice Machines	2015	2054	sqft	unit	312	0	0	312	NEW	1	1	9.00	$312.00
4507	Hydraulic-type door closer on reach-in cooler glass doors	2015	2054	sqft	unit	85	36.82	0	121.82	NEW	1	1	8.00	$121.82
6000	Base Water Heating	2015	2054	sqft	kBtu/hr	0	0	0	0	NEW	1	1	15.00	$0.00
6001	Demand controlled circulating systems	2015	2054	sqft	unit	59	165	0	224	NEW	1	1	15.00	$224.00
6003	Tankless Water Heater	2015	2054	sqft	kBtu/hr	6.73	4.54	0	11.27	NEW	1	1	20.00	$11.27
6004	Heat Pump Water Heater (air source)	2015	2054	sqft	kBtu/hr	925	0	0	925	NEW	1	1	10.00	$925.00
6005	Solar Water Heater	2015	2054	sqft	kBtu/hr	85.19	0	0	85.19	NEW	1	1	20.00	$85.19
7000	Base Refrigerated Vending Machines	2015	2054	sqft	machine	0	0	0	0	NEW	1	1	10.00	$0.00
7500	Base Non-Refrigerated Vending Machines	2015	2054	sqft	machine	0	0	0	0	NEW	1	1	10.00	$0.00
8000	Base Oven	2015	2054	sqft	unit	0	0	0	0	NEW	1	1	10.00	$0.00
8001	Convection Oven	2015	2054	sqft	unit	590	0	0	590	NEW	1	1	12.00	$590.00
8100	Base Fryer	2015	2054	sqft	unit	0	0	0	0	NEW	1	1	10.00	$0.00
8101	Efficient Fryer	2015	2054	sqft	unit	1771.25	0	0	1771.25	NEW	1	1	12.00	$1,771.25
8200	Base Steamer	2015	2054	sqft	steamer	0	0	0	0	NEW	1	1	10.00	$0.00
8201	Efficient Steamer	2015	2054	sqft	steamer	5000	0	0	5000	NEW	1	1	12.00	$5,000.00
8300	Base Hot Food Holding Cabinet	2015	2054	sqft	steamer	0	0	0	0	NEW	1	1	10.00	$0.00
8301	ENERGY STAR Hot Food Holding Cabinets	2015	2054	sqft	steamer	50	0	0	50	NEW	1	1	12.00	$50.00
8500	Base Compressed Air	2015	2054	sqft	sqft	0	0	0	0	NEW	1	1	10.00	$0.00

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Commercial Electric Measure Costs

Measure #	Measure Description	First Year	End Year	Savings Units	Cost Units	Unit Equipment Cost	Unit Labor Costs	NPV of Lifetime O&M Cost	Implementation Cost Factor	Implementation Type (RET/ROB)	Initial Cost	Replacement Cost	Measure File Service Life (Yrs)	Full Per Unit Cost
8700	Base Heating	2015	2054	sqft	sqft	0	0	0	0	NEW	1	1	10.00	$0.00
8701	Air Source Heat Pump, EER=11.3, 10 tons	2015	2054	sqft	unit	5946.666667			5946.666667	NEW	1	1	15.00	$5,946.67
8702	Geothermal Heat Pump, EER=18, 10 tons	2015	2054	sqft	unit	33623.33333			33623.33333	NEW	1	1	15.00	$33,623.33
8703	VRF Conditioning Systems	2015	2054	sqft	sqft	0.5648			0.5648	NEW	1	1	20.00	$0.56
9000	Base Miscellaneous	2015	2054	sqft	sqft	0	0	0	0	NEW	1	1	10.00	$0.00
9500	Base Building Design - Standard Code	2015	2054	sqft	sqft	0	0		0	NEW	1	1	20.00	$0.00
9501	15% better than code - Campuses	2015	2054	sqft	sqft	5.117810733			5.117810733	NEW	1	1	20.00	$5.12
9502	15% better than code - Education	2015	2054	sqft	sqft	4.489377795			4.489377795	NEW	1	1	20.00	$4.49
9503	15% better than code - Food Sales	2015	2054	sqft	sqft	2.906968733			2.906968733	NEW	1	1	20.00	$2.91
9504	15% better than code - Food Service	2015	2054	sqft	sqft	5.781956145			5.781956145	NEW	1	1	20.00	$5.78
9505	15% better than code - Healthcare	2015	2054	sqft	sqft	8.216867269			8.216867269	NEW	1	1	20.00	$8.22
9506	15% better than code - Lodging	2015	2054	sqft	sqft	4.727572001			4.727572001	NEW	1	1	20.00	$4.73
9507	15% better than code - Office	2015	2054	sqft	sqft	4.748892881			4.748892881	NEW	1	1	20.00	$4.75
9508	15% better than code - Other	2015	2054	sqft	sqft	4.619693348			4.619693348	NEW	1	1	20.00	$4.62
9509	15% better than code - Public Assembly	2015	2054	sqft	sqft	4.241195			4.241195	NEW	1	1	20.00	$4.24
9510	15% better than code - Retail	2015	2054	sqft	sqft	3.36248045			3.36248045	NEW	1	1	20.00	$3.36
9511	15% better than code - Warehouse	2015	2054	sqft	sqft	2.60381247			2.60381247	NEW	1	1	20.00	$2.60
9512	Commissioning	2015	2054	sqft	sqft	1.16			1.16	NEW	1	1	5.00	$1.16
9600	Base Building Design - Standard Code	2015	2054	sqft	sqft	0			0	NEW	1	1	20.00	$0.00
9601	30% better than code - Campuses	2015	2054	sqft	sqft	7.31115819			7.31115819	NEW	1	1	20.00	$7.31
9602	30% better than code - Education	2015	2054	sqft	sqft	6.41339685			6.41339685	NEW	1	1	20.00	$6.41
9603	30% better than code - Food Sales	2015	2054	sqft	sqft	4.152812475			4.152812475	NEW	1	1	20.00	$4.15
9604	30% better than code - Food Service	2015	2054	sqft	sqft	8.25993735			8.25993735	NEW	1	1	20.00	$8.26
9605	30% better than code - Healthcare	2015	2054	sqft	sqft	11.73838181			11.73838181	NEW	1	1	20.00	$11.74
9606	30% better than code - Lodging	2015	2054	sqft	sqft	6.753674288			6.753674288	NEW	1	1	20.00	$6.75
9607	30% better than code - Office	2015	2054	sqft	sqft	6.784132688			6.784132688	NEW	1	1	20.00	$6.78
9608	30% better than code - Other	2015	2054	sqft	sqft	6.599561925			6.599561925	NEW	1	1	20.00	$6.60
9609	30% better than code - Public Assembly	2015	2054	sqft	sqft	6.05885			6.05885	NEW	1	1	20.00	$6.06
9610	30% better than code - Retail	2015	2054	sqft	sqft	4.8035435			4.8035435	NEW	1	1	20.00	$4.80
9611	30% better than code - Warehouse	2015	2054	sqft	sqft	3.7197321			3.7197321	NEW	1	1	20.00	$3.72
9612	Commissioning	2015	2054	sqft	sqft	1.16			1.16	NEW	1	1	5.00	$1.16
9700	Base Building Design - Standard Code	2015	2054	sqft	sqft	0			0	NEW	1	1	20.00	$0.00
9701	50% better than code - Campuses	2015	2054	sqft	sqft	12.79452683			12.79452683	NEW	1	1	20.00	$12.79
9702	50% better than code - Education	2015	2054	sqft	sqft	11.22344449			11.22344449	NEW	1	1	20.00	$11.22
9703	50% better than code - Food Sales	2015	2054	sqft	sqft	7.267421831			7.267421831	NEW	1	1	20.00	$7.27
9704	50% better than code - Food Service	2015	2054	sqft	sqft	14.45489036			14.45489036	NEW	1	1	20.00	$14.45
9705	50% better than code - Healthcare	2015	2054	sqft	sqft	20.54216817			20.54216817	NEW	1	1	20.00	$20.54
9706	50% better than code - Lodging	2015	2054	sqft	sqft	11.81893			11.81893	NEW	1	1	20.00	$11.82
9707	50% better than code - Office	2015	2054	sqft	sqft	11.8722322			11.8722322	NEW	1	1	20.00	$11.87
9708	50% better than code - Other	2015	2054	sqft	sqft	11.54923337			11.54923337	NEW	1	1	20.00	$11.55
9709	50% better than code - Public Assembly	2015	2054	sqft	sqft	10.6029875			10.6029875	NEW	1	1	20.00	$10.60
9710	50% better than code - Retail	2015	2054	sqft	sqft	8.406201125			8.406201125	NEW	1	1	20.00	$8.41
9711	50% better than code - Warehouse	2015	2054	sqft	sqft	6.509531175			6.509531175	NEW	1	1	20.00	$6.51
9712	Commissioning	2015	2054	sqft	sqft	1.16			1.16	NEW	1	1	5.00	$1.16
9800	Base Building Design - Standard Code	2015	2054	sqft	sqft	0			0	NEW	1	1	20.00	$0.00
9801	70% better than code - Campuses	2015	2054	sqft	sqft	20.10568502			20.10568502	NEW	1	1	20.00	$20.11
9802	70% better than code - Education	2015	2054	sqft	sqft	17.63684134			17.63684134	NEW	1	1	20.00	$17.64
9803	70% better than code - Food Sales	2015	2054	sqft	sqft	11.42023431			11.42023431	NEW	1	1	20.00	$11.42
9804	70% better than code - Food Service	2015	2054	sqft	sqft	22.71482771			22.71482771	NEW	1	1	20.00	$22.71
9805	70% better than code - Healthcare	2015	2054	sqft	sqft	32.28054998			32.28054998	NEW	1	1	20.00	$32.28
9806	70% better than code - Lodging	2015	2054	sqft	sqft	18.57260429			18.57260429	NEW	1	1	20.00	$18.57
9807	70% better than code - Office	2015	2054	sqft	sqft	18.65636489			18.65636489	NEW	1	1	20.00	$18.66
9808	70% better than code - Other	2015	2054	sqft	sqft	18.14879529			18.14879529	NEW	1	1	20.00	$18.15
9809	70% better than code - Public Assembly	2015	2054	sqft	sqft	16.6618375			16.6618375	NEW	1	1	20.00	$16.66
9810	70% better than code - Retail	2015	2054	sqft	sqft	13.20974463			13.20974463	NEW	1	1	20.00	$13.21
9811	70% better than code - Warehouse	2015	2054	sqft	sqft	10.22926328			10.22926328	NEW	1	1	20.00	$10.23
9812	Commissioning	2015	2054	sqft	sqft	1.16			1.16	NEW	1	1	5.00	$1.16

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Commercial Electric Measure Inputs		APPLICABILITY FACTOR (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--RET	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1001	RET 4L4' Low Watt High Performance T8 (83 W), 2015	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1002	RET 4L4' LED Tube, 2015	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1003	RET LED Troffer (base 4L4'T8), 2015	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1004	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base RET)	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1005	Advanced Lighting Controls (2015 Base RET)	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1006	Daylight Dimming Controls (2015 Base RET)	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1007	Custom Lighting, Base 4L4'T8, 2015	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--ROB	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1011	ROB 4L4' Low Watt High Performance T8 (83 W), 2015	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1012	ROB 4L4' LED Tube, 2015	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1013	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base ROB)	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1014	Advanced Lighting Controls (2015 Base ROB)	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1015	Daylight Dimming Controls (2015 Base ROB)	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1020	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1021	Upstream 4L4' Low Watt High Performance T8 (83 W), 2015	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1022	Upstream 4L4' LED Tube, 2015	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1023	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base Upstream)	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1024	Advanced Lighting Controls (2015 Base Up)	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1025	Daylight Dimming Controls (2015 Base Up)	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--RET	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1051	RET 4L4' Low Watt High Performance T8 (83 W), 2016-2017	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1052	RET 4L4' LED Tube, 2016-2017	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1053	RET LED Troffer (base 4L4'T8), 2016-2017	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1054	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base RET)	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1055	Advanced Lighting Controls (2016-2017 Base RET)	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1056	Daylight Dimming Controls (2016-2017 Base RET)	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1057	Custom Lighting, Base 4L4'T8, 2016-2017	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--ROB	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1061	ROB 4L4' Low Watt High Performance T8 (83 W), 2016-2017	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1062	ROB 4L4' LED Tube, 2016-2017	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1063	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base ROB)	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1064	Advanced Lighting Controls (2016-2017 Base ROB)	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1065	Daylight Dimming Controls (2016-2017 Base ROB)	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1070	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1071	Upstream 4L4' Low Watt High Performance T8 (83 W), 2016-2017	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1072	Upstream 4L4' LED Tube, 2016-2017	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1073	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base Upstream)	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1074	Advanced Lighting Controls (2016-2017 Base Up)	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1075	Daylight Dimming Controls (2016-2017 Base Up)	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1080	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--RET	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1081	RET 4L4' Low Watt High Performance T8 (83 W), 2018-2019	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1082	RET 4L4' LED Tube, 2018-2019	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1083	RET LED Troffer (base 4L4'T8), 2018-2019	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1084	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base RET)	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1085	Advanced Lighting Controls (2018-2019 Base RET)	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1086	Daylight Dimming Controls (2018-2019 Base RET)	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1087	Custom Lighting, Base 4L4'T8, 2018-2019	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--ROB	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1101	ROB 4L4' Low Watt High Performance T8 (83 W), 2018-2019	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1102	ROB 4L4' LED Tube, 2018-2019	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1103	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base ROB)	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1104	Advanced Lighting Controls (2018-2019 Base ROB)	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1105	Daylight Dimming Controls (2018-2019 Base ROB)	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1111	Upstream 4L4' Low Watt High Performance T8 (83 W), 2018-2019	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1112	Upstream 4L4' LED Tube, 2018-2019	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1113	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base Upstream)	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1114	Advanced Lighting Controls (2018-2019 Base Up)	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1115	Daylight Dimming Controls (2018-2019 Base Up)	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1120	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--RET	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%

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Commercial Electric Measure Inputs		APPLICABILITY FACTOR (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1121	RET 4L4' Low Watt High Performance T8 (83 W), 2020	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1122	RET 4L4' LED Tube, 2020	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1123	RET LED Troffer (base 4L4'T8), 2020	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1124	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base RET)	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1125	Advanced Lighting Controls (2020 Base RET)	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1126	Daylight Dimming Controls (2020 Base RET)	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1127	Custom Lighting, Base 4L4'T8, 2020	12.6%	46.0%	42.8%	33.6%	40.6%	31.3%	35.7%	46.4%	12.1%	23.6%	47.6%	47%
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--ROB	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1151	ROB 4L4' Low Watt High Performance T8 (83 W), 2020	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1152	ROB 4L4' LED Tube, 2020	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1153	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base ROB)	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1154	Advanced Lighting Controls (2020 Base ROB)	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1155	Daylight Dimming Controls (2020 Base ROB)	5.0%	18.4%	17.1%	13.4%	16.2%	12.5%	14.3%	18.6%	4.8%	9.4%	19.0%	19%
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1161	Upstream 4L4' Low Watt High Performance T8 (83 W), 2020	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1162	Upstream 4L4' LED Tube, 2020	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1163	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base Upstream)	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1164	Advanced Lighting Controls (2020 Base Up)	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1165	Daylight Dimming Controls (2020 Base Up)	7.6%	27.6%	25.7%	20.2%	24.3%	18.8%	21.4%	27.9%	7.3%	14.1%	28.5%	28%
1200	Base Other Fluorescent Fixture--RET	8.0%	17.9%	16.2%	5.9%	1.8%	22.7%	11.8%	17.4%	0.1%	6.9%	3.6%	2%
1201	RET Low Watt High Performance T8	8.0%	17.9%	16.2%	5.9%	1.8%	22.7%	11.8%	17.4%	0.1%	6.9%	3.6%	2%
1202	RET LED Tube	8.0%	17.9%	16.2%	5.9%	1.8%	22.7%	11.8%	17.4%	0.1%	6.9%	3.6%	2%
1203	RET LED Troffer	8.0%	17.9%	16.2%	5.9%	1.8%	22.7%	11.8%	17.4%	0.1%	6.9%	3.6%	2%
1204	Occupancy Sensor (Base Other Fluor RET)	8.0%	17.9%	16.2%	5.9%	1.8%	22.7%	11.8%	17.4%	0.1%	6.9%	3.6%	2%
1205	Advanced Lighting Controls (Base Other Fluor RET)	8.0%	17.9%	16.2%	5.9%	1.8%	22.7%	11.8%	17.4%	0.1%	6.9%	3.6%	2%
1206	Daylight Dimming Controls (Base Other Fluor RET)	8.0%	17.9%	16.2%	5.9%	1.8%	22.7%	11.8%	17.4%	0.1%	6.9%	3.6%	2%
1207	Custom Lighting, Base Other Fluorescent	8.0%	17.9%	16.2%	5.9%	1.8%	22.7%	11.8%	17.4%	0.1%	6.9%	3.6%	2%
1210	Base Other Fluorescent Fixture--ROB	3.2%	7.2%	6.5%	2.4%	0.7%	9.1%	4.7%	7.0%	0.0%	2.8%	1.5%	1%
1211	ROB Low Watt High Performance T8	3.2%	7.2%	6.5%	2.4%	0.7%	9.1%	4.7%	7.0%	0.0%	2.8%	1.5%	1%
1212	ROB LED Tube	3.2%	7.2%	6.5%	2.4%	0.7%	9.1%	4.7%	7.0%	0.0%	2.8%	1.5%	1%
1213	Occupancy Sensor (Base Other Fluor ROB)	3.2%	7.2%	6.5%	2.4%	0.7%	9.1%	4.7%	7.0%	0.0%	2.8%	1.5%	1%
1214	Advanced Lighting Controls (Base Other Fluor ROB)	3.2%	7.2%	6.5%	2.4%	0.7%	9.1%	4.7%	7.0%	0.0%	2.8%	1.5%	1%
1215	Daylight Dimming Controls (Base Other Fluor ROB)	3.2%	7.2%	6.5%	2.4%	0.7%	9.1%	4.7%	7.0%	0.0%	2.8%	1.5%	1%
1220	Base Other Fluorescent Fixture--Upstream	4.8%	10.8%	9.7%	3.5%	1.1%	13.6%	7.1%	10.5%	0.0%	4.2%	2.2%	1%
1221	Upstream Low Watt High Performance T8	4.8%	10.8%	9.7%	3.5%	1.1%	13.6%	7.1%	10.5%	0.0%	4.2%	2.2%	1%
1222	Upstream LED Tube	4.8%	10.8%	9.7%	3.5%	1.1%	13.6%	7.1%	10.5%	0.0%	4.2%	2.2%	1%
1223	Occupancy Sensor (Base Other Fluor Upstream)	4.8%	10.8%	9.7%	3.5%	1.1%	13.6%	7.1%	10.5%	0.0%	4.2%	2.2%	1%
1224	Advanced Lighting (Base Other Fluor Upstream)	4.8%	10.8%	9.7%	3.5%	1.1%	13.6%	7.1%	10.5%	0.0%	4.2%	2.2%	1%
1225	Daylight Dimming Controls (Base Other Fluor Upstream)	4.8%	10.8%	9.7%	3.5%	1.1%	13.6%	7.1%	10.5%	0.0%	4.2%	2.2%	1%
1300	Base Incandescent Lamp, 72W 2015--Hardwired	0.4%	1.0%	0.9%	1.8%	1.3%	1.1%	1.1%	1.0%	0.2%	1.4%	0.3%	1%
1301	LED Track Lighting (base Incandescent 72W) 2015	0.4%	1.0%	0.9%	1.8%	1.3%	1.1%	1.1%	1.0%	0.2%	1.4%	0.3%	1%
1310	Base Incandescent Lamp, 72W 2015--Upstream	18.5%	46.8%	45.3%	86.6%	62.4%	56.2%	51.7%	46.8%	11.1%	68.4%	15.8%	30%
1311	Upstream LEDs (base Incandescent 72W) 2015	18.5%	46.8%	45.3%	86.6%	62.4%	56.2%	51.7%	46.8%	11.1%	68.4%	15.8%	30%
1320	Base Incandescent Lamp, 72W 2016-2017--Hardwired	0.4%	1.0%	0.9%	1.8%	1.3%	1.1%	1.1%	1.0%	0.2%	1.4%	0.3%	1%
1321	LED Track Lighting (base Incandescent 72W) 2016-2017	0.4%	1.0%	0.9%	1.8%	1.3%	1.1%	1.1%	1.0%	0.2%	1.4%	0.3%	1%
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream	18.5%	46.8%	45.3%	86.6%	62.4%	56.2%	51.7%	46.8%	11.1%	68.4%	15.8%	30%
1331	Upstream LEDs (base Incandescent 72W) 2016-2017	18.5%	46.8%	45.3%	86.6%	62.4%	56.2%	51.7%	46.8%	11.1%	68.4%	15.8%	30%
1340	Base Incandescent Lamp, 72W 2018-2019--Hardwired	0.4%	1.0%	0.9%	1.8%	1.3%	1.1%	1.1%	1.0%	0.2%	1.4%	0.3%	1%
1341	LED Track Lighting (base Incandescent 72W) 2018-2019	0.4%	1.0%	0.9%	1.8%	1.3%	1.1%	1.1%	1.0%	0.2%	1.4%	0.3%	1%
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream	18.5%	46.8%	45.3%	86.6%	62.4%	56.2%	51.7%	46.8%	11.1%	68.4%	15.8%	30%
1351	Upstream LEDs (base Incandescent 72W) 2018-2019	18.5%	46.8%	45.3%	86.6%	62.4%	56.2%	51.7%	46.8%	11.1%	68.4%	15.8%	30%
1360	Base Incandescent Lamp, 72W 2020--Hardwired	0.4%	1.0%	0.9%	1.8%	1.3%	1.1%	1.1%	1.0%	0.2%	1.4%	0.3%	1%
1361	LED Track Lighting (base Incandescent 72W) 2020	0.4%	1.0%	0.9%	1.8%	1.3%	1.1%	1.1%	1.0%	0.2%	1.4%	0.3%	1%
1370	Base Incandescent Lamp, 72W 2020--Upstream	18.5%	46.8%	45.3%	86.6%	62.4%	56.2%	51.7%	46.8%	11.1%	68.4%	15.8%	30%
1371	Upstream LEDs (base Incandescent 72W) 2020	18.5%	46.8%	45.3%	86.6%	62.4%	56.2%	51.7%	46.8%	11.1%	68.4%	15.8%	30%
1400	Base CFL Lamp, 23W 2015--Hardwired	0.4%	0.7%	0.3%	0.7%	1.4%	0.9%	1.2%	1.3%	1.1%	0.8%	0.2%	0%
1401	LED Track Lighting (base CFL spiral 23W) 2015	0.4%	0.7%	0.3%	0.7%	1.4%	0.9%	1.2%	1.3%	1.1%	0.8%	0.2%	0%
1410	Base CFL Lamp, 23W 2015--Upstream	18.1%	35.7%	12.5%	36.0%	68.0%	46.4%	60.1%	62.5%	54.0%	37.6%	11.6%	3%
1411	Upstream LEDs (base CFL spiral 23W) 2015	18.1%	35.7%	12.5%	36.0%	68.0%	46.4%	60.1%	62.5%	54.0%	37.6%	11.6%	3%
1420	Base CFL Lamp, 23W 2016-2017--Hardwired	0.4%	0.7%	0.3%	0.7%	1.4%	0.9%	1.2%	1.3%	1.1%	0.8%	0.2%	0%
1421	LED Track Lighting (base CFL spiral 23W) 2016-2017	0.4%	0.7%	0.3%	0.7%	1.4%	0.9%	1.2%	1.3%	1.1%	0.8%	0.2%	0%
1430	Base CFL Lamp, 23W 2016-2017--Upstream	18.1%	35.7%	12.5%	36.0%	68.0%	46.4%	60.1%	62.5%	54.0%	37.6%	11.6%	3%

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Commercial Electric Measure Inputs		APPLICABILITY FACTOR (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	18.1%	35.7%	12.5%	36.0%	68.0%	46.4%	60.1%	62.5%	54.0%	37.6%	11.6%	3%
1440	Base CFL Lamp, 23W 2018-2019--Hardwired	0.4%	0.7%	0.3%	0.7%	1.4%	0.9%	1.2%	1.3%	1.1%	0.8%	0.2%	0%
1441	LED Track Lighting (base CFL spiral 23W) 2018-2019	0.4%	0.7%	0.3%	0.7%	1.4%	0.9%	1.2%	1.3%	1.1%	0.8%	0.2%	0%
1450	Base CFL Lamp, 23W 2018-2019--Upstream	18.1%	35.7%	12.5%	36.0%	68.0%	46.4%	60.1%	62.5%	54.0%	37.6%	11.6%	3%
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	18.1%	35.7%	12.5%	36.0%	68.0%	46.4%	60.1%	62.5%	54.0%	37.6%	11.6%	3%
1460	Base CFL Lamp, 23W 2020--Hardwired	0.4%	0.7%	0.3%	0.7%	1.4%	0.9%	1.2%	1.3%	1.1%	0.8%	0.2%	0%
1461	LED Track Lighting (base CFL spiral 23W) 2020	0.4%	0.7%	0.3%	0.7%	1.4%	0.9%	1.2%	1.3%	1.1%	0.8%	0.2%	0%
1470	Base CFL Lamp, 23W 2020--Upstream	18.1%	35.7%	12.5%	36.0%	68.0%	46.4%	60.1%	62.5%	54.0%	37.6%	11.6%	3%
1471	Upstream LEDs (base CFL spiral 23W) 2020	18.1%	35.7%	12.5%	36.0%	68.0%	46.4%	60.1%	62.5%	54.0%	37.6%	11.6%	3%
1500	Base Metal Halide, 400W	7.3%	67.0%	31.9%	19.5%	3.9%	44.8%	7.1%	15.5%	7.3%	21.3%	4.7%	63%
1501	High Bay T5 HO (240W)	7.3%	67.0%	31.9%	19.5%	3.9%	44.8%	7.1%	15.5%	7.3%	21.3%	4.7%	63%
1502	High Bay Induction Lighting	7.3%	67.0%	31.9%	19.5%	3.9%	44.8%	7.1%	15.5%	7.3%	21.3%	4.7%	63%
1503	PSMH with electronic ballast	7.3%	67.0%	31.9%	19.5%	3.9%	44.8%	7.1%	15.5%	7.3%	21.3%	4.7%	63%
1504	High Bay LED Lighting	7.3%	67.0%	31.9%	19.5%	3.9%	44.8%	7.1%	15.5%	7.3%	21.3%	4.7%	63%
1600	Base HPS (high pressure sodium) Parking Garage Lighting	18.3%	0.0%	0.0%	0.0%	6.9%	6.9%	2.0%	50.0%	6.5%	6.5%	0.0%	0%
1601	High-efficiency fluorescent parking garage fixture	18.3%	0.0%	0.0%	0.0%	6.9%	6.9%	2.0%	50.0%	6.5%	6.5%	0.0%	0%
1602	LED Parking Garage Fixtures	18.28%	0.00%	0.00%	0.00%	6.92%	6.92%	2.03%	50.00%	6.53%	6.53%	0.00%	0%
1603	Bi-Level LED Parking Garage Fixtures	18.28%	0.00%	0.00%	0.00%	6.92%	6.92%	2.03%	50.00%	6.53%	6.53%	0.00%	0%
1700	Base CFL Exit Sign	99.73%	95.73%	88.19%	97.89%	75.73%	97.13%	88.79%	93.11%	24.21%	55.50%	95.91%	89%
1701	LED Exit Sign	99.73%	95.73%	88.19%	97.89%	75.73%	97.13%	88.79%	93.11%	24.21%	55.50%	95.91%	89%
1800	Base Outdoor High Pressure Sodium 250W Lamp	19.11%	26.50%	10.44%	24.10%	42.13%	44.02%	31.89%	38.44%	9.75%	76.96%	1.29%	73%
1801	LED Outdoor Area Lighting (other than pole-mounted)	19.11%	26.50%	10.44%	24.10%	42.13%	44.02%	31.89%	38.44%	9.75%	76.96%	1.29%	73%
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	77.40%	10.84%	11.17%	0.00%	3.75%	99.52%	19.24%	5.96%	10.98%	15.68%	4.25%	0%
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	77.40%	10.84%	11.17%	0.00%	3.75%	99.52%	19.24%	5.96%	10.98%	15.68%	4.25%	0%
2002	Chiller VSD	77.40%	10.84%	11.17%	0.00%	3.75%	99.52%	19.24%	5.96%	10.98%	15.68%	4.25%	0%
2003	EMS - Chiller	77.40%	10.84%	11.17%	0.00%	3.75%	99.52%	19.24%	5.96%	10.98%	15.68%	4.25%	0%
2004	Cool Roof - Chiller	77.40%	10.84%	11.17%	0.00%	3.75%	99.52%	19.24%	5.96%	10.98%	15.68%	4.25%	0%
2006	VSD for Chiller Pumps and Towers	77.40%	10.84%	11.17%	0.00%	3.75%	99.52%	19.24%	5.96%	10.98%	15.68%	4.25%	0%
2008	Ceiling/roof Insulation - Chiller	77.40%	10.84%	11.17%	0.00%	3.75%	99.52%	19.24%	5.96%	10.98%	15.68%	4.25%	0%
2009	Custom HVAC--Base Chiller	77.40%	10.84%	11.17%	0.00%	3.75%	99.52%	19.24%	5.96%	10.98%	15.68%	4.25%	0%
2010	Custom Shell--Base Chiller	77.40%	10.84%	11.17%	0.00%	3.75%	99.52%	19.24%	5.96%	10.98%	15.68%	4.25%	0%
2100	Base DX Packaged System, EER=10.0, 30 tons	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2101	ROB DX Packaged System, EER=10.8, 30 tons	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2102	ROB DX Packaged System, EER=11.7, 30 tons	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2104	Automated Fault Detection	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2106	Advanced Controllers for RTUs	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2107	Programmable Communicating Thermostat	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2108	Prog. Thermostat - DX	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2109	Cool Roof - DX	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2110	RTU VSD	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2111	Dual Enthalpy Economizer Controls	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2113	Aerosol Duct Sealing	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2114	Ceiling/roof Insulation - DX	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2115	Duct/Pipe Insulation - DX	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2116	Custom HVAC--DX	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2117	Custom Shell--DX	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	6.61%	2.41%	0.56%	2.10%	18.69%	0.67%	11.09%	8.97%	0.19%	0.13%	0.05%	1%
2201	Air Source Heat Pump, EER=11.3, 10 tons	6.61%	2.41%	0.56%	2.10%	18.69%	0.67%	11.09%	8.97%	0.19%	0.13%	0.05%	1%
2300	Base PTAC, EER=8.3, 1 ton	0.43%	77.48%	10.51%	12.45%	29.41%	4.17%	41.37%	3.90%	2.28%	17.92%	7.94%	0%
2301	Occupancy Sensor (hotels)	0.43%	77.48%	10.51%	12.45%	29.41%	4.17%	41.37%	3.90%	2.28%	17.92%	7.94%	0%
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	81.29%	88.36%	43.32%	40.20%	39.66%	100.00%	61.99%	70.00%	12.49%	45.52%	36.22%	25%
3001	Variable Speed Drive Control, 5 HP	81.29%	88.36%	43.32%	40.20%	39.66%	100.00%	61.99%	70.00%	12.49%	45.52%	36.22%	25%
3002	Custom HVAC--Base Fan Motor, 5hp	81.29%	88.36%	43.32%	40.20%	39.66%	100.00%	61.99%	70.00%	12.49%	45.52%	36.22%	25%
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	6.06%	4.00%	0.00%	0.00%	7.01%	40.27%	1.09%	3.98%	0.18%	1.56%	4.18%	0%
3101	Variable Speed Drive Control, 15 HP	6.06%	4.00%	0.00%	0.00%	7.01%	40.27%	1.09%	3.98%	0.18%	1.56%	4.18%	0%
3102	Air Handler Optimization, 15 HP	6.06%	4.00%	0.00%	0.00%	7.01%	40.27%	1.09%	3.98%	0.18%	1.56%	4.18%	0%
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	6.06%	4.00%	0.00%	0.00%	7.01%	40.27%	1.09%	3.98%	0.18%	1.56%	4.18%	0%
3104	Separate Makeup Air / Exhaust Hoods AC	0.61%	0.40%	0.00%	0.00%	0.70%	8.05%	0.11%	0.40%	0.02%	0.16%	0.42%	0%
3105	Custom HVAC--Base Fan Motor, 15hp	6.06%	4.00%	0.00%	0.00%	7.01%	40.27%	1.09%	3.98%	0.18%	1.56%	4.18%	0%
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	1.16%	1.06%	9.50%	0.00%	0.00%	0.52%	0.00%	1.42%	0.18%	0.00%	3.77%	0%
3201	Variable Speed Drive Control, 40 HP	1.16%	1.06%	9.50%	0.00%	0.00%	0.52%	0.00%	1.42%	0.18%	0.00%	3.77%	0%
3202	Air Handler Optimization, 40 HP	1.16%	1.06%	9.50%	0.00%	0.00%	0.52%	0.00%	1.42%	0.18%	0.00%	3.77%	0%

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Commercial Electric Measure Inputs		APPLICABILITY FACTOR (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
3203	Demand Controlled Ventilation (40 HP fan motor)	1.16%	1.06%	9.50%	0.00%	0.00%	0.52%	0.00%	1.42%	0.18%	0.00%	3.77%	0%
3204	Custom HVAC--Base Fan Motor, 40hp	1.16%	1.06%	9.50%	0.00%	0.00%	0.52%	0.00%	1.42%	0.18%	0.00%	3.77%	0%
4000	Base Built-Up Refrigeration System	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4001	Strip curtains for walk-ins (built-up)	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4002	Auto-closer on main door to walk-in freezer (built-up)	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4003	Night covers for display cases	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	0%
4004	Evaporator fan controller for MT walk-ins	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4005	Electronically commutated evaporator fan motor	0.00%	23.91%	20.98%	36.28%	12.56%	27.16%	21.26%	7.14%	1.35%	24.94%	0.99%	11%
4006	Efficient compressor motor	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4007	Floating head pressure controls	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4008	Refrigeration Commissioning	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4009	Demand Hot Gas Defrost	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4010	Demand Defrost Electric	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4011	Anti-sweat (humidistat) controls	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4012	Freezer-Cooler Replacement Gaskets	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4013	High R-Value Glass Doors	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4014	LED Display Lighting (Base T8 Lighting)	0.00%	5.98%	5.24%	9.07%	3.14%	6.79%	5.31%	1.78%	0.34%	6.24%	0.25%	3%
4016	Multiplex Compressor System	0.00%	0.00%	50.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0%
4017	Oversized Air Cooled Condenser	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4018	Custom Refrigeration	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4500	Base Self-Contained Refrigeration	98.09%	97.50%	100.00%	100.00%	96.25%	93.80%	98.92%	75.13%	92.10%	96.29%	24.22%	69%
4501	Strip curtains for walk-ins (self-contained)	29.43%	29.25%	30.00%	30.00%	28.88%	28.14%	29.67%	22.54%	27.63%	28.89%	7.26%	21%
4502	Auto-closer on main door to walk-in freezer (self-contained)	29.43%	29.25%	30.00%	30.00%	28.88%	28.14%	29.67%	22.54%	27.63%	28.89%	7.26%	21%
4503	Night covers for display cases (self-contained)	29.43%	29.25%	30.00%	30.00%	28.88%	28.14%	29.67%	22.54%	27.63%	28.89%	7.26%	0%
4504	LED Display Lighting (Base T8 Lighting)	9.81%	9.75%	10.00%	10.00%	9.63%	9.38%	9.89%	7.51%	9.21%	9.63%	2.42%	7%
4506	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	49.04%	48.75%	50.00%	50.00%	48.13%	46.90%	49.46%	37.57%	46.05%	48.14%	12.11%	35%
4507	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	49.04%	48.75%	50.00%	50.00%	48.13%	46.90%	49.46%	37.57%	46.05%	48.14%	12.11%	35%
4508	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	49.04%	48.75%	50.00%	50.00%	48.13%	46.90%	49.46%	37.57%	46.05%	48.14%	12.11%	35%
4509	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	49.04%	48.75%	50.00%	50.00%	48.13%	46.90%	49.46%	37.57%	46.05%	48.14%	12.11%	35%
4510	ENERGY STAR Ice Machines	49.04%	48.75%	50.00%	50.00%	48.13%	46.90%	49.46%	37.57%	46.05%	48.14%	12.11%	35%
4511	Hydraulic-type door closer on reach-in cooler glass doors	98.09%	97.50%	100.00%	100.00%	96.25%	93.80%	98.92%	75.13%	92.10%	96.29%	24.22%	69%
4512	Doors for open cases	29.43%	29.25%	30.00%	30.00%	28.88%	28.14%	29.67%	22.54%	27.63%	28.89%	7.26%	21%
6000	Base Water Heating	90.00%	4.01%	17.35%	27.31%	21.55%	11.54%	55.17%	85.32%	9.68%	32.24%	92.10%	73%
6001	Demand controlled circulating systems	90.00%	4.01%	17.35%	27.31%	21.55%	11.54%	55.17%	85.32%	9.68%	32.24%	92.10%	73%
6003	Hot Water Pipe Insulation	90.00%	4.01%	17.35%	27.31%	21.55%	11.54%	55.17%	85.32%	9.68%	32.24%	92.10%	73%
6004	Tankless Water Heater	90.00%	4.01%	17.35%	27.31%	21.55%	11.54%	55.17%	85.32%	9.68%	32.24%	92.10%	73%
6005	Heat Pump Water Heater (air source)	90.00%	4.01%	17.35%	27.31%	21.55%	11.54%	55.17%	85.32%	9.68%	32.24%	92.10%	73%
6006	Heat Recovery Unit	90.00%	4.01%	17.35%	27.31%	21.55%	11.54%	55.17%	85.32%	9.68%	32.24%	92.10%	73%
6007	Heat Trap	90.00%	4.01%	17.35%	27.31%	21.55%	11.54%	55.17%	85.32%	9.68%	32.24%	92.10%	73%
6008	Solar Water Heater	90.00%	4.01%	17.35%	27.31%	21.55%	11.54%	55.17%	85.32%	9.68%	32.24%	92.10%	73%
6009	High Temperature Dishwasher	2.25%	0.20%	3.47%	13.66%	0.54%	0.29%	0.69%	2.13%	0.24%	0.81%	2.30%	2%
7000	Base Refrigerated Vending Machines	81.26%	33.26%	49.95%	20.95%	31.99%	69.03%	40.28%	27.71%	10.45%	48.69%	71.31%	76%
7001	Vending Misers (Refrigerated units)	56.88%	23.28%	34.97%	14.67%	22.40%	48.32%	28.20%	19.40%	7.31%	34.08%	49.92%	53%
7002	Vending Misers (Refrigerated glass-front units)	24.38%	9.98%	14.99%	6.29%	9.60%	20.71%	12.08%	8.31%	3.13%	14.61%	21.39%	23%
7003	Refrigerated Vending Low Watt High Performance T8	81.26%	33.26%	49.95%	20.95%	31.99%	69.03%	40.28%	27.71%	10.45%	48.69%	71.31%	76%
7500	Base Non-Refrigerated Vending Machines	81.26%	33.26%	49.95%	20.95%	31.99%	69.03%	40.28%	27.71%	10.45%	48.69%	71.31%	76%
7501	Vending Misers (Non-Refrigerated)	81.26%	33.26%	49.95%	20.95%	31.99%	69.03%	40.28%	27.71%	10.45%	48.69%	71.31%	76%
7502	Non-refrigerated Vending Low Watt High Performance T8	81.26%	33.26%	49.95%	20.95%	31.99%	69.03%	40.28%	27.71%	10.45%	48.69%	71.31%	76%
8000	Base Oven	76.42%	45.22%	24.57%	9.64%	37.96%	0.00%	23.94%	11.38%	9.31%	74.97%	3.11%	0%
8001	Convection Oven	76.42%	45.22%	24.57%	9.64%	37.96%	0.00%	23.94%	11.38%	9.31%	74.97%	3.11%	0%
8100	Base Fryer	0.00%	4.95%	7.43%	3.94%	0.00%	0.00%	4.22%	0.35%	0.00%	40.99%	0.00%	0%
8101	Efficient Fryer	0.00%	4.95%	7.43%	3.94%	0.00%	0.00%	4.22%	0.35%	0.00%	40.99%	0.00%	0%
8200	Base Steamer	0.00%	41.36%	3.48%	20.79%	21.00%	0.00%	15.12%	3.16%	3.22%	41.56%	0.06%	0%
8201	Efficient Steamer	0.00%	41.36%	3.48%	20.79%	21.00%	0.00%	15.12%	3.16%	3.22%	41.56%	0.06%	0%
8300	Base Hot Food Holding Cabinet	0.00%	65.51%	21.74%	30.47%	7.82%	37.40%	12.94%	9.40%	0.10%	49.46%	0.28%	0%
8301	ENERGY STAR Hot Food Holding Cabinets	0.00%	65.51%	21.74%	30.47%	7.82%	37.40%	12.94%	9.40%	0.10%	49.46%	0.28%	0%
8500	Base Compressed Air	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8700	Base Heating	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9000	Base Miscellaneous	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9500	Base Whole Building	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9501	NEMA Premium Efficiency Transformer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9502	Retrocommissioning/Building tune up	80.00%	80.00%	0.00%	0.00%	80.00%	80.00%	80.00%	80.00%	30.00%	50.00%	50.00%	0%

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Commercial Electric Measure Inputs		**APPLICABILITY FACTOR (percent)**											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
9503	Custom O&M	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50%
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015 (New)	7.55%	27.63%	25.67%	20.17%	24.34%	18.76%	21.42%	27.87%	7.27%	14.14%	28.53%	28%
1001	NEW 3L4'T5, 2015	7.55%	27.63%	25.67%	20.17%	24.34%	18.76%	21.42%	27.87%	7.27%	14.14%	28.53%	28%
1002	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015	7.55%	27.63%	25.67%	20.17%	24.34%	18.76%	21.42%	27.87%	7.27%	14.14%	28.53%	28%
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream New	17.62%	64.46%	59.90%	47.06%	56.80%	43.78%	49.97%	65.03%	16.96%	33.00%	66.58%	65%
1012	Upstream 4L4' LED Tube, 2015	17.62%	64.46%	59.90%	47.06%	56.80%	43.78%	49.97%	65.03%	16.96%	33.00%	66.58%	65%
1013	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015 (Base Upstream)	17.62%	64.46%	59.90%	47.06%	56.80%	43.78%	49.97%	65.03%	16.96%	33.00%	66.58%	65%
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017 (New)	7.55%	27.63%	25.67%	20.17%	24.34%	18.76%	21.42%	27.87%	7.27%	14.14%	28.53%	28%
1051	NEW 3L4'T5, 2016-2017	7.55%	27.63%	25.67%	20.17%	24.34%	18.76%	21.42%	27.87%	7.27%	14.14%	28.53%	28%
1052	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017	7.55%	27.63%	25.67%	20.17%	24.34%	18.76%	21.42%	27.87%	7.27%	14.14%	28.53%	28%
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream New	17.62%	64.46%	59.90%	47.06%	56.80%	43.78%	49.97%	65.03%	16.96%	33.00%	66.58%	65%
1062	Upstream 4L4' LED Tube, 2016-2017	17.62%	64.46%	59.90%	47.06%	56.80%	43.78%	49.97%	65.03%	16.96%	33.00%	66.58%	65%
1063	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017 (Base Upstre	17.62%	64.46%	59.90%	47.06%	56.80%	43.78%	49.97%	65.03%	16.96%	33.00%	66.58%	65%
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019 (New)	7.55%	27.63%	25.67%	20.17%	24.34%	18.76%	21.42%	27.87%	7.27%	14.14%	28.53%	28%
1101	NEW 3L4'T5, 2018-2019	7.55%	27.63%	25.67%	20.17%	24.34%	18.76%	21.42%	27.87%	7.27%	14.14%	28.53%	28%
1102	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019	7.55%	27.63%	25.67%	20.17%	24.34%	18.76%	21.42%	27.87%	7.27%	14.14%	28.53%	28%
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream New	17.62%	64.46%	59.90%	47.06%	56.80%	43.78%	49.97%	65.03%	16.96%	33.00%	66.58%	65%
1112	Upstream 4L4' LED Tube, 2018-2019	17.62%	64.46%	59.90%	47.06%	56.80%	43.78%	49.97%	65.03%	16.96%	33.00%	66.58%	65%
1113	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019 (Base Upstre	17.62%	64.46%	59.90%	47.06%	56.80%	43.78%	49.97%	65.03%	16.96%	33.00%	66.58%	65%
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020 (New)	7.55%	27.63%	25.67%	20.17%	24.34%	18.76%	21.42%	27.87%	7.27%	14.14%	28.53%	28%
1151	NEW 3L4'T5, 2020	7.55%	27.63%	25.67%	20.17%	24.34%	18.76%	21.42%	27.87%	7.27%	14.14%	28.53%	28%
1152	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020	7.55%	27.63%	25.67%	20.17%	24.34%	18.76%	21.42%	27.87%	7.27%	14.14%	28.53%	28%
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream New	17.62%	64.46%	59.90%	47.06%	56.80%	43.78%	49.97%	65.03%	16.96%	33.00%	66.58%	65%
1162	Upstream 4L4' LED Tube, 2020	17.62%	64.46%	59.90%	47.06%	56.80%	43.78%	49.97%	65.03%	16.96%	33.00%	66.58%	65%
1163	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020 (Base Upstream)	17.62%	64.46%	59.90%	47.06%	56.80%	43.78%	49.97%	65.03%	16.96%	33.00%	66.58%	65%
1200	Base Other Fluorescent Fixture (New)	4.78%	10.75%	9.70%	3.54%	1.07%	13.60%	7.08%	10.47%	0.04%	4.16%	2.19%	1%
1201	NEW T5	4.78%	10.75%	9.70%	3.54%	1.07%	13.60%	7.08%	10.47%	0.04%	4.16%	2.19%	1%
1202	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings	4.78%	10.75%	9.70%	3.54%	1.07%	13.60%	7.08%	10.47%	0.04%	4.16%	2.19%	1%
1210	Base Other Fluorescent Fixture--Upstream New	11.15%	25.09%	22.64%	8.27%	2.50%	31.72%	16.52%	24.43%	0.09%	9.71%	5.10%	3%
1211	Upstream Low Watt High Performance T8	11.15%	25.09%	22.64%	8.27%	2.50%	31.72%	16.52%	24.43%	0.09%	9.71%	5.10%	3%
1212	Upstream LED Tube	11.15%	25.09%	22.64%	8.27%	2.50%	31.72%	16.52%	24.43%	0.09%	9.71%	5.10%	3%
1213	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings (Base Upstream)	11.15%	25.09%	22.64%	8.27%	2.50%	31.72%	16.52%	24.43%	0.09%	9.71%	5.10%	3%
1300	Base Incandescent Lamp, 72W 2015--New	0.38%	0.96%	0.92%	1.77%	1.27%	1.15%	1.05%	0.96%	0.23%	1.40%	0.32%	1%
1301	New LEDs (base incandescent 72W) 2015	0.38%	0.96%	0.92%	1.77%	1.27%	1.15%	1.05%	0.96%	0.23%	1.40%	0.32%	1%
1310	Base Incandescent Lamp, 72W 2015--Upstream New	18.53%	46.82%	45.28%	86.64%	62.44%	56.24%	51.66%	46.80%	11.11%	68.45%	15.77%	30%
1311	Upstream LEDs (base incandescent 72W) 2015	18.53%	46.82%	45.28%	86.64%	62.44%	56.24%	51.66%	46.80%	11.11%	68.45%	15.77%	30%
1320	Base Incandescent Lamp, 72W 2016-2017--New	0.38%	0.96%	0.92%	1.77%	1.27%	1.15%	1.05%	0.96%	0.23%	1.40%	0.32%	1%
1321	New LEDs (base incandescent 72W) 2016-2017	0.38%	0.96%	0.92%	1.77%	1.27%	1.15%	1.05%	0.96%	0.23%	1.40%	0.32%	1%
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream New	18.53%	46.82%	45.28%	86.64%	62.44%	56.24%	51.66%	46.80%	11.11%	68.45%	15.77%	30%
1331	Upstream LEDs (base incandescent 72W) 2016-2017	18.53%	46.82%	45.28%	86.64%	62.44%	56.24%	51.66%	46.80%	11.11%	68.45%	15.77%	30%
1340	Base Incandescent Lamp, 72W 2018-2019--New	0.38%	0.96%	0.92%	1.77%	1.27%	1.15%	1.05%	0.96%	0.23%	1.40%	0.32%	1%
1341	New LEDs (base incandescent 72W) 2018-2019	0.38%	0.96%	0.92%	1.77%	1.27%	1.15%	1.05%	0.96%	0.23%	1.40%	0.32%	1%
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream New	18.53%	46.82%	45.28%	86.64%	62.44%	56.24%	51.66%	46.80%	11.11%	68.45%	15.77%	30%
1351	Upstream LEDs (base incandescent 72W) 2018-2019	18.53%	46.82%	45.28%	86.64%	62.44%	56.24%	51.66%	46.80%	11.11%	68.45%	15.77%	30%
1360	Base Incandescent Lamp, 72W 2020--New	0.38%	0.96%	0.92%	1.77%	1.27%	1.15%	1.05%	0.96%	0.23%	1.40%	0.32%	1%
1361	New LEDs (base incandescent 72W) 2020	0.38%	0.96%	0.92%	1.77%	1.27%	1.15%	1.05%	0.96%	0.23%	1.40%	0.32%	1%
1370	Base Incandescent Lamp, 72W 2020--Upstream New	18.53%	46.82%	45.28%	86.64%	62.44%	56.24%	51.66%	46.80%	11.11%	68.45%	15.77%	30%
1371	Upstream LEDs (base incandescent 72W) 2020	18.53%	46.82%	45.28%	86.64%	62.44%	56.24%	51.66%	46.80%	11.11%	68.45%	15.77%	30%
1400	Base CFL Lamp, 23W 2015--New	0.37%	0.73%	0.25%	0.73%	1.39%	0.95%	1.23%	1.28%	1.10%	0.77%	0.24%	0%
1401	New LEDs (base CFL spiral 23W) 2015	0.37%	0.73%	0.25%	0.73%	1.39%	0.95%	1.23%	1.28%	1.10%	0.77%	0.24%	0%
1410	Base CFL Lamp, 23W 2015--Upstream New	18.10%	35.66%	12.47%	36.01%	67.97%	46.45%	60.06%	62.54%	53.96%	37.58%	11.60%	3%
1411	Upstream LEDs (base CFL spiral 23W) 2015	18.10%	35.66%	12.47%	36.01%	67.97%	46.45%	60.06%	62.54%	53.96%	37.58%	11.60%	3%
1420	Base CFL Lamp, 23W 2016-2017--New	0.37%	0.73%	0.25%	0.73%	1.39%	0.95%	1.23%	1.28%	1.10%	0.77%	0.24%	0%
1421	New LEDs (base CFL spiral 23W) 2016-2017	0.37%	0.73%	0.25%	0.73%	1.39%	0.95%	1.23%	1.28%	1.10%	0.77%	0.24%	0%
1430	Base CFL Lamp, 23W 2016-2017--Upstream New	18.10%	35.66%	12.47%	36.01%	67.97%	46.45%	60.06%	62.54%	53.96%	37.58%	11.60%	3%
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	18.10%	35.66%	12.47%	36.01%	67.97%	46.45%	60.06%	62.54%	53.96%	37.58%	11.60%	3%
1440	Base CFL Lamp, 23W 2018-2019--New	0.37%	0.73%	0.25%	0.73%	1.39%	0.95%	1.23%	1.28%	1.10%	0.77%	0.24%	0%
1441	New LEDs (base CFL spiral 23W) 2018-2019	0.37%	0.73%	0.25%	0.73%	1.39%	0.95%	1.23%	1.28%	1.10%	0.77%	0.24%	0%
1450	Base CFL Lamp, 23W 2018-2019--Upstream New	18.10%	35.66%	12.47%	36.01%	67.97%	46.45%	60.06%	62.54%	53.96%	37.58%	11.60%	3%
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	18.10%	35.66%	12.47%	36.01%	67.97%	46.45%	60.06%	62.54%	53.96%	37.58%	11.60%	3%
1460	Base CFL Lamp, 23W 2020--New	0.37%	0.73%	0.25%	0.73%	1.39%	0.95%	1.23%	1.28%	1.10%	0.77%	0.24%	0%
1461	New LEDs (base CFL spiral 23W) 2020	0.37%	0.73%	0.25%	0.73%	1.39%	0.95%	1.23%	1.28%	1.10%	0.77%	0.24%	0%

DNV·GL

Commercial Electric Measure Inputs		APPLICABILITY FACTOR (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1470	Base CFL Lamp, 23W 2020--Upstream New	18.10%	35.66%	12.47%	36.01%	67.97%	46.45%	60.06%	62.54%	53.96%	37.58%	11.60%	3%
1471	Upstream LEDs (base CFL spiral 23W) 2020	18.10%	35.66%	12.47%	36.01%	67.97%	46.45%	60.06%	62.54%	53.96%	37.58%	11.60%	3%
1500	Base Metal Halide, 400W	7.26%	67.00%	31.87%	19.50%	3.92%	44.79%	7.11%	15.53%	7.35%	21.26%	4.68%	63%
1501	High Bay T5 HO (240W)	7.26%	67.00%	31.87%	19.50%	3.92%	44.79%	7.11%	15.53%	7.35%	21.26%	4.68%	63%
1502	High Bay Induction Lighting	7.26%	67.00%	31.87%	19.50%	3.92%	44.79%	7.11%	15.53%	7.35%	21.26%	4.68%	63%
1600	Base HID Parking Garage Lighting	18.28%	0.00%	0.00%	0.00%	6.92%	6.92%	2.03%	50.00%	6.53%	6.53%	0.00%	0%
1601	LED Parking Garage Fixtures	18.28%	0.00%	0.00%	0.00%	6.92%	6.92%	2.03%	50.00%	6.53%	6.53%	0.00%	0%
1602	Bi-Level LED Parking Garage Fixtures	18.28%	0.00%	0.00%	0.00%	6.92%	6.92%	2.03%	50.00%	6.53%	6.53%	0.00%	0%
1700	Base CFL Exit Sign	99.73%	95.73%	88.19%	97.89%	75.73%	97.13%	88.79%	93.11%	24.21%	55.50%	95.91%	89%
1800	Base Outdoor High Pressure Sodium 250W Lamp	19.11%	26.50%	10.44%	24.10%	42.13%	44.02%	31.89%	38.44%	9.75%	76.96%	1.29%	73%
1801	LED Outdoor Area Lighting (other than pole-mounted)	19.11%	26.50%	10.44%	24.10%	42.13%	44.02%	31.89%	38.44%	9.75%	76.96%	1.29%	73%
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	77.40%	10.84%	11.17%	0.00%	3.75%	99.52%	19.24%	5.96%	10.98%	15.68%	4.25%	0%
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	77.40%	10.84%	11.17%	0.00%	3.75%	99.52%	19.24%	5.96%	10.98%	15.68%	4.25%	0%
2002	Chilled Beams	77.40%	10.84%	11.17%	0.00%	3.75%	99.52%	19.24%	5.96%	10.98%	15.68%	4.25%	0%
2003	Cool Roof - Chiller	77.40%	10.84%	11.17%	0.00%	3.75%	99.52%	19.24%	5.96%	10.98%	15.68%	4.25%	0%
2005	VSD for Chiller Pumps and Towers	77.40%	10.84%	11.17%	0.00%	3.75%	99.52%	19.24%	5.96%	10.98%	15.68%	4.25%	0%
2100	Base DX Packaged System, EER=10.0, 30 tons	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2101	ROB DX Packaged System, EER=10.8, 30 tons	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2102	ROB DX Packaged System, EER=11.7, 30 tons	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2103	Automated Fault Detection	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2104	RTU VSD	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2106	Aerosol Duct Sealing	8.28%	28.54%	68.39%	76.70%	57.09%	60.34%	8.80%	80.46%	3.21%	55.29%	67.65%	53%
2107	VRF Conditioning Systems	6.61%	2.41%	0.56%	2.10%	18.69%	0.67%	11.09%	8.97%	0.19%	0.13%	0.05%	1%
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	6.61%	2.41%	0.56%	2.10%	18.69%	0.67%	11.09%	8.97%	0.19%	0.13%	0.05%	1%
2201	Air Source Heat Pump, EER=11.3, 10 tons	6.61%	2.41%	0.56%	2.10%	18.69%	0.67%	11.09%	8.97%	0.19%	0.13%	0.05%	1%
2202	Geothermal Heat Pump, EER=18, 10 tons	6.61%	2.41%	0.56%	2.10%	18.69%	0.67%	11.09%	8.97%	0.19%	0.13%	0.05%	1%
2203	VRF Conditioning Systems	6.61%	2.41%	0.56%	2.10%	18.69%	0.67%	11.09%	8.97%	0.19%	0.13%	0.05%	1%
2300	Base PTAC, EER=8.3, 1 ton	0.43%	77.48%	10.51%	12.45%	29.41%	4.17%	41.37%	3.90%	2.28%	17.92%	7.94%	0%
2301	Occupancy Sensor (hotels)	0.43%	77.48%	10.51%	12.45%	29.41%	4.17%	41.37%	3.90%	2.28%	17.92%	7.94%	0%
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	81.29%	88.36%	43.32%	40.20%	39.66%	100.00%	61.99%	43.79%	12.49%	45.52%	36.22%	25%
3001	Variable Speed Drive Control, 5 HP	81.29%	88.36%	43.32%	40.20%	39.66%	100.00%	61.99%	43.79%	12.49%	45.52%	36.22%	25%
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	6.06%	4.00%	0.00%	0.00%	7.01%	40.27%	1.09%	3.98%	0.18%	1.56%	4.18%	0%
3101	Variable Speed Drive Control, 15 HP	6.06%	4.00%	0.00%	0.00%	7.01%	40.27%	1.09%	3.98%	0.18%	1.56%	4.18%	0%
3102	Air Handler Optimization, 15 HP	6.06%	4.00%	0.00%	0.00%	7.01%	40.27%	1.09%	3.98%	0.18%	1.56%	4.18%	0%
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	6.06%	4.00%	0.00%	0.00%	7.01%	40.27%	1.09%	3.98%	0.18%	1.56%	4.18%	0%
3104	Separate Makeup Air / Exhaust Hoods AC	0.61%	0.40%	0.00%	0.00%	0.70%	8.05%	0.11%	0.40%	0.02%	0.16%	0.42%	0%
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	1.16%	1.06%	9.50%	0.00%	0.00%	0.52%	0.00%	1.42%	0.18%	0.00%	3.77%	0%
3201	Variable Speed Drive Control, 40 HP	1.16%	1.06%	9.50%	0.00%	0.00%	0.52%	0.00%	1.42%	0.18%	0.00%	3.77%	0%
3202	Air Handler Optimization, 40 HP	1.16%	1.06%	9.50%	0.00%	0.00%	0.52%	0.00%	1.42%	0.18%	0.00%	3.77%	0%
3203	Demand Controlled Ventilation (40 HP fan motor)	1.16%	1.06%	9.50%	0.00%	0.00%	0.52%	0.00%	1.42%	0.18%	0.00%	3.77%	0%
4000	Base Built-Up Refrigeration System	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4001	Auto-closer on main door to walk-in freezer (built-up)	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4002	Evaporator fan controller for MT walk-ins	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4003	Efficient compressor motor	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4004	Refrigeration Commissioning	0.00%	59.78%	52.44%	90.69%	31.41%	67.91%	53.15%	17.84%	3.38%	62.36%	2.48%	26%
4500	Base Self-Contained Refrigeration	98.09%	97.50%	100.00%	100.00%	96.25%	93.80%	98.92%	75.13%	92.10%	96.29%	24.22%	69%
4501	Auto-closer on main door to walk-in freezer (self-contained)	98.09%	97.50%	100.00%	100.00%	96.25%	93.80%	98.92%	75.13%	92.10%	96.29%	24.22%	69%
4502	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	98.09%	97.50%	100.00%	100.00%	96.25%	93.80%	98.92%	75.13%	92.10%	96.29%	24.22%	69%
4503	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	98.09%	97.50%	100.00%	100.00%	96.25%	93.80%	98.92%	75.13%	92.10%	96.29%	24.22%	69%
4504	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	98.09%	97.50%	100.00%	100.00%	96.25%	93.80%	98.92%	75.13%	92.10%	96.29%	24.22%	69%
4505	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	98.09%	97.50%	100.00%	100.00%	96.25%	93.80%	98.92%	75.13%	92.10%	96.29%	24.22%	69%
4506	ENERGY STAR Ice Machines	98.09%	97.50%	100.00%	100.00%	96.25%	93.80%	98.92%	75.13%	92.10%	96.29%	24.22%	69%
4507	Hydraulic-type door closer on reach-in cooler glass doors	98.09%	97.50%	100.00%	100.00%	96.25%	93.80%	98.92%	75.13%	92.10%	96.29%	24.22%	69%
6000	Base Water Heating	90.00%	4.01%	17.35%	27.31%	21.55%	11.54%	55.17%	85.32%	9.68%	32.24%	92.10%	73%
6001	Demand controlled circulating systems	90.00%	4.01%	17.35%	27.31%	21.55%	11.54%	55.17%	85.32%	9.68%	32.24%	92.10%	73%
6003	Tankless Water Heater	90.00%	4.01%	17.35%	27.31%	21.55%	11.54%	55.17%	85.32%	9.68%	32.24%	92.10%	73%
6004	Heat Pump Water Heater (air source)	90.00%	4.01%	17.35%	27.31%	21.55%	11.54%	55.17%	85.32%	9.68%	32.24%	92.10%	73%
6005	Solar Water Heater	90.00%	4.01%	17.35%	27.31%	21.55%	11.54%	55.17%	85.32%	9.68%	32.24%	92.10%	73%
7000	Base Refrigerated Vending Machines	81.26%	33.26%	49.95%	20.95%	31.99%	69.03%	40.28%	27.71%	10.45%	48.69%	71.31%	76%
7500	Base Non-Refrigerated Vending Machines	81.26%	33.26%	49.95%	20.95%	31.99%	69.03%	40.28%	27.71%	10.45%	48.69%	71.31%	76%
8000	Base Oven	76.42%	45.22%	24.57%	9.64%	37.96%	0.00%	23.94%	11.38%	9.31%	74.97%	3.11%	0%
8001	Convection Oven	76.42%	45.22%	24.57%	9.64%	37.96%	0.00%	23.94%	11.38%	9.31%	74.97%	3.11%	0%

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Commercial Electric Measure Inputs		APPLICABILITY FACTOR (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
8100	Base Fryer	0.00%	4.95%	7.43%	3.94%	0.00%	0.00%	4.22%	0.35%	0.00%	40.99%	0.00%	0%
8101	Efficient Fryer	0.00%	4.95%	7.43%	3.94%	0.00%	0.00%	4.22%	0.35%	0.00%	40.99%	0.00%	0%
8200	Base Steamer	0.00%	41.36%	3.48%	20.79%	21.00%	0.00%	15.12%	3.16%	3.22%	41.56%	0.06%	0%
8201	Efficient Steamer	0.00%	41.36%	3.48%	20.79%	21.00%	0.00%	15.12%	3.16%	3.22%	41.56%	0.06%	0%
8300	Base Hot Food Holding Cabinet	0.00%	65.51%	21.74%	30.47%	7.82%	37.40%	12.94%	9.40%	0.10%	49.46%	0.28%	0%
8301	ENERGY STAR Hot Food Holding Cabinets	0.00%	65.51%	21.74%	30.47%	7.82%	37.40%	12.94%	9.40%	0.10%	49.46%	0.28%	0%
8500	Base Compressed Air	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8700	Base Heating	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8701	Air Source Heat Pump, EER=11.3, 10 tons	6.61%	2.41%	0.56%	2.10%	18.69%	0.67%	11.09%	8.97%	0.19%	0.13%	0.05%	1%
8702	Geothermal Heat Pump, EER=18, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8703	VRF Conditioning Systems	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9000	Base Miscellaneous	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9500	Base Building Design - Standard Code	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15%
9501	15% better than code - Campuses	15.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9502	15% better than code - Education	0.00%	15.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9503	15% better than code - Food Sales	0.00%	0.00%	15.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9504	15% better than code - Food Service	0.00%	0.00%	0.00%	15.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9505	15% better than code - Healthcare	0.00%	0.00%	0.00%	0.00%	15.00%	15.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9506	15% better than code - Lodging	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	15.00%	0.00%	0.00%	0.00%	0.00%	0%
9507	15% better than code - Office	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	15.00%	0.00%	0.00%	0.00%	0%
9508	15% better than code - Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	15.00%	0.00%	0.00%	0%
9509	15% better than code - Public Assembly	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	15.00%	0.00%	0%
9510	15% better than code - Retail	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	15.00%	0%
9511	15% better than code - Warehouse	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	15%
9512	Commissioning	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15%
9600	Base Building Design - Standard Code	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6%
9601	30% better than code - Campuses	6.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9602	30% better than code - Education	0.00%	6.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9603	30% better than code - Food Sales	0.00%	0.00%	6.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9604	30% better than code - Food Service	0.00%	0.00%	0.00%	6.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9605	30% better than code - Healthcare	0.00%	0.00%	0.00%	0.00%	6.00%	6.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9606	30% better than code - Lodging	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.00%	0.00%	0.00%	0.00%	0.00%	0%
9607	30% better than code - Office	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.00%	0.00%	0.00%	0.00%	0%
9608	30% better than code - Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.00%	0.00%	0.00%	0%
9609	30% better than code - Public Assembly	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.00%	0.00%	0%
9610	30% better than code - Retail	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.00%	0%
9611	30% better than code - Warehouse	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6%
9612	Commissioning	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6%
9700	Base Building Design - Standard Code	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3%
9701	50% better than code - Campuses	3.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9702	50% better than code - Education	0.00%	3.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9703	50% better than code - Food Sales	0.00%	0.00%	3.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9704	50% better than code - Food Service	0.00%	0.00%	0.00%	3.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9705	50% better than code - Healthcare	0.00%	0.00%	0.00%	0.00%	3.00%	3.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9706	50% better than code - Lodging	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.00%	0.00%	0.00%	0.00%	0.00%	0%
9707	50% better than code - Office	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.00%	0.00%	0.00%	0.00%	0%
9708	50% better than code - Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.00%	0.00%	0.00%	0%
9709	50% better than code - Public Assembly	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.00%	0.00%	0%
9710	50% better than code - Retail	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.00%	0%
9711	50% better than code - Warehouse	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3%
9712	Commissioning	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3%
9800	Base Building Design - Standard Code	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1%
9801	70% better than code - Campuses	1.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9802	70% better than code - Education	0.00%	1.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9803	70% better than code - Food Sales	0.00%	0.00%	1.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9804	70% better than code - Food Service	0.00%	0.00%	0.00%	1.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9805	70% better than code - Healthcare	0.00%	0.00%	0.00%	0.00%	1.00%	1.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9806	70% better than code - Lodging	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.00%	0.00%	0.00%	0.00%	0.00%	0%
9807	70% better than code - Office	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.00%	0.00%	0.00%	0.00%	0%
9808	70% better than code - Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.00%	0.00%	0.00%	0%
9809	70% better than code - Public Assembly	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.00%	0.00%	0%
9810	70% better than code - Retail	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.00%	0%

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Commercial Electric Measure Inputs		APPLICABILITY FACTOR (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
9811	70% better than code - Warehouse	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1%
9812	Commissioning	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1%

Commercial Electric Measure Inputs		ENERGY SAVINGS (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--RET	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1001	RET 4L4' Low Watt High Performance T8 (83 W), 2015	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
1002	RET 4L4' LED Tube, 2015	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1003	RET LED Troffer (base 4L4'T8), 2015	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1004	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base RET)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1005	Advanced Lighting Controls (2015 Base RET)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1006	Daylight Dimming Controls (2015 Base RET)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
1007	Custom Lighting, Base 4L4'T8, 2015	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--ROB	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1011	ROB 4L4' Low Watt High Performance T8 (83 W), 2015	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%
1012	ROB 4L4' LED Tube, 2015	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
1013	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base ROB)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1014	Advanced Lighting Controls (2015 Base ROB)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1015	Daylight Dimming Controls (2015 Base ROB)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
1020	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1021	Upstream 4L4' Low Watt High Performance T8 (83 W), 2015	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
1022	Upstream 4L4' LED Tube, 2015	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%
1023	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base Upstream)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1024	Advanced Lighting Controls (2015 Base Up)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1025	Daylight Dimming Controls (2015 Base Up)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--RET	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1051	RET 4L4' Low Watt High Performance T8 (83 W), 2016-2017	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
1052	RET 4L4' LED Tube, 2016-2017	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1053	RET LED Troffer (base 4L4'T8), 2016-2017	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1054	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base RET)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1055	Advanced Lighting Controls (2016-2017 Base RET)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1056	Daylight Dimming Controls (2016-2017 Base RET)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
1057	Custom Lighting, Base 4L4'T8, 2016-2017	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--ROB	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1061	ROB 4L4' Low Watt High Performance T8 (83 W), 2016-2017	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%
1062	ROB 4L4' LED Tube, 2016-2017	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
1063	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base ROB)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1064	Advanced Lighting Controls (2016-2017 Base ROB)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1065	Daylight Dimming Controls (2016-2017 Base ROB)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
1070	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1071	Upstream 4L4' Low Watt High Performance T8 (83 W), 2016-2017	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
1072	Upstream 4L4' LED Tube, 2016-2017	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%
1073	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base Upstream)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1074	Advanced Lighting Controls (2016-2017 Base Up)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1075	Daylight Dimming Controls (2016-2017 Base Up)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
1080	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--RET	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1081	RET 4L4' Low Watt High Performance T8 (83 W), 2018-2019	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
1082	RET 4L4' LED Tube, 2018-2019	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1083	RET LED Troffer (base 4L4'T8), 2018-2019	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1084	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base RET)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1085	Advanced Lighting Controls (2018-2019 Base RET)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1086	Daylight Dimming Controls (2018-2019 Base RET)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
1087	Custom Lighting, Base 4L4'T8, 2018-2019	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--ROB	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1101	ROB 4L4' Low Watt High Performance T8 (83 W), 2018-2019	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%
1102	ROB 4L4' LED Tube, 2018-2019	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
1103	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base ROB)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1104	Advanced Lighting Controls (2018-2019 Base ROB)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1105	Daylight Dimming Controls (2018-2019 Base ROB)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1111	Upstream 4L4' Low Watt High Performance T8 (83 W), 2018-2019	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
1112	Upstream 4L4' LED Tube, 2018-2019	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%
1113	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base Upstream)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1114	Advanced Lighting Controls (2018-2019 Base Up)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1115	Daylight Dimming Controls (2018-2019 Base Up)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
1120	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--RET	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

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Measure #	Measure Description	ENERGY SAVINGS (percent) College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1121	RET 4L4' Low Watt High Performance T8 (83 W), 2020	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
1122	RET 4L4' LED Tube, 2020	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1123	RET LED Troffer (base 4L4'T8), 2020	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1124	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base RET)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1125	Advanced Lighting Controls (2020 Base RET)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1126	Daylight Dimming Controls (2020 Base RET)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
1127	Custom Lighting, Base 4L4'T8, 2020	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--ROB	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1151	ROB 4L4' Low Watt High Performance T8 (83 W), 2020	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%
1152	ROB 4L4' LED Tube, 2020	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
1153	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base ROB)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1154	Advanced Lighting Controls (2020 Base ROB)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1155	Daylight Dimming Controls (2020 Base ROB)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1161	Upstream 4L4' Low Watt High Performance T8 (83 W), 2020	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
1162	Upstream 4L4' LED Tube, 2020	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%
1163	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base Upstream)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1164	Advanced Lighting Controls (2020 Base Up)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1165	Daylight Dimming Controls (2020 Base Up)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
1200	Base Other Fluorescent Fixture--RET	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1201	RET Low Watt High Performance T8	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
1202	RET LED Tube	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1203	RET LED Troffer	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1204	Occupancy Sensor (Base Other Fluor RET)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1205	Advanced Lighting Controls (Base Other Fluor RET)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1206	Daylight Dimming Controls (Base Other Fluor RET)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
1207	Custom Lighting, Base Other Fluorescent	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1210	Base Other Fluorescent Fixture--ROB	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1211	ROB Low Watt High Performance T8	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
1212	ROB LED Tube	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
1213	Occupancy Sensor (Base Other Fluor ROB)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1214	Advanced Lighting Controls (Base Other Fluor ROB)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1215	Daylight Dimming Controls (Base Other Fluor ROB)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
1220	Base Other Fluorescent Fixture--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1221	Upstream Low Watt High Performance T8	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
1222	Upstream LED Tube	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%
1223	Occupancy Sensor (Base Other Fluor Upstream)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1224	Advanced Lighting (Base Other Fluor Upstream)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1225	Daylight Dimming Controls (Base Other Fluor Upstream)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
1300	Base Incandescent Lamp, 72W 2015--Hardwired	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1301	LED Track Lighting (base Incandescent 72W) 2015	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
1310	Base Incandescent Lamp, 72W 2015--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1311	Upstream LEDs (base Incandescent 72W) 2015	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
1320	Base Incandescent Lamp, 72W 2016-2017--Hardwired	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1321	LED Track Lighting (base Incandescent 72W) 2016-2017	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1331	Upstream LEDs (base Incandescent 72W) 2016-2017	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
1340	Base Incandescent Lamp, 72W 2018-2019--Hardwired	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1341	LED Track Lighting (base Incandescent 72W) 2018-2019	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1351	Upstream LEDs (base Incandescent 72W) 2018-2019	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
1360	Base Incandescent Lamp, 72W 2020--Hardwired	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1361	LED Track Lighting (base Incandescent 72W) 2020	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
1370	Base Incandescent Lamp, 72W 2020--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1371	Upstream LEDs (base Incandescent 72W) 2020	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
1400	Base CFL Lamp, 23W 2015--Hardwired	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1401	LED Track Lighting (base CFL spiral 23W) 2015	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%
1410	Base CFL Lamp, 23W 2015--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1411	Upstream LEDs (base CFL spiral 23W) 2015	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1420	Base CFL Lamp, 23W 2016-2017--Hardwired	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1421	LED Track Lighting (base CFL spiral 23W) 2016-2017	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%
1430	Base CFL Lamp, 23W 2016-2017--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

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Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1440	Base CFL Lamp, 23W 2018-2019--Hardwired	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1441	LED Track Lighting (base CFL spiral 23W) 2018-2019	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%
1450	Base CFL Lamp, 23W 2018-2019--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1460	Base CFL Lamp, 23W 2020--Hardwired	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1461	LED Track Lighting (base CFL spiral 23W) 2020	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%
1470	Base CFL Lamp, 23W 2020--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1471	Upstream LEDs (base CFL spiral 23W) 2020	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1500	Base Metal Halide, 400W	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1501	High Bay T5 HO (240W)	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
1502	High Bay Induction Lighting	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%
1503	PSMH with electronic ballast	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1504	High Bay LED Lighting	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
1600	Base HPS (high pressure sodium) Parking Garage Lighting	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1601	High-efficiency fluorescent parking garage fixture	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1602	LED Parking Garage Fixtures	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
1603	Bi-Level LED Parking Garage Fixtures	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
1700	Base CFL Exit Sign	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1701	LED Exit Sign	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%
1800	Base Outdoor High Pressure Sodium 250W Lamp	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1801	LED Outdoor Area Lighting (other than pole-mounted)	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%
2002	Chiller VSD	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%
2003	EMS - Chiller	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
2004	Cool Roof - Chiller	6%	6%	15%	7%	1%	0%	0%	2%	0%	0%	13%	18%
2006	VSD for Chiller Pumps and Towers	2%	2%	5%	5%	8%	4%	4%	4%	4%	4%	3%	3%
2008	Ceiling/roof Insulation - Chiller	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
2009	Custom HVAC--Base Chiller	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2010	Custom Shell--Base Chiller	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2100	Base DX Packaged System, EER=10.0, 30 tons	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2101	ROB DX Packaged System, EER=10.8, 30 tons	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%
2102	ROB DX Packaged System, EER=11.7, 30 tons	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2104	Automated Fault Detection	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
2106	Advanced Controllers for RTUs	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%
2107	Programmable Communicating Thermostat	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2108	Prog. Thermostat - DX	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2109	Cool Roof - DX	6%	6%	15%	7%	1%	0%	0%	2%	0%	0%	13%	18%
2110	RTU VSD	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
2111	Dual Enthalpy Economizer Controls	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
2113	Aerosol Duct Sealing	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
2114	Ceiling/roof Insulation - DX	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
2115	Duct/Pipe Insulation - DX	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
2116	Custom HVAC--DX	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2117	Custom Shell--DX	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2201	Air Source Heat Pump, EER=11.3, 10 tons	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
2300	Base PTAC, EER=8.3, 1 ton	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2301	Occupancy Sensor (hotels)	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3001	Variable Speed Drive Control, 5 HP	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
3002	Custom HVAC--Base Fan Motor, 5hp	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3101	Variable Speed Drive Control, 15 HP	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
3102	Air Handler Optimization, 15 HP	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
3104	Separate Makeup Air / Exhaust Hoods AC	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
3105	Custom HVAC--Base Fan Motor, 15hp	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3201	Variable Speed Drive Control, 40 HP	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
3202	Air Handler Optimization, 40 HP	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%

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3203	Demand Controlled Ventilation (40 HP fan motor)	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
3204	Custom HVAC--Base Fan Motor, 40hp	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
4000	Base Built-Up Refrigeration System	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4001	Strip curtains for walk-ins (built-up)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4002	Auto-closer on main door to walk-in freezer (built-up)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
4003	Night covers for display cases	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
4004	Evaporator fan controller for MT walk-ins	1%	1%	0%	1%	1%	1%	1%	1%	1%	1%	1%	0%
4005	Electronically commutated evaporator fan motor	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
4006	Efficient compressor motor	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%
4007	Floating head pressure controls	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%
4008	Refrigeration Commissioning	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
4009	Demand Hot Gas Defrost	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4010	Demand Defrost Electric	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4011	Anti-sweat (humidistat) controls	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4012	Freezer-Cooler Replacement Gaskets	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
4013	High R-Value Glass Doors	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
4014	LED Display Lighting (Base T8 Lighting)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
4016	Multiplex Compressor System	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
4017	Oversized Air Cooled Condenser	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
4018	Custom Refrigeration	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
4500	Base Self-Contained Refrigeration	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4501	Strip curtains for walk-ins (self-contained)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4502	Auto-closer on main door to walk-in freezer (self-contained)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
4503	Night covers for display cases (self-contained)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
4504	LED Display Lighting (Base T8 Lighting)	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
4506	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
4507	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
4508	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
4509	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
4510	ENERGY STAR Ice Machines	0%	0%	0%	0%	1%	0%	0%	0%	1%	1%	0%	0%
4511	Hydraulic-type door closer on reach-in cooler glass doors	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
4512	Doors for open cases	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
6000	Base Water Heating	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6001	Demand controlled circulating systems	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
6003	Hot Water Pipe Insulation	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
6004	Tankless Water Heater	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
6005	Heat Pump Water Heater (air source)	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
6006	Heat Recovery Unit	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%
6007	Heat Trap	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%
6008	Solar Water Heater	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
6009	High Temperature Dishwasher	1%	1%	27%	27%	1%	1%	1%	1%	1%	1%	1%	1%
7000	Base Refrigerated Vending Machines	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7001	Vending Misers (Refrigerated units)	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%
7002	Vending Misers (Refrigerated glass-front units)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
7003	Refrigerated Vending Low Watt High Performance T8	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
7500	Base Non-Refrigerated Vending Machines	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7501	Vending Misers (Non-Refrigerated)	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%
7502	Non-refrigerated Vending Low Watt High Performance T8	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
8000	Base Oven	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8001	Convection Oven	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%
8100	Base Fryer	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8101	Efficient Fryer	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
8200	Base Steamer	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8201	Efficient Steamer	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
8300	Base Hot Food Holding Cabinet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8301	ENERGY STAR Hot Food Holding Cabinets	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
8500	Base Compressed Air	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8700	Base Heating	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9000	Base Miscellaneous	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9500	Base Whole Building	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9501	NEMA Premium Efficiency Transformer	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9502	Retrocommissioning/Building tune up	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%

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Commercial Electric Measure Inputs		ENERGY SAVINGS (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
9503	Custom O&M	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015 (New)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1001	NEW 3L4'T5, 2015	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
1002	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1012	Upstream 4L4' LED Tube, 2015	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%
1013	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015 (Base Upstream)	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017 (New)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1051	NEW 3L4'T5, 2016-2017	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
1052	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1062	Upstream 4L4' LED Tube, 2016-2017	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%
1063	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017 (Base Upstream)	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019 (New)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1101	NEW 3L4'T5, 2018-2019	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
1102	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1112	Upstream 4L4' LED Tube, 2018-2019	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%
1113	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019 (Base Upstream)	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020 (New)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1151	NEW 3L4'T5, 2020	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
1152	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1162	Upstream 4L4' LED Tube, 2020	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%
1163	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020 (Base Upstream)	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1200	Base Other Fluorescent Fixture (New)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1201	NEW T5	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
1202	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1210	Base Other Fluorescent Fixture--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1211	Upstream Low Watt High Performance T8	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%
1212	Upstream LED Tube	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%
1213	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings (Base Upstream)	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1300	Base Incandescent Lamp, 72W 2015--New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1301	New LEDs (base incandescent 72W) 2015	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
1310	Base Incandescent Lamp, 72W 2015--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1311	Upstream LEDs (base incandescent 72W) 2015	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
1320	Base Incandescent Lamp, 72W 2016-2017--New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1321	New LEDs (base incandescent 72W) 2016-2017	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1331	Upstream LEDs (base incandescent 72W) 2016-2017	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
1340	Base Incandescent Lamp, 72W 2018-2019--New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1341	New LEDs (base incandescent 72W) 2018-2019	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1351	Upstream LEDs (base incandescent 72W) 2018-2019	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
1360	Base Incandescent Lamp, 72W 2020--New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1361	New LEDs (base incandescent 72W) 2020	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
1370	Base Incandescent Lamp, 72W 2020--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1371	Upstream LEDs (base incandescent 72W) 2020	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
1400	Base CFL Lamp, 23W 2015--New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1401	New LEDs (base CFL spiral 23W) 2015	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1410	Base CFL Lamp, 23W 2015--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1411	Upstream LEDs (base CFL spiral 23W) 2015	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1420	Base CFL Lamp, 23W 2016-2017--New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1421	New LEDs (base CFL spiral 23W) 2016-2017	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1430	Base CFL Lamp, 23W 2016-2017--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1440	Base CFL Lamp, 23W 2018-2019--New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1441	New LEDs (base CFL spiral 23W) 2018-2019	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1450	Base CFL Lamp, 23W 2018-2019--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1460	Base CFL Lamp, 23W 2020--New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1461	New LEDs (base CFL spiral 23W) 2020	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%

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Commercial Electric Measure Inputs		ENERGY SAVINGS (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1470	Base CFL Lamp, 23W 2020--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1471	Upstream LEDs (base CFL spiral 23W) 2020	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1500	Base Metal Halide, 400W	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1501	High Bay T5 HO (240W)	60%	60%	60%	60%	100%	60%	60%	60%	60%	60%	60%	60%
1502	High Bay Induction Lighting	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%
1600	Base HID Parking Garage Lighting	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1601	LED Parking Garage Fixtures	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
1602	Bi-Level LED Parking Garage Fixtures	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
1700	Base CFL Exit Sign	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1800	Base Outdoor High Pressure Sodium 250W Lamp	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1801	LED Outdoor Area Lighting (other than pole-mounted)	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%
2002	Chilled Beams	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
2003	Cool Roof - Chiller	6%	6%	15%	7%	1%	0%	0%	2%	0%	0%	13%	18%
2005	VSD for Chiller Pumps and Towers	2%	2%	5%	5%	8%	4%	4%	4%	4%	4%	3%	3%
2100	Base DX Packaged System, EER=10.0, 30 tons	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2101	ROB DX Packaged System, EER=10.8, 30 tons	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%
2102	ROB DX Packaged System, EER=11.7, 30 tons	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2103	Automated Fault Detection	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
2104	RTU VSD	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
2106	Aerosol Duct Sealing	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
2107	VRF Conditioning Systems	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2201	Air Source Heat Pump, EER=11.3, 10 tons	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
2202	Geothermal Heat Pump, EER=18, 10 tons	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
2203	VRF Conditioning Systems	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2300	Base PTAC, EER=8.3, 1 ton	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2301	Occupancy Sensor (hotels)	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3001	Variable Speed Drive Control, 5 HP	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3101	Variable Speed Drive Control, 15 HP	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
3102	Air Handler Optimization, 15 HP	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
3104	Separate Makeup Air / Exhaust Hoods AC	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3201	Variable Speed Drive Control, 40 HP	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
3202	Air Handler Optimization, 40 HP	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
3203	Demand Controlled Ventilation (40 HP fan motor)	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
4000	Base Built-Up Refrigeration System	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4001	Auto-closer on main door to walk-in freezer (built-up)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
4002	Evaporator fan controller for MT walk-ins	1%	1%	0%	1%	1%	1%	1%	1%	1%	1%	1%	0%
4003	Efficient compressor motor	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%
4004	Refrigeration Commissioning	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
4500	Base Self-Contained Refrigeration	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4501	Auto-closer on main door to walk-in freezer (self-contained)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
4502	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
4503	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
4504	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
4505	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
4506	ENERGY STAR Ice Machines	0%	0%	0%	0%	1%	0%	0%	0%	1%	1%	0%	0%
4507	Hydraulic-type door closer on reach-in cooler glass doors	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
6000	Base Water Heating	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6001	Demand controlled circulating systems	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
6003	Tankless Water Heater	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
6004	Heat Pump Water Heater (air source)	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
6005	Solar Water Heater	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
7000	Base Refrigerated Vending Machines	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7500	Base Non-Refrigerated Vending Machines	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8000	Base Oven	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8001	Convection Oven	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%

Commercial Electric Measure Inputs		ENERGY SAVINGS (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
8100	Base Fryer	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8101	Efficient Fryer	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
8200	Base Steamer	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8201	Efficient Steamer	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
8300	Base Hot Food Holding Cabinet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8301	ENERGY STAR Hot Food Holding Cabinets	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
8500	Base Compressed Air	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8700	Base Heating	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8701	Air Source Heat Pump, EER=11.3, 10 tons	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
8702	Geothermal Heat Pump, EER=18, 10 tons	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
8703	VRF Conditioning Systems	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
9000	Base Miscellaneous	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9500	Base Building Design - Standard Code	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9501	15% better than code - Campuses	15%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9502	15% better than code - Education	0%	15%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9503	15% better than code - Food Sales	0%	0%	15%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9504	15% better than code - Food Service	0%	0%	0%	15%	0%	0%	0%	0%	0%	0%	0%	0%
9505	15% better than code - Healthcare	0%	0%	0%	0%	15%	15%	0%	0%	0%	0%	0%	0%
9506	15% better than code - Lodging	0%	0%	0%	0%	0%	0%	15%	0%	0%	0%	0%	0%
9507	15% better than code - Office	0%	0%	0%	0%	0%	0%	0%	15%	0%	0%	0%	0%
9508	15% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	15%	0%	0%	0%
9509	15% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	15%	0%	0%
9510	15% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15%	0%
9511	15% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15%
9512	Commissioning	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
9600	Base Building Design - Standard Code	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9601	30% better than code - Campuses	30%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9602	30% better than code - Education	0%	30%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9603	30% better than code - Food Sales	0%	0%	30%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9604	30% better than code - Food Service	0%	0%	0%	30%	0%	0%	0%	0%	0%	0%	0%	0%
9605	30% better than code - Healthcare	0%	0%	0%	0%	30%	30%	0%	0%	0%	0%	0%	0%
9606	30% better than code - Lodging	0%	0%	0%	0%	0%	0%	30%	0%	0%	0%	0%	0%
9607	30% better than code - Office	0%	0%	0%	0%	0%	0%	0%	30%	0%	0%	0%	0%
9608	30% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	30%	0%	0%	0%
9609	30% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	30%	0%	0%
9610	30% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	30%	0%
9611	30% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	30%
9612	Commissioning	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
9700	Base Building Design - Standard Code	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9701	50% better than code - Campuses	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9702	50% better than code - Education	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9703	50% better than code - Food Sales	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9704	50% better than code - Food Service	0%	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%
9705	50% better than code - Healthcare	0%	0%	0%	0%	50%	50%	0%	0%	0%	0%	0%	0%
9706	50% better than code - Lodging	0%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%
9707	50% better than code - Office	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%
9708	50% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	0%
9709	50% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%
9710	50% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%	0%
9711	50% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%
9712	Commissioning	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
9800	Base Building Design - Standard Code	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9801	70% better than code - Campuses	70%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9802	70% better than code - Education	0%	70%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9803	70% better than code - Food Sales	0%	0%	70%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9804	70% better than code - Food Service	0%	0%	0%	70%	0%	0%	0%	0%	0%	0%	0%	0%
9805	70% better than code - Healthcare	0%	0%	0%	0%	70%	70%	0%	0%	0%	0%	0%	0%
9806	70% better than code - Lodging	0%	0%	0%	0%	0%	0%	70%	0%	0%	0%	0%	0%
9807	70% better than code - Office	0%	0%	0%	0%	0%	0%	0%	70%	0%	0%	0%	0%
9808	70% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	70%	0%	0%	0%
9809	70% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	70%	0%	0%
9810	70% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	70%	0%

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Commercial Electric Measure Inputs		ENERGY SAVINGS (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
9811	70% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	70%
9812	Commissioning	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%

DNV·GL

Commercial Electric Measure Inputs		DEMAND SAVINGS (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--RET	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1001	RET 4L4' Low Watt High Performance T8 (83 W), 2015	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%
1002	RET 4L4' LED Tube, 2015	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
1003	RET LED Troffer (base 4L4'T8), 2015	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%
1004	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base RET)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1005	Advanced Lighting Controls (2015 Base RET)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1006	Daylight Dimming Controls (2015 Base RET)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1007	Custom Lighting, Base 4L4'T8, 2015	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--ROB	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1011	ROB 4L4' Low Watt High Performance T8 (83 W), 2015	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%
1012	ROB 4L4' LED Tube, 2015	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%
1013	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base ROB)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1014	Advanced Lighting Controls (2015 Base ROB)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1015	Daylight Dimming Controls (2015 Base ROB)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1020	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1021	Upstream 4L4' Low Watt High Performance T8 (83 W), 2015	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%
1022	Upstream 4L4' LED Tube, 2015	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%
1023	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base Upstream)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1024	Advanced Lighting Controls (2015 Base Up)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1025	Daylight Dimming Controls (2015 Base Up)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--RET	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1051	RET 4L4' Low Watt High Performance T8 (83 W), 2016-2017	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%
1052	RET 4L4' LED Tube, 2016-2017	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
1053	RET LED Troffer (base 4L4'T8), 2016-2017	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%
1054	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base RET)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1055	Advanced Lighting Controls (2016-2017 Base RET)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1056	Daylight Dimming Controls (2016-2017 Base RET)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1057	Custom Lighting, Base 4L4'T8, 2016-2017	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--ROB	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1061	ROB 4L4' Low Watt High Performance T8 (83 W), 2016-2017	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%
1062	ROB 4L4' LED Tube, 2016-2017	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%
1063	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base ROB)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1064	Advanced Lighting Controls (2016-2017 Base ROB)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1065	Daylight Dimming Controls (2016-2017 Base ROB)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1070	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1071	Upstream 4L4' Low Watt High Performance T8 (83 W), 2016-2017	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%
1072	Upstream 4L4' LED Tube, 2016-2017	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%
1073	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base Upstream)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1074	Advanced Lighting Controls (2016-2017 Base Up)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1075	Daylight Dimming Controls (2016-2017 Base Up)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1080	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--RET	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1081	RET 4L4' Low Watt High Performance T8 (83 W), 2018-2019	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%
1082	RET 4L4' LED Tube, 2018-2019	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
1083	RET LED Troffer (base 4L4'T8), 2018-2019	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%
1084	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base RET)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1085	Advanced Lighting Controls (2018-2019 Base RET)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1086	Daylight Dimming Controls (2018-2019 Base RET)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1087	Custom Lighting, Base 4L4'T8, 2018-2019	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--ROB	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1101	ROB 4L4' Low Watt High Performance T8 (83 W), 2018-2019	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%
1102	ROB 4L4' LED Tube, 2018-2019	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%
1103	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base ROB)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1104	Advanced Lighting Controls (2018-2019 Base ROB)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1105	Daylight Dimming Controls (2018-2019 Base ROB)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1111	Upstream 4L4' Low Watt High Performance T8 (83 W), 2018-2019	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%
1112	Upstream 4L4' LED Tube, 2018-2019	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%
1113	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base Upstream)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1114	Advanced Lighting Controls (2018-2019 Base Up)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1115	Daylight Dimming Controls (2018-2019 Base Up)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1120	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--RET	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

DNV·GL

Commercial Electric Measure Inputs		DEMAND SAVINGS (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1121	RET 4L4' Low Watt High Performance T8 (83 W), 2020	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%
1122	RET 4L4' LED Tube, 2020	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
1123	RET LED Troffer (base 4L4'T8), 2020	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%
1124	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base RET)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1125	Advanced Lighting Controls (2020 Base RET)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1126	Daylight Dimming Controls (2020 Base RET)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1127	Custom Lighting, Base 4L4'T8, 2020	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--ROB	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1151	ROB 4L4' Low Watt High Performance T8 (83 W), 2020	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%
1152	ROB 4L4' LED Tube, 2020	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%
1153	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base ROB)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1154	Advanced Lighting Controls (2020 Base ROB)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1155	Daylight Dimming Controls (2020 Base ROB)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1161	Upstream 4L4' Low Watt High Performance T8 (83 W), 2020	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%
1162	Upstream 4L4' LED Tube, 2020	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%
1163	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base Upstream)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1164	Advanced Lighting Controls (2020 Base Up)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1165	Daylight Dimming Controls (2020 Base Up)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1200	Base Other Fluorescent Fixture--RET	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1201	RET Low Watt High Performance T8	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%
1202	RET LED Tube	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
1203	RET LED Troffer	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%
1204	Occupancy Sensor (Base Other Fluor RET)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1205	Advanced Lighting Controls (Base Other Fluor RET)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1206	Daylight Dimming Controls (Base Other Fluor RET)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1207	Custom Lighting, Base Other Fluorescent	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1210	Base Other Fluorescent Fixture--ROB	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1211	ROB Low Watt High Performance T8	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%
1212	ROB LED Tube	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%
1213	Occupancy Sensor (Base Other Fluor ROB)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1214	Advanced Lighting Controls (Base Other Fluor ROB)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1215	Daylight Dimming Controls (Base Other Fluor ROB)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1220	Base Other Fluorescent Fixture--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1221	Upstream Low Watt High Performance T8	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%
1222	Upstream LED Tube	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%
1223	Occupancy Sensor (Base Other Fluor Upstream)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1224	Advanced Lighting (Base Other Fluor Upstream)	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1225	Daylight Dimming Controls (Base Other Fluor Upstream)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1300	Base Incandescent Lamp, 72W 2015--Hardwired	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1301	LED Track Lighting (base Incandescent 72W) 2015	79%	79%	79%	79%	79%	79%	79%	79%	79%	79%	79%	79%
1310	Base Incandescent Lamp, 72W 2015--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1311	Upstream LEDs (base Incandescent 72W) 2015	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
1320	Base Incandescent Lamp, 72W 2016-2017--Hardwired	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1321	LED Track Lighting (base Incandescent 72W) 2016-2017	79%	79%	79%	79%	79%	79%	79%	79%	79%	79%	79%	79%
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1331	Upstream LEDs (base Incandescent 72W) 2016-2017	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
1340	Base Incandescent Lamp, 72W 2018-2019--Hardwired	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1341	LED Track Lighting (base Incandescent 72W) 2018-2019	79%	79%	79%	79%	79%	79%	79%	79%	79%	79%	79%	79%
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1351	Upstream LEDs (base Incandescent 72W) 2018-2019	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
1360	Base Incandescent Lamp, 72W 2020--Hardwired	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1361	LED Track Lighting (base Incandescent 72W) 2020	79%	79%	79%	79%	79%	79%	79%	79%	79%	79%	79%	79%
1370	Base Incandescent Lamp, 72W 2020--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1371	Upstream LEDs (base Incandescent 72W) 2020	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
1400	Base CFL Lamp, 23W 2015--Hardwired	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1401	LED Track Lighting (base CFL spiral 23W) 2015	22%	22%	22%	22%	22%	22%	22%	22%	22%	22%	22%	22%
1410	Base CFL Lamp, 23W 2015--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1411	Upstream LEDs (base CFL spiral 23W) 2015	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1420	Base CFL Lamp, 23W 2016-2017--Hardwired	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1421	LED Track Lighting (base CFL spiral 23W) 2016-2017	22%	22%	22%	22%	22%	22%	22%	22%	22%	22%	22%	22%
1430	Base CFL Lamp, 23W 2016-2017--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

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Commercial Electric Measure Inputs		**DEMAND SAVINGS (percent)**											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1440	Base CFL Lamp, 23W 2018-2019--Hardwired	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1441	LED Track Lighting (base CFL spiral 23W) 2018-2019	22%	22%	22%	22%	22%	22%	22%	22%	22%	22%	22%	22%
1450	Base CFL Lamp, 23W 2018-2019--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1460	Base CFL Lamp, 23W 2020--Hardwired	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1461	LED Track Lighting (base CFL spiral 23W) 2020	22%	22%	22%	22%	22%	22%	22%	22%	22%	22%	22%	22%
1470	Base CFL Lamp, 23W 2020--Upstream	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1471	Upstream LEDs (base CFL spiral 23W) 2020	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1500	Base Metal Halide, 400W	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1501	High Bay T5 HO (240W)	56%	56%	56%	56%	56%	56%	56%	56%	56%	56%	56%	56%
1502	High Bay Induction Lighting	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%
1503	PSMH with electronic ballast	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
1504	High Bay LED Lighting	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%
1600	Base HPS (high pressure sodium) Parking Garage Lighting	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1601	High-efficiency fluorescent parking garage fixture	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
1602	LED Parking Garage Fixtures	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%
1603	Bi-Level LED Parking Garage Fixtures	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
1700	Base CFL Exit Sign	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1701	LED Exit Sign	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%
1800	Base Outdoor High Pressure Sodium 250W Lamp	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1801	LED Outdoor Area Lighting (other than pole-mounted)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2002	Chiller VSD	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2003	EMS - Chiller	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
2004	Cool Roof - Chiller	5%	5%	11%	5%	0%	5%	5%	11%	5%	0%	0%	0%
2006	VSD for Chiller Pumps and Towers	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2008	Ceiling/roof Insulation - Chiller	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
2009	Custom HVAC--Base Chiller	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2010	Custom Shell--Base Chiller	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2100	Base DX Packaged System, EER=10.0, 30 tons	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2101	ROB DX Packaged System, EER=10.8, 30 tons	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%
2102	ROB DX Packaged System, EER=11.7, 30 tons	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2104	Automated Fault Detection	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
2106	Advanced Controllers for RTUs	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2107	Programmable Communicating Thermostat	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2108	Prog. Thermostat - DX	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2109	Cool Roof - DX	5%	5%	11%	5%	0%	5%	5%	11%	5%	0%	0%	0%
2110	RTU VSD	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2111	Dual Enthalpy Economizer Controls	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
2113	Aerosol Duct Sealing	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
2114	Ceiling/roof Insulation - DX	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
2115	Duct/Pipe Insulation - DX	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
2116	Custom HVAC--DX	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2117	Custom Shell--DX	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2201	Air Source Heat Pump, EER=11.3, 10 tons	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
2300	Base PTAC, EER=8.3, 1 ton	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2301	Occupancy Sensor (hotels)	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3001	Variable Speed Drive Control, 5 HP	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%
3002	Custom HVAC--Base Fan Motor, 5hp	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3101	Variable Speed Drive Control, 15 HP	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%
3102	Air Handler Optimization, 15 HP	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
3104	Separate Makeup Air / Exhaust Hoods AC	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
3105	Custom HVAC--Base Fan Motor, 15hp	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3201	Variable Speed Drive Control, 40 HP	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%
3202	Air Handler Optimization, 40 HP	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%

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Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
3203	Demand Controlled Ventilation (40 HP fan motor)	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
3204	Custom HVAC--Base Fan Motor, 40hp	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
4000	Base Built-Up Refrigeration System	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4001	Strip curtains for walk-ins (built-up)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%
4002	Auto-closer on main door to walk-in freezer (built-up)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4003	Night covers for display cases	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4004	Evaporator fan controller for MT walk-ins	1%	1%	0%	1%	1%	1%	1%	0%	1%	1%	1%	1%
4005	Electronically commutated evaporator fan motor	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
4006	Efficient compressor motor	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%
4007	Floating head pressure controls	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%
4008	Refrigeration Commissioning	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
4009	Demand Hot Gas Defrost	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4010	Demand Defrost Electric	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4011	Anti-sweat (humidistat) controls	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4012	Freezer-Cooler Replacement Gaskets	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
4013	High R-Value Glass Doors	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
4014	LED Display Lighting (Base T8 Lighting)	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%
4016	Multiplex Compressor System	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4017	Oversized Air Cooled Condenser	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4018	Custom Refrigeration	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
4500	Base Self-Contained Refrigeration	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4501	Strip curtains for walk-ins (self-contained)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4502	Auto-closer on main door to walk-in freezer (self-contained)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
4503	Night covers for display cases (self-contained)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4504	LED Display Lighting (Base T8 Lighting)	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
4506	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
4507	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
4508	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
4509	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
4510	ENERGY STAR Ice Machines	0%	0%	0%	0%	1%	0%	0%	0%	0%	1%	0%	0%
4511	Hydraulic-type door closer on reach-in cooler glass doors	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
4512	Doors for open cases	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
6000	Base Water Heating	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6001	Demand controlled circulating systems	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6003	Hot Water Pipe Insulation	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
6004	Tankless Water Heater	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
6005	Heat Pump Water Heater (air source)	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
6006	Heat Recovery Unit	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6007	Heat Trap	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6008	Solar Water Heater	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
6009	High Temperature Dishwasher	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%
7000	Base Refrigerated Vending Machines	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7001	Vending Misers (Refrigerated units)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7002	Vending Misers (Refrigerated glass-front units)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7003	Refrigerated Vending Low Watt High Performance T8	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
7500	Base Non-Refrigerated Vending Machines	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7501	Vending Misers (Non-Refrigerated)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7502	Non-refrigerated Vending Low Watt High Performance T8	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
8000	Base Oven	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8001	Convection Oven	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%
8100	Base Fryer	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8101	Efficient Fryer	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
8200	Base Steamer	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8201	Efficient Steamer	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
8300	Base Hot Food Holding Cabinet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8301	ENERGY STAR Hot Food Holding Cabinets	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%
8500	Base Compressed Air	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8700	Base Heating	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9000	Base Miscellaneous	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9500	Base Whole Building	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9501	NEMA Premium Efficiency Transformer	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9502	Retrocommissioning/Building tune up	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%

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Commercial Electric Measure Inputs		DEMAND SAVINGS (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
9503	Custom O&M	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015 (New)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1001	NEW 3L4'T5, 2015	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1002	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1012	Upstream 4L4' LED Tube, 2015	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%
1013	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015 (Base Upstream)	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017 (New)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1051	NEW 3L4'T5, 2016-2017	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1052	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1062	Upstream 4L4' LED Tube, 2016-2017	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%
1063	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017 (Base Upstream)	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019 (New)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1101	NEW 3L4'T5, 2018-2019	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1102	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1112	Upstream 4L4' LED Tube, 2018-2019	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%
1113	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019 (Base Upstream)	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020 (New)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1151	NEW 3L4'T5, 2020	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1152	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1162	Upstream 4L4' LED Tube, 2020	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%
1163	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020 (Base Upstream)	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1200	Base Other Fluorescent Fixture (New)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1201	NEW T5	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1202	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1210	Base Other Fluorescent Fixture--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1211	Upstream Low Watt High Performance T8	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%
1212	Upstream LED Tube	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%
1213	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings (Base Upstream)	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1300	Base Incandescent Lamp, 72W 2015--New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1301	New LEDs (base incandescent 72W) 2015	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
1310	Base Incandescent Lamp, 72W 2015--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1311	Upstream LEDs (base incandescent 72W) 2015	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
1320	Base Incandescent Lamp, 72W 2016-2017--New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1321	New LEDs (base incandescent 72W) 2016-2017	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1331	Upstream LEDs (base incandescent 72W) 2016-2017	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
1340	Base Incandescent Lamp, 72W 2018-2019--New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1341	New LEDs (base incandescent 72W) 2018-2019	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1351	Upstream LEDs (base incandescent 72W) 2018-2019	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
1360	Base Incandescent Lamp, 72W 2020--New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1361	New LEDs (base incandescent 72W) 2020	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
1370	Base Incandescent Lamp, 72W 2020--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1371	Upstream LEDs (base incandescent 72W) 2020	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
1400	Base CFL Lamp, 23W 2015--New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1401	New LEDs (base CFL spiral 23W) 2015	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1410	Base CFL Lamp, 23W 2015--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1411	Upstream LEDs (base CFL spiral 23W) 2015	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1420	Base CFL Lamp, 23W 2016-2017--New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1421	New LEDs (base CFL spiral 23W) 2016-2017	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1430	Base CFL Lamp, 23W 2016-2017--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1440	Base CFL Lamp, 23W 2018-2019--New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1441	New LEDs (base CFL spiral 23W) 2018-2019	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1450	Base CFL Lamp, 23W 2018-2019--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1460	Base CFL Lamp, 23W 2020--New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1461	New LEDs (base CFL spiral 23W) 2020	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%

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Commercial Electric Measure Inputs		DEMAND SAVINGS (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1470	Base CFL Lamp, 23W 2020--Upstream New	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1471	Upstream LEDs (base CFL spiral 23W) 2020	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1500	Base Metal Halide, 400W	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1501	High Bay T5 HO (240W)	56%	56%	56%	56%	100%	56%	56%	56%	56%	56%	56%	56%
1502	High Bay Induction Lighting	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%
1600	Base HID Parking Garage Lighting	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1601	LED Parking Garage Fixtures	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%
1602	Bi-Level LED Parking Garage Fixtures	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
1700	Base CFL Exit Sign	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1800	Base Outdoor High Pressure Sodium 250W Lamp	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1801	LED Outdoor Area Lighting (other than pole-mounted)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2002	Chilled Beams	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
2003	Cool Roof - Chiller	5%	5%	11%	5%	0%	5%	5%	11%	5%	0%	0%	0%
2005	VSD for Chiller Pumps and Towers	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2100	Base DX Packaged System, EER=10.0, 30 tons	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2101	ROB DX Packaged System, EER=10.8, 30 tons	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%
2102	ROB DX Packaged System, EER=11.7, 30 tons	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2103	Automated Fault Detection	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
2104	RTU VSD	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2106	Aerosol Duct Sealing	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
2107	VRF Conditioning Systems	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2201	Air Source Heat Pump, EER=11.3, 10 tons	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
2202	Geothermal Heat Pump, EER=18, 10 tons	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%
2203	VRF Conditioning Systems	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
2300	Base PTAC, EER=8.3, 1 ton	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2301	Occupancy Sensor (hotels)	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3001	Variable Speed Drive Control, 5 HP	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3101	Variable Speed Drive Control, 15 HP	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%
3102	Air Handler Optimization, 15 HP	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
3104	Separate Makeup Air / Exhaust Hoods AC	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3201	Variable Speed Drive Control, 40 HP	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%
3202	Air Handler Optimization, 40 HP	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
3203	Demand Controlled Ventilation (40 HP fan motor)	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
4000	Base Built-Up Refrigeration System	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4001	Auto-closer on main door to walk-in freezer (built-up)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4002	Evaporator fan controller for MT walk-ins	1%	1%	0%	1%	1%	1%	1%	0%	1%	1%	1%	1%
4003	Efficient compressor motor	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%
4004	Refrigeration Commissioning	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
4500	Base Self-Contained Refrigeration	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4501	Auto-closer on main door to walk-in freezer (self-contained)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
4502	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
4503	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
4504	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
4505	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
4506	ENERGY STAR Ice Machines	0%	0%	0%	0%	1%	0%	0%	0%	0%	1%	0%	0%
4507	Hydraulic-type door closer on reach-in cooler glass doors	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
6000	Base Water Heating	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6001	Demand controlled circulating systems	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6003	Tankless Water Heater	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
6004	Heat Pump Water Heater (air source)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
6005	Solar Water Heater	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
7000	Base Refrigerated Vending Machines	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7500	Base Non-Refrigerated Vending Machines	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8000	Base Oven	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8001	Convection Oven	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%

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Commercial Electric Measure Inputs		DEMAND SAVINGS (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
8100	Base Fryer	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8101	Efficient Fryer	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
8200	Base Steamer	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8201	Efficient Steamer	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
8300	Base Hot Food Holding Cabinet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8301	ENERGY STAR Hot Food Holding Cabinets	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%
8500	Base Compressed Air	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8700	Base Heating	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8701	Air Source Heat Pump, EER=11.3, 10 tons	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
8702	Geothermal Heat Pump, EER=18, 10 tons	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%
8703	VRF Conditioning Systems	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
9000	Base Miscellaneous	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9500	Base Building Design - Standard Code	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9501	15% better than code - Campuses	15%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9502	15% better than code - Education	0%	15%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9503	15% better than code - Food Sales	0%	0%	15%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9504	15% better than code - Food Service	0%	0%	0%	15%	0%	0%	0%	0%	0%	0%	0%	0%
9505	15% better than code - Healthcare	0%	0%	0%	0%	15%	15%	0%	0%	0%	0%	0%	0%
9506	15% better than code - Lodging	0%	0%	0%	0%	0%	0%	15%	0%	0%	0%	0%	0%
9507	15% better than code - Office	0%	0%	0%	0%	0%	0%	0%	15%	0%	0%	0%	0%
9508	15% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	15%	0%	0%	0%
9509	15% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	15%	0%	0%
9510	15% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15%	0%
9511	15% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15%
9512	Commissioning	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
9600	Base Building Design - Standard Code	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9601	30% better than code - Campuses	30%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9602	30% better than code - Education	0%	30%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9603	30% better than code - Food Sales	0%	0%	30%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9604	30% better than code - Food Service	0%	0%	0%	30%	0%	0%	0%	0%	0%	0%	0%	0%
9605	30% better than code - Healthcare	0%	0%	0%	0%	30%	30%	0%	0%	0%	0%	0%	0%
9606	30% better than code - Lodging	0%	0%	0%	0%	0%	0%	30%	0%	0%	0%	0%	0%
9607	30% better than code - Office	0%	0%	0%	0%	0%	0%	0%	30%	0%	0%	0%	0%
9608	30% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	30%	0%	0%	0%
9609	30% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	30%	0%	0%
9610	30% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	30%	0%
9611	30% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	30%
9612	Commissioning	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
9700	Base Building Design - Standard Code	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9701	50% better than code - Campuses	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9702	50% better than code - Education	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9703	50% better than code - Food Sales	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9704	50% better than code - Food Service	0%	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%
9705	50% better than code - Healthcare	0%	0%	0%	0%	50%	50%	0%	0%	0%	0%	0%	0%
9706	50% better than code - Lodging	0%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%
9707	50% better than code - Office	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%
9708	50% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	0%
9709	50% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%
9710	50% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%	0%
9711	50% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%
9712	Commissioning	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
9800	Base Building Design - Standard Code	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9801	70% better than code - Campuses	70%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9802	70% better than code - Education	0%	70%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9803	70% better than code - Food Sales	0%	0%	70%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9804	70% better than code - Food Service	0%	0%	0%	70%	0%	0%	0%	0%	0%	0%	0%	0%
9805	70% better than code - Healthcare	0%	0%	0%	0%	70%	70%	0%	0%	0%	0%	0%	0%
9806	70% better than code - Lodging	0%	0%	0%	0%	0%	0%	70%	0%	0%	0%	0%	0%
9807	70% better than code - Office	0%	0%	0%	0%	0%	0%	0%	70%	0%	0%	0%	0%
9808	70% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	70%	0%	0%	0%
9809	70% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	70%	0%	0%
9810	70% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	70%	0%

Commercial Electric Measure Inputs		DEMAND SAVINGS (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
9811	70% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	70%
9812	Commissioning	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%

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Commercial Electric Measure Inputs		Standards Adjustment Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--RET	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1001	RET 4L4' Low Watt High Performance T8 (83 W), 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1002	RET 4L4' LED Tube, 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1003	RET LED Troffer (base 4L4'T8), 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1004	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base RET)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1005	Advanced Lighting Controls (2015 Base RET)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1006	Daylight Dimming Controls (2015 Base RET)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1007	Custom Lighting, Base 4L4'T8, 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--ROB	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1011	ROB 4L4' Low Watt High Performance T8 (83 W), 2015	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1012	ROB 4L4' LED Tube, 2015	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1013	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base ROB)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1014	Advanced Lighting Controls (2015 Base ROB)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1015	Daylight Dimming Controls (2015 Base ROB)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1020	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1021	Upstream 4L4' Low Watt High Performance T8 (83 W), 2015	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1022	Upstream 4L4' LED Tube, 2015	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1023	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base Upstream)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1024	Advanced Lighting Controls (2015 Base Up)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1025	Daylight Dimming Controls (2015 Base Up)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--RET	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1051	RET 4L4' Low Watt High Performance T8 (83 W), 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1052	RET 4L4' LED Tube, 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1053	RET LED Troffer (base 4L4'T8), 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1054	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base RET)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1055	Advanced Lighting Controls (2016-2017 Base RET)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1056	Daylight Dimming Controls (2016-2017 Base RET)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1057	Custom Lighting, Base 4L4'T8, 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--ROB	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1061	ROB 4L4' Low Watt High Performance T8 (83 W), 2016-2017	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1062	ROB 4L4' LED Tube, 2016-2017	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1063	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base ROB)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1064	Advanced Lighting Controls (2016-2017 Base ROB)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1065	Daylight Dimming Controls (2016-2017 Base ROB)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1070	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1071	Upstream 4L4' Low Watt High Performance T8 (83 W), 2016-2017	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1072	Upstream 4L4' LED Tube, 2016-2017	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1073	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base Upstream)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1074	Advanced Lighting Controls (2016-2017 Base Up)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1075	Daylight Dimming Controls (2016-2017 Base Up)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1080	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--RET	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1081	RET 4L4' Low Watt High Performance T8 (83 W), 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1082	RET 4L4' LED Tube, 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1083	RET LED Troffer (base 4L4'T8), 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1084	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base RET)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1085	Advanced Lighting Controls (2018-2019 Base RET)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1086	Daylight Dimming Controls (2018-2019 Base RET)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1087	Custom Lighting, Base 4L4'T8, 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--ROB	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1101	ROB 4L4' Low Watt High Performance T8 (83 W), 2018-2019	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1102	ROB 4L4' LED Tube, 2018-2019	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1103	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base ROB)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1104	Advanced Lighting Controls (2018-2019 Base ROB)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1105	Daylight Dimming Controls (2018-2019 Base ROB)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1111	Upstream 4L4' Low Watt High Performance T8 (83 W), 2018-2019	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1112	Upstream 4L4' LED Tube, 2018-2019	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1113	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base Upstream)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%

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Commercial Electric Measure Inputs		Standards Adjustment Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
1114	Advanced Lighting Controls (2018-2019 Base Up)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1115	Daylight Dimming Controls (2018-2019 Base Up)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1120	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--RET	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1121	RET 4L4' Low Watt High Performance T8 (83 W), 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1122	RET 4L4' LED Tube, 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1123	RET LED Troffer (base 4L4'T8), 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1124	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base RET)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1125	Advanced Lighting Controls (2020 Base RET)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1126	Daylight Dimming Controls (2020 Base RET)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1127	Custom Lighting, Base 4L4'T8, 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--ROB	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1151	ROB 4L4' Low Watt High Performance T8 (83 W), 2020	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1152	ROB 4L4' LED Tube, 2020	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1153	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base ROB)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1154	Advanced Lighting Controls (2020 Base ROB)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1155	Daylight Dimming Controls (2020 Base ROB)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1161	Upstream 4L4' Low Watt High Performance T8 (83 W), 2020	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1162	Upstream 4L4' LED Tube, 2020	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1163	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base Upstream)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1164	Advanced Lighting Controls (2020 Base Up)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1165	Daylight Dimming Controls (2020 Base Up)	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
1200	Base Other Fluorescent Fixture--RET	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1201	RET Low Watt High Performance T8	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1202	RET LED Tube	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1203	RET LED Troffer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1204	Occupancy Sensor (Base Other Fluor RET)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1205	Advanced Lighting Controls (Base Other Fluor RET)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1206	Daylight Dimming Controls (Base Other Fluor RET)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1207	Custom Lighting, Base Other Fluorescent	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1210	Base Other Fluorescent Fixture--ROB	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1211	ROB Low Watt High Performance T8	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1212	ROB LED Tube	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1213	Occupancy Sensor (Base Other Fluor ROB)	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1214	Advanced Lighting Controls (Base Other Fluor ROB)	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1215	Daylight Dimming Controls (Base Other Fluor ROB)	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1220	Base Other Fluorescent Fixture--Upstream	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1221	Upstream Low Watt High Performance T8	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1222	Upstream LED Tube	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1223	Occupancy Sensor (Base Other Fluor Upstream)	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1224	Advanced Lighting (Base Other Fluor Upstream)	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1225	Daylight Dimming Controls (Base Other Fluor Upstream)	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1300	Base Incandescent Lamp, 72W 2015--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1301	LED Track Lighting (base Incandescent 72W) 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1310	Base Incandescent Lamp, 72W 2015--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1311	Upstream LEDs (base Incandescent 72W) 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1320	Base Incandescent Lamp, 72W 2016-2017--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1321	LED Track Lighting (base Incandescent 72W) 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1331	Upstream LEDs (base Incandescent 72W) 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1340	Base Incandescent Lamp, 72W 2018-2019--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1341	LED Track Lighting (base Incandescent 72W) 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1351	Upstream LEDs (base Incandescent 72W) 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1360	Base Incandescent Lamp, 72W 2020--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1361	LED Track Lighting (base Incandescent 72W) 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1370	Base Incandescent Lamp, 72W 2020--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1371	Upstream LEDs (base Incandescent 72W) 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

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Commercial Electric Measure Inputs		Standards Adjustment Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
1400	Base CFL Lamp, 23W 2015--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1401	LED Track Lighting (base CFL spiral 23W) 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1410	Base CFL Lamp, 23W 2015--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1411	Upstream LEDs (base CFL spiral 23W) 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1420	Base CFL Lamp, 23W 2016-2017--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1421	LED Track Lighting (base CFL spiral 23W) 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1430	Base CFL Lamp, 23W 2016-2017--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1440	Base CFL Lamp, 23W 2018-2019--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1441	LED Track Lighting (base CFL spiral 23W) 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1450	Base CFL Lamp, 23W 2018-2019--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1460	Base CFL Lamp, 23W 2020--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1461	LED Track Lighting (base CFL spiral 23W) 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1470	Base CFL Lamp, 23W 2020--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1471	Upstream LEDs (base CFL spiral 23W) 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1500	Base Metal Halide, 400W	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1501	High Bay T5 HO (240W)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1502	High Bay Induction Lighting	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1503	PSMH with electronic ballast	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1504	High Bay LED Lighting	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1600	Base HPS (high pressure sodium) Parking Garage Lighting	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1601	High-efficiency fluorescent parking garage fixture	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1602	LED Parking Garage Fixtures	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1603	Bi-Level LED Parking Garage Fixtures	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1700	Base CFL Exit Sign	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1701	LED Exit Sign	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1800	Base Outdoor High Pressure Sodium 250W Lamp	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1801	LED Outdoor Area Lighting (other than pole-mounted)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	96.50%	96.50%	96.50%	96.50%	96.50%	96.50%	96.50%	96.50%	96.50%	96.50%	96.50%	97%
2002	Chiller VSD	96.50%	96.50%	96.50%	96.50%	96.50%	96.50%	96.50%	96.50%	96.50%	96.50%	96.50%	97%
2003	EMS - Chiller	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2004	Cool Roof - Chiller	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2006	VSD for Chiller Pumps and Towers	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2008	Ceiling/roof Insulation - Chiller	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2009	Custom HVAC--Base Chiller	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2010	Custom Shell--Base Chiller	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2100	Base DX Packaged System, EER=10.0, 30 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2101	ROB DX Packaged System, EER=10.8, 30 tons	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98%
2102	ROB DX Packaged System, EER=11.7, 30 tons	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98%
2104	Automated Fault Detection	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2106	Advanced Controllers for RTUs	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2107	Programmable Communicating Thermostat	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2108	Prog. Thermostat - DX	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2109	Cool Roof - DX	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2110	RTU VSD	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2111	Dual Enthalpy Economizer Controls	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2113	Aerosol Duct Sealing	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2114	Ceiling/roof Insulation - DX	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2115	Duct/Pipe Insulation - DX	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2116	Custom HVAC--DX	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2117	Custom Shell--DX	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2201	Air Source Heat Pump, EER=11.3, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2300	Base PTAC, EER=8.3, 1 ton	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2301	Occupancy Sensor (hotels)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%

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Commercial Electric Measure Inputs		Standards Adjustment Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
3001	Variable Speed Drive Control, 5 HP	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3002	Custom HVAC--Base Fan Motor, 5hp	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3101	Variable Speed Drive Control, 15 HP	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3102	Air Handler Optimization, 15 HP	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3104	Separate Makeup Air / Exhaust Hoods AC	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3105	Custom HVAC--Base Fan Motor, 15hp	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3201	Variable Speed Drive Control, 40 HP	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3202	Air Handler Optimization, 40 HP	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3203	Demand Controlled Ventilation (40 HP fan motor)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3204	Custom HVAC--Base Fan Motor, 40hp	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4000	Base Built-Up Refrigeration System	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4001	Strip curtains for walk-ins (built-up)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4002	Auto-closer on main door to walk-in freezer (built-up)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4003	Night covers for display cases	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4004	Evaporator fan controller for MT walk-ins	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4005	Electronically commutated evaporator fan motor	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4006	Efficient compressor motor	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4007	Floating head pressure controls	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4008	Refrigeration Commissioning	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4009	Demand Hot Gas Defrost	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4010	Demand Defrost Electric	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4011	Anti-sweat (humidistat) controls	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4012	Freezer-Cooler Replacement Gaskets	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4013	High R-Value Glass Doors	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4014	LED Display Lighting (Base T8 Lighting)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4016	Multiplex Compressor System	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4017	Oversized Air Cooled Condenser	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4018	Custom Refrigeration	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4500	Base Self-Contained Refrigeration	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4501	Strip curtains for walk-ins (self-contained)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4502	Auto-closer on main door to walk-in freezer (self-contained)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4503	Night covers for display cases (self-contained)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4504	LED Display Lighting (Base T8 Lighting)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4506	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4507	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4508	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4509	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4510	ENERGY STAR Ice Machines	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4511	Hydraulic-type door closer on reach-in cooler glass doors	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4512	Doors for open cases	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6000	Base Water Heating	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6001	Demand controlled circulating systems	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6003	Hot Water Pipe Insulation	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6004	Tankless Water Heater	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6005	Heat Pump Water Heater (air source)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6006	Heat Recovery Unit	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6007	Heat Trap	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6008	Solar Water Heater	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6009	High Temperature Dishwasher	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
7000	Base Refrigerated Vending Machines	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
7001	Vending Misers (Refrigerated units)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
7002	Vending Misers (Refrigerated glass-front units)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
7003	Refrigerated Vending Low Watt High Performance T8	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
7500	Base Non-Refrigerated Vending Machines	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
7501	Vending Misers (Non-Refrigerated)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%

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Commercial Electric Measure Inputs		**Standards Adjustment Factor (percent)**											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
7502	Non-refrigerated Vending Low Watt High Performance T8	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8000	Base Oven	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8001	Convection Oven	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8100	Base Fryer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8101	Efficient Fryer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8200	Base Steamer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8201	Efficient Steamer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8300	Base Hot Food Holding Cabinet	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8301	ENERGY STAR Hot Food Holding Cabinets	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8500	Base Compressed Air	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8700	Base Heating	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9000	Base Miscellaneous	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9500	Base Whole Building	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9501	NEMA Premium Efficiency Transformer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9502	Retrocommissioning/Building tune up	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9503	Custom O&M	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015 (New)	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1001	NEW 3L4'T5, 2015	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1002	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream New	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1012	Upstream 4L4' LED Tube, 2015	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1013	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015 (Base Upstream)	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017 (New)	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1051	NEW 3L4'T5, 2016-2017	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1052	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream New	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1062	Upstream 4L4' LED Tube, 2016-2017	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1063	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017 (Base Upstrea	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019 (New)	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1101	NEW 3L4'T5, 2018-2019	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1102	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream New	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1112	Upstream 4L4' LED Tube, 2018-2019	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1113	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019 (Base Upstrea	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020 (New)	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1151	NEW 3L4'T5, 2020	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1152	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream New	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1162	Upstream 4L4' LED Tube, 2020	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1163	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020 (Base Upstream)	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	93.70%	94%
1200	Base Other Fluorescent Fixture (New)	98.93%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1201	NEW T5	98.93%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1202	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings	98.93%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1210	Base Other Fluorescent Fixture--Upstream New	98.93%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1211	Upstream Low Watt High Performance T8	98.93%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1212	Upstream LED Tube	98.93%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1213	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings (Base Upstream)	98.93%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1300	Base Incandescent Lamp, 72W 2015--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1301	New LEDs (base incandescent 72W) 2015	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1310	Base Incandescent Lamp, 72W 2015--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1311	Upstream LEDs (base incandescent 72W) 2015	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1320	Base Incandescent Lamp, 72W 2016-2017--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1321	New LEDs (base incandescent 72W) 2016-2017	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1331	Upstream LEDs (base incandescent 72W) 2016-2017	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1340	Base Incandescent Lamp, 72W 2018-2019--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1341	New LEDs (base incandescent 72W) 2018-2019	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%

DNV·GL

Commercial Electric Measure Inputs		Standards Adjustment Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
1351	Upstream LEDs (base incandescent 72W) 2018-2019	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1360	Base Incandescent Lamp, 72W 2020--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1361	New LEDs (base incandescent 72W) 2020	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1370	Base Incandescent Lamp, 72W 2020--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1371	Upstream LEDs (base incandescent 72W) 2020	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1400	Base CFL Lamp, 23W 2015--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1401	New LEDs (base CFL spiral 23W) 2015	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1410	Base CFL Lamp, 23W 2015--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1411	Upstream LEDs (base CFL spiral 23W) 2015	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1420	Base CFL Lamp, 23W 2016-2017--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1421	New LEDs (base CFL spiral 23W) 2016-2017	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1430	Base CFL Lamp, 23W 2016-2017--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1440	Base CFL Lamp, 23W 2018-2019--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1441	New LEDs (base CFL spiral 23W) 2018-2019	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1450	Base CFL Lamp, 23W 2018-2019--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1460	Base CFL Lamp, 23W 2020--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1461	New LEDs (base CFL spiral 23W) 2020	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1470	Base CFL Lamp, 23W 2020--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1471	Upstream LEDs (base CFL spiral 23W) 2020	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1500	Base Metal Halide, 400W	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1501	High Bay T5 HO (240W)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1502	High Bay Induction Lighting	100.00%	100.00%	100.00%	100.00%	0.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1600	Base HID Parking Garage Lighting	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1601	LED Parking Garage Fixtures	100.00%	100.00%	100.00%	100.00%	0.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1602	Bi-Level LED Parking Garage Fixtures	100.00%	100.00%	100.00%	100.00%	0.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1700	Base CFL Exit Sign	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1800	Base Outdoor High Pressure Sodium 250W Lamp	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1801	LED Outdoor Area Lighting (other than pole-mounted)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2002	Chilled Beams	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2003	Cool Roof - Chiller	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2005	VSD for Chiller Pumps and Towers	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2100	Base DX Packaged System, EER=10.0, 30 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2101	ROB DX Packaged System, EER=10.8, 30 tons	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96%
2102	ROB DX Packaged System, EER=11.7, 30 tons	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96%
2103	Automated Fault Detection	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96%
2104	RTU VSD	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96%
2106	Aerosol Duct Sealing	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96%
2107	VRF Conditioning Systems	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96.40%	96%
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2201	Air Source Heat Pump, EER=11.3, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2202	Geothermal Heat Pump, EER=18, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2203	VRF Conditioning Systems	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2300	Base PTAC, EER=8.3, 1 ton	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2301	Occupancy Sensor (hotels)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3001	Variable Speed Drive Control, 5 HP	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3101	Variable Speed Drive Control, 15 HP	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3102	Air Handler Optimization, 15 HP	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3104	Separate Makeup Air / Exhaust Hoods AC	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3201	Variable Speed Drive Control, 40 HP	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3202	Air Handler Optimization, 40 HP	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%

DNV·GL

Commercial Electric Measure Inputs		Standards Adjustment Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
3203	Demand Controlled Ventilation (40 HP fan motor)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4000	Base Built-Up Refrigeration System	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4001	Auto-closer on main door to walk-in freezer (built-up)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4002	Evaporator fan controller for MT walk-ins	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4003	Efficient compressor motor	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4004	Refrigeration Commissioning	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4500	Base Self-Contained Refrigeration	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4501	Auto-closer on main door to walk-in freezer (self-contained)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4502	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4503	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4504	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4505	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4506	ENERGY STAR Ice Machines	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4507	Hydraulic-type door closer on reach-in cooler glass doors	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6000	Base Water Heating	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6001	Demand controlled circulating systems	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6003	Tankless Water Heater	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6004	Heat Pump Water Heater (air source)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6005	Solar Water Heater	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
7000	Base Refrigerated Vending Machines	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
7500	Base Non-Refrigerated Vending Machines	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8000	Base Oven	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8001	Convection Oven	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8100	Base Fryer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8101	Efficient Fryer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8200	Base Steamer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8201	Efficient Steamer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8300	Base Hot Food Holding Cabinet	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8301	ENERGY STAR Hot Food Holding Cabinets	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8500	Base Compressed Air	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8700	Base Heating	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8701	Air Source Heat Pump, EER=11.3, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8702	Geothermal Heat Pump, EER=18, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8703	VRF Conditioning Systems	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9000	Base Miscellaneous	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9500	Base Building Design - Standard Code	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9501	15% better than code - Campuses	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9502	15% better than code - Education	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9503	15% better than code - Food Sales	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9504	15% better than code - Food Service	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9505	15% better than code - Healthcare	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9506	15% better than code - Lodging	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0%
9507	15% better than code - Office	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0%
9508	15% better than code - Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0%
9509	15% better than code - Public Assembly	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0%
9510	15% better than code - Retail	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0%
9511	15% better than code - Warehouse	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
9512	Commissioning	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9600	Base Building Design - Standard Code	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9601	30% better than code - Campuses	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9602	30% better than code - Education	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9603	30% better than code - Food Sales	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9604	30% better than code - Food Service	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9605	30% better than code - Healthcare	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9606	30% better than code - Lodging	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0%
9607	30% better than code - Office	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0%
9608	30% better than code - Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0%
9609	30% better than code - Public Assembly	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0%

DNV·GL

Commercial Electric Measure Inputs		Standards Adjustment Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
9610	30% better than code - Retail	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0%
9611	30% better than code - Warehouse	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
9612	Commissioning	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9700	Base Building Design - Standard Code	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9701	50% better than code - Campuses	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9702	50% better than code - Education	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9703	50% better than code - Food Sales	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9704	50% better than code - Food Service	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9705	50% better than code - Healthcare	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9706	50% better than code - Lodging	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0%
9707	50% better than code - Office	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0%
9708	50% better than code - Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0%
9709	50% better than code - Public Assembly	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0%
9710	50% better than code - Retail	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0%
9711	50% better than code - Warehouse	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
9712	Commissioning	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9800	Base Building Design - Standard Code	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9801	70% better than code - Campuses	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9802	70% better than code - Education	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9803	70% better than code - Food Sales	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9804	70% better than code - Food Service	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9805	70% better than code - Healthcare	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9806	70% better than code - Lodging	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0%
9807	70% better than code - Office	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0%
9808	70% better than code - Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0%
9809	70% better than code - Public Assembly	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0%
9810	70% better than code - Retail	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0%
9811	70% better than code - Warehouse	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
9812	Commissioning	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%

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Commercial Electric Measure Inputs		Incomplete Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--RET	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1001	RET 4L4' Low Watt High Performance T8 (83 W), 2015	62%	98%	80%	97%	82%	82%	100%	89%	82%	93%	27%	39%
1002	RET 4L4' LED Tube, 2015	100%	100%	100%	100%	100%	100%	93%	100%	100%	100%	100%	100%
1003	RET LED Troffer (base 4L4'T8), 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1004	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base RET)	77%	89%	54%	100%	68%	81%	85%	84%	79%	96%	84%	90%
1005	Advanced Lighting Controls (2015 Base RET)	100%	99%	73%	100%	100%	99%	100%	92%	100%	89%	30%	100%
1006	Daylight Dimming Controls (2015 Base RET)	64%	99%	100%	99%	76%	82%	95%	91%	77%	88%	31%	100%
1007	Custom Lighting, Base 4L4'T8, 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--ROB	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1011	ROB 4L4' Low Watt High Performance T8 (83 W), 2015	62%	98%	80%	97%	82%	82%	100%	89%	82%	93%	27%	39%
1012	ROB 4L4' LED Tube, 2015	100%	100%	100%	100%	100%	100%	93%	100%	100%	100%	100%	100%
1013	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base ROB)	77%	89%	54%	100%	68%	81%	85%	84%	79%	96%	84%	90%
1014	Advanced Lighting Controls (2015 Base ROB)	100%	99%	73%	100%	100%	99%	100%	92%	100%	89%	30%	100%
1015	Daylight Dimming Controls (2015 Base ROB)	64%	99%	100%	99%	76%	82%	95%	91%	77%	88%	31%	100%
1020	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1021	Upstream 4L4' Low Watt High Performance T8 (83 W), 2015	62%	98%	80%	97%	82%	82%	100%	89%	82%	93%	27%	39%
1022	Upstream 4L4' LED Tube, 2015	100%	100%	100%	100%	100%	100%	93%	100%	100%	100%	100%	100%
1023	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base Upstream)	77%	89%	54%	100%	68%	81%	85%	84%	79%	96%	84%	90%
1024	Advanced Lighting Controls (2015 Base Up)	100%	99%	73%	100%	100%	99%	100%	92%	100%	89%	30%	100%
1025	Daylight Dimming Controls (2015 Base Up)	64%	99%	100%	99%	76%	82%	95%	91%	77%	88%	31%	100%
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--RET	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1051	RET 4L4' Low Watt High Performance T8 (83 W), 2016-2017	62%	98%	80%	97%	82%	82%	100%	89%	82%	93%	27%	39%
1052	RET 4L4' LED Tube, 2016-2017	100%	100%	100%	100%	100%	100%	93%	100%	100%	100%	100%	100%
1053	RET LED Troffer (base 4L4'T8), 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1054	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base RET)	77%	89%	54%	100%	68%	81%	85%	84%	79%	96%	84%	90%
1055	Advanced Lighting Controls (2016-2017 Base RET)	100%	99%	73%	100%	100%	99%	100%	92%	100%	89%	30%	100%
1056	Daylight Dimming Controls (2016-2017 Base RET)	64%	99%	100%	99%	76%	82%	95%	91%	77%	88%	31%	100%
1057	Custom Lighting, Base 4L4'T8, 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--ROB	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1061	ROB 4L4' Low Watt High Performance T8 (83 W), 2016-2017	62%	98%	80%	97%	82%	82%	100%	89%	82%	93%	27%	39%
1062	ROB 4L4' LED Tube, 2016-2017	100%	100%	100%	100%	100%	100%	93%	100%	100%	100%	100%	100%
1063	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base ROB)	77%	89%	54%	100%	68%	81%	85%	84%	79%	96%	84%	90%
1064	Advanced Lighting Controls (2016-2017 Base ROB)	100%	99%	73%	100%	100%	99%	100%	92%	100%	89%	30%	100%
1065	Daylight Dimming Controls (2016-2017 Base ROB)	64%	99%	100%	99%	76%	82%	95%	91%	77%	88%	31%	100%
1070	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1071	Upstream 4L4' Low Watt High Performance T8 (83 W), 2016-2017	62%	98%	80%	97%	82%	82%	100%	89%	82%	93%	27%	39%
1072	Upstream 4L4' LED Tube, 2016-2017	100%	100%	100%	100%	100%	100%	93%	100%	100%	100%	100%	100%
1073	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base Upstream)	77%	89%	54%	100%	68%	81%	85%	84%	79%	96%	84%	90%
1074	Advanced Lighting Controls (2016-2017 Base Up)	100%	99%	73%	100%	100%	99%	100%	92%	100%	89%	30%	100%
1075	Daylight Dimming Controls (2016-2017 Base Up)	64%	99%	100%	99%	76%	82%	95%	91%	77%	88%	31%	100%
1080	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--RET	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1081	RET 4L4' Low Watt High Performance T8 (83 W), 2018-2019	62%	98%	80%	97%	82%	82%	100%	89%	82%	93%	27%	39%
1082	RET 4L4' LED Tube, 2018-2019	100%	100%	100%	100%	100%	100%	93%	100%	100%	100%	100%	100%
1083	RET LED Troffer (base 4L4'T8), 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1084	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base RET)	77%	89%	54%	100%	68%	81%	85%	84%	79%	96%	84%	90%
1085	Advanced Lighting Controls (2018-2019 Base RET)	100%	99%	73%	100%	100%	99%	100%	92%	100%	89%	30%	100%
1086	Daylight Dimming Controls (2018-2019 Base RET)	64%	99%	100%	99%	76%	82%	95%	91%	77%	88%	31%	100%
1087	Custom Lighting, Base 4L4'T8, 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--ROB	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1101	ROB 4L4' Low Watt High Performance T8 (83 W), 2018-2019	62%	98%	80%	97%	82%	82%	100%	89%	82%	93%	27%	39%
1102	ROB 4L4' LED Tube, 2018-2019	100%	100%	100%	100%	100%	100%	93%	100%	100%	100%	100%	100%
1103	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base ROB)	77%	89%	54%	100%	68%	81%	85%	84%	79%	96%	84%	90%
1104	Advanced Lighting Controls (2018-2019 Base ROB)	100%	99%	73%	100%	100%	99%	100%	92%	100%	89%	30%	100%
1105	Daylight Dimming Controls (2018-2019 Base ROB)	64%	99%	100%	99%	76%	82%	95%	91%	77%	88%	31%	100%
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1111	Upstream 4L4' Low Watt High Performance T8 (83 W), 2018-2019	62%	98%	80%	97%	82%	82%	100%	89%	82%	93%	27%	39%
1112	Upstream 4L4' LED Tube, 2018-2019	100%	100%	100%	100%	100%	100%	93%	100%	100%	100%	100%	100%
1113	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base Upstream)	77%	89%	54%	100%	68%	81%	85%	84%	79%	96%	84%	90%

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Commercial Electric Measure Inputs		Incomplete Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
1114	Advanced Lighting Controls (2018-2019 Base Up)	100%	99%	73%	100%	100%	99%	100%	92%	100%	89%	30%	100%
1115	Daylight Dimming Controls (2018-2019 Base Up)	64%	99%	100%	99%	76%	82%	95%	91%	77%	88%	31%	100%
1120	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--RET	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1121	RET 4L4' Low Watt High Performance T8 (83 W), 2020	62%	98%	80%	97%	82%	82%	100%	89%	82%	93%	27%	39%
1122	RET 4L4' LED Tube, 2020	100%	100%	100%	100%	100%	100%	93%	100%	100%	100%	100%	100%
1123	RET LED Troffer (base 4L4'T8), 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1124	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base RET)	77%	89%	54%	100%	68%	81%	85%	84%	79%	96%	84%	90%
1125	Advanced Lighting Controls (2020 Base RET)	100%	99%	73%	100%	100%	99%	100%	92%	100%	89%	30%	100%
1126	Daylight Dimming Controls (2020 Base RET)	64%	99%	100%	99%	76%	82%	95%	91%	77%	88%	31%	100%
1127	Custom Lighting, Base 4L4'T8, 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--ROB	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1151	ROB 4L4' Low Watt High Performance T8 (83 W), 2020	62%	98%	80%	97%	82%	82%	100%	89%	82%	93%	27%	39%
1152	ROB 4L4' LED Tube, 2020	100%	100%	100%	100%	100%	100%	93%	100%	100%	100%	100%	100%
1153	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base ROB)	77%	89%	54%	100%	68%	81%	85%	84%	79%	96%	84%	90%
1154	Advanced Lighting Controls (2020 Base ROB)	100%	99%	73%	100%	100%	99%	100%	92%	100%	89%	30%	100%
1155	Daylight Dimming Controls (2020 Base ROB)	64%	99%	100%	99%	76%	82%	95%	91%	77%	88%	31%	100%
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1161	Upstream 4L4' Low Watt High Performance T8 (83 W), 2020	62%	98%	80%	97%	82%	82%	100%	89%	82%	93%	27%	39%
1162	Upstream 4L4' LED Tube, 2020	100%	100%	100%	100%	100%	100%	93%	100%	100%	100%	100%	100%
1163	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base Upstream)	77%	89%	54%	100%	68%	81%	85%	84%	79%	96%	84%	90%
1164	Advanced Lighting Controls (2020 Base Up)	100%	99%	73%	100%	100%	99%	100%	92%	100%	89%	30%	100%
1165	Daylight Dimming Controls (2020 Base Up)	64%	99%	100%	99%	76%	82%	95%	91%	77%	88%	31%	100%
1200	Base Other Fluorescent Fixture--RET	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1201	RET Low Watt High Performance T8	85%	81%	100%	100%	100%	100%	100%	71%	100%	100%	100%	100%
1202	RET LED Tube	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1203	RET LED Troffer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1204	Occupancy Sensor (Base Other Fluor RET)	93%	94%	99%	89%	100%	99%	100%	98%	100%	100%	100%	100%
1205	Advanced Lighting Controls (Base Other Fluor RET)	100%	91%	100%	100%	100%	100%	100%	95%	51%	62%	40%	100%
1206	Daylight Dimming Controls (Base Other Fluor RET)	72%	98%	100%	100%	100%	100%	88%	99%	100%	62%	95%	100%
1207	Custom Lighting, Base Other Fluorescent	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1210	Base Other Fluorescent Fixture--ROB	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1211	ROB Low Watt High Performance T8	85%	81%	100%	100%	100%	100%	100%	71%	100%	100%	100%	100%
1212	ROB LED Tube	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1213	Occupancy Sensor (Base Other Fluor ROB)	93%	94%	99%	89%	100%	99%	100%	98%	100%	100%	100%	100%
1214	Advanced Lighting Controls (Base Other Fluor ROB)	100%	91%	100%	100%	100%	100%	100%	95%	51%	62%	40%	100%
1215	Daylight Dimming Controls (Base Other Fluor ROB)	72%	98%	100%	100%	100%	100%	88%	99%	100%	62%	95%	100%
1220	Base Other Fluorescent Fixture--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1221	Upstream Low Watt High Performance T8	85%	81%	100%	100%	100%	100%	100%	71%	100%	100%	100%	100%
1222	Upstream LED Tube	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1223	Occupancy Sensor (Base Other Fluor Upstream)	93%	94%	99%	89%	100%	99%	100%	98%	100%	100%	100%	100%
1224	Advanced Lighting (Base Other Fluor Upstream)	100%	91%	100%	100%	100%	100%	100%	95%	51%	62%	40%	100%
1225	Daylight Dimming Controls (Base Other Fluor Upstream)	72%	98%	100%	100%	100%	100%	88%	99%	100%	62%	95%	100%
1300	Base Incandescent Lamp, 72W 2015--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1301	LED Track Lighting (base Incandescent 72W) 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1310	Base Incandescent Lamp, 72W 2015--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1311	Upstream LEDs (base Incandescent 72W) 2015	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%
1320	Base Incandescent Lamp, 72W 2016-2017--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1321	LED Track Lighting (base Incandescent 72W) 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1331	Upstream LEDs (base Incandescent 72W) 2016-2017	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%
1340	Base Incandescent Lamp, 72W 2018-2019--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1341	LED Track Lighting (base Incandescent 72W) 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1351	Upstream LEDs (base Incandescent 72W) 2018-2019	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%
1360	Base Incandescent Lamp, 72W 2020--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1361	LED Track Lighting (base Incandescent 72W) 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1370	Base Incandescent Lamp, 72W 2020--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1371	Upstream LEDs (base Incandescent 72W) 2020	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%

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Commercial Electric Measure Inputs		Incomplete Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
1400	Base CFL Lamp, 23W 2015--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1401	LED Track Lighting (base CFL spiral 23W) 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1410	Base CFL Lamp, 23W 2015--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1411	Upstream LEDs (base CFL spiral 23W) 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1420	Base CFL Lamp, 23W 2016-2017--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1421	LED Track Lighting (base CFL spiral 23W) 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1430	Base CFL Lamp, 23W 2016-2017--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1440	Base CFL Lamp, 23W 2018-2019--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1441	LED Track Lighting (base CFL spiral 23W) 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1450	Base CFL Lamp, 23W 2018-2019--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1460	Base CFL Lamp, 23W 2020--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1461	LED Track Lighting (base CFL spiral 23W) 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1470	Base CFL Lamp, 23W 2020--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1471	Upstream LEDs (base CFL spiral 23W) 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1500	Base Metal Halide, 400W	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1501	High Bay T5 HO (240W)	5%	47%	100%	91%	100%	100%	99%	3%	68%	54%	25%	100%
1502	High Bay Induction Lighting	100%	100%	100%	100%	100%	100%	100%	97%	100%	100%	100%	100%
1503	PSMH with electronic ballast	100%	34%	97%	100%	100%	100%	99%	100%	99%	99%	100%	100%
1504	High Bay LED Lighting	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1600	Base HPS (high pressure sodium) Parking Garage Lighting	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1601	High-efficiency fluorescent parking garage fixture	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1602	LED Parking Garage Fixtures	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1603	Bi-Level LED Parking Garage Fixtures	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90%
1700	Base CFL Exit Sign	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1701	LED Exit Sign	20.13%	39.40%	33.82%	66.18%	80.23%	42.43%	20.15%	12.55%	56.43%	48.67%	79.86%	5%
1800	Base Outdoor High Pressure Sodium 250W Lamp	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1801	LED Outdoor Area Lighting (other than pole-mounted)	98.58%	31.58%	100.00%	100.00%	100.00%	85.91%	95.18%	96.72%	100.00%	92.83%	97.74%	21%
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	68.00%	68.00%	68.00%	68.00%	68.00%	68.00%	68.00%	68.00%	68.00%	68.00%	68.00%	68%
2002	Chiller VSD	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40%
2003	EMS - Chiller	81.21%	87.93%	38.70%	100.00%	100.00%	51.43%	100.00%	90.74%	7.26%	38.87%	26.88%	0%
2004	Cool Roof - Chiller	100.00%	48.70%	100.00%	0.00%	87.80%	87.80%	100.00%	33.80%	100.00%	100.00%	0.00%	0%
2006	VSD for Chiller Pumps and Towers	100.00%	99.55%	100.00%	100.00%	93.12%	100.00%	96.72%	83.72%	99.05%	39.10%	99.53%	100%
2008	Ceiling/roof Insulation - Chiller	0.00%	0.00%	0.00%	57.00%	0.00%	0.00%	0.00%	15.00%	19.00%	19.00%	15.00%	33%
2009	Custom HVAC--Base Chiller	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2010	Custom Shell--Base Chiller	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2100	Base DX Packaged System, EER=10.0, 30 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2101	ROB DX Packaged System, EER=10.8, 30 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2102	ROB DX Packaged System, EER=11.7, 30 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2104	Automated Fault Detection	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2106	Advanced Controllers for RTUs	6.71%	3.16%	2.16%	2.12%	1.74%	25.84%	3.45%	0.83%	7.93%	0.00%	0.00%	0%
2107	Programmable Communicating Thermostat	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2108	Prog. Thermostat - DX	12.70%	75.40%	2.80%	31.30%	27.30%	27.30%	33.00%	13.00%	8.50%	8.50%	62.20%	64%
2109	Cool Roof - DX	100.00%	93.70%	100.00%	90.90%	100.00%	100.00%	100.00%	94.30%	99.90%	99.90%	65.50%	78%
2110	RTU VSD	100.00%	99.55%	100.00%	100.00%	93.12%	100.00%	96.72%	83.72%	99.05%	39.10%	99.53%	100%
2111	Dual Enthalpy Economizer Controls	53.00%	53.00%	53.00%	53.00%	53.00%	53.00%	53.00%	53.00%	53.00%	53.00%	53.00%	53%
2113	Aerosol Duct Sealing	37.10%	100.00%	100.00%	91.60%	100.00%	100.00%	100.00%	100.00%	96.00%	96.00%	100.00%	97%
2114	Ceiling/roof Insulation - DX	0.00%	1.10%	0.90%	0.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	35%
2115	Duct/Pipe Insulation - DX	27.00%	96.00%	100.00%	81.00%	73.00%	73.00%	72.00%	42.70%	42.00%	42.00%	48.50%	13%
2116	Custom HVAC--DX	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2117	Custom Shell--DX	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2201	Air Source Heat Pump, EER=11.3, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2300	Base PTAC, EER=8.3, 1 ton	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2301	Occupancy Sensor (hotels)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%

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Commercial Electric Measure Inputs		Incomplete Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
3001	Variable Speed Drive Control, 5 HP	100.00%	99.73%	100.00%	100.00%	100.00%	80.56%	100.00%	96.00%	100.00%	100.00%	100.00%	100%
3002	Custom HVAC--Base Fan Motor, 5hp	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3101	Variable Speed Drive Control, 15 HP	100.00%	27.66%	100.00%	100.00%	100.00%	100.00%	100.00%	41.36%	54.91%	100.00%	100.00%	100%
3102	Air Handler Optimization, 15 HP	81.00%	100.00%	100.00%	100.00%	0.00%	0.00%	100.00%	95.00%	100.00%	100.00%	100.00%	100%
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	71.06%	97.81%	100.00%	100.00%	100.00%	100.00%	100.00%	42.12%	100.00%	100.00%	100.00%	100%
3104	Separate Makeup Air / Exhaust Hoods AC	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3105	Custom HVAC--Base Fan Motor, 15hp	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3201	Variable Speed Drive Control, 40 HP	0.00%	81.50%	100.00%	100.00%	0.00%	0.00%	100.00%	33.80%	1.60%	1.60%	100.00%	7%
3202	Air Handler Optimization, 40 HP	81.00%	100.00%	100.00%	100.00%	0.00%	0.00%	100.00%	95.00%	100.00%	100.00%	100.00%	100%
3203	Demand Controlled Ventilation (40 HP fan motor)	100.00%	90.20%	100.00%	100.00%	65.20%	65.20%	100.00%	42.10%	12.60%	12.60%	100.00%	7%
3204	Custom HVAC--Base Fan Motor, 40hp	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4000	Base Built-Up Refrigeration System	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4001	Strip curtains for walk-ins (built-up)	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
4002	Auto-closer on main door to walk-in freezer (built-up)	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50%
4003	Night covers for display cases	68.42%	100.00%	90.56%	95.66%	96.90%	99.30%	99.00%	69.00%	96.00%	100.00%	97.00%	100%
4004	Evaporator fan controller for MT walk-ins	43.80%	20.81%	22.03%	26.40%	37.28%	29.56%	29.60%	60.40%	56.60%	65.80%	51.30%	5%
4005	Electronically commutated evaporator fan motor	82.00%	100.00%	57.00%	100.00%	100.00%	100.00%	100.00%	64.00%	100.00%	100.00%	48.00%	48%
4006	Efficient compressor motor	0.00%	0.00%	2.65%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
4007	Floating head pressure controls	0.00%	0.00%	3.38%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
4008	Refrigeration Commissioning	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50%
4009	Demand Hot Gas Defrost	0.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	57.90%	100.00%	100.00%	100.00%	0%
4010	Demand Defrost Electric	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	19.40%	0%
4011	Anti-sweat (humidistat) controls	0.00%	0.00%	27.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
4012	Freezer-Cooler Replacement Gaskets	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50%
4013	High R-Value Glass Doors	0.00%	0.00%	94.80%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	100.00%	0%
4014	LED Display Lighting (Base T8 Lighting)	100.00%	100.00%	80.39%	76.07%	100.00%	60.13%	90.27%	96.44%	92.82%	94.40%	99.14%	100%
4016	Multiplex Compressor System	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	88.61%	100.00%	100.00%	100%
4017	Oversized Air Cooled Condenser	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50%
4018	Custom Refrigeration	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	88.61%	100.00%	100.00%	100%
4500	Base Self-Contained Refrigeration	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4501	Strip curtains for walk-ins (self-contained)	48.20%	86.95%	20.90%	59.68%	72.77%	72.77%	47.99%	87.74%	40.12%	100.00%	80.20%	10%
4502	Auto-closer on main door to walk-in freezer (self-contained)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
4503	Night covers for display cases (self-contained)	68.42%	100.00%	90.56%	95.66%	96.90%	96.90%	99.30%	69.46%	95.81%	100.00%	96.96%	100%
4504	LED Display Lighting (Base T8 Lighting)	100.00%	100.00%	80.39%	76.07%	100.00%	60.13%	90.27%	96.44%	92.82%	94.40%	99.14%	100%
4506	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64%
4507	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66%
4508	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64%
4509	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64%
4510	ENERGY STAR Ice Machines	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64%
4511	Hydraulic-type door closer on reach-in cooler glass doors	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50%
4512	Doors for open cases	86.56%	100.00%	96.26%	100.00%	98.76%	98.82%	100.00%	100.00%	61.54%	100.00%	100.00%	100%
6000	Base Water Heating	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6001	Demand controlled circulating systems	100.00%	100.00%	97.10%	100.00%	100.00%	100.00%	100.00%	78.90%	100.00%	100.00%	39.80%	51%
6003	Hot Water Pipe Insulation	94.60%	9.10%	97.10%	0.00%	100.00%	100.00%	100.00%	27.80%	79.10%	79.10%	100.00%	99%
6004	Tankless Water Heater	100.00%	87.13%	100.00%	100.00%	100.00%	100.00%	90.04%	98.39%	98.98%	100.00%	99.21%	95%
6005	Heat Pump Water Heater (air source)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6006	Heat Recovery Unit	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6007	Heat Trap	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75%
6008	Solar Water Heater	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6009	High Temperature Dishwasher	89.47%	100.00%	97.09%	100.00%	100.00%	100.00%	78.94%	100.00%	39.84%	50.64%	50.64%	51%
7000	Base Refrigerated Vending Machines	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
7001	Vending Misers (Refrigerated units)	100.00%	85.35%	100.00%	87.23%	100.00%	45.83%	97.47%	72.77%	66.63%	100.00%	99.56%	24%
7002	Vending Misers (Refrigerated glass-front units)	100.00%	85.35%	100.00%	87.23%	100.00%	45.83%	97.47%	72.77%	66.63%	100.00%	99.56%	24%
7003	Refrigerated Vending Low Watt High Performance T8	85.22%	92.18%	85.46%	99.51%	95.63%	91.96%	88.19%	100.00%	80.36%	56.76%	56.76%	57%
7500	Base Non-Refrigerated Vending Machines	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
7501	Vending Misers (Non-Refrigerated)	100.00%	85.35%	100.00%	87.23%	100.00%	45.83%	97.47%	72.77%	66.63%	100.00%	99.56%	24%

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Commercial Electric Measure Inputs		**Incomplete Factor (percent)**											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
7502	Non-refrigerated Vending Low Watt High Performance T8	85.22%	92.18%	85.46%	99.51%	95.63%	91.96%	88.19%	100.00%	80.36%	56.76%	56.76%	57%
8000	Base Oven	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8001	Convection Oven	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	59.78%	100.00%	100.00%	100.00%	100.00%	100%
8100	Base Fryer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8101	Efficient Fryer	100.00%	100.00%	100.00%	83.12%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8200	Base Steamer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8201	Efficient Steamer	100.00%	98.78%	100.00%	100.00%	100.00%	100.00%	100.00%	26.11%	100.00%	100.00%	100.00%	100%
8300	Base Hot Food Holding Cabinet	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8301	ENERGY STAR Hot Food Holding Cabinets	100.00%	97.42%	100.00%	91.36%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8500	Base Compressed Air	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8700	Base Heating	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9000	Base Miscellaneous	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9500	Base Whole Building	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9501	NEMA Premium Efficiency Transformer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9502	Retrocommissioning/Building tune up	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80%
9503	Custom O&M	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015 (New)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1001	NEW 3L4'T5, 2015	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1002	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015	98.28%	86.01%	98.41%	92.63%	99.38%	100.00%	97.36%	99.21%	100.00%	100.00%	100.00%	100%
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1012	Upstream 4L4' LED Tube, 2015	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1013	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015 (Base Upstream)	98.28%	86.01%	98.41%	92.63%	99.38%	100.00%	97.36%	99.21%	100.00%	100.00%	100.00%	100%
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017 (New)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1051	NEW 3L4'T5, 2016-2017	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1052	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017	98.28%	86.01%	98.41%	92.63%	99.38%	100.00%	97.36%	99.21%	100.00%	100.00%	100.00%	100%
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1062	Upstream 4L4' LED Tube, 2016-2017	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1063	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017 (Base Upstrea	98.28%	86.01%	98.41%	92.63%	99.38%	100.00%	97.36%	99.21%	100.00%	100.00%	100.00%	100%
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019 (New)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1101	NEW 3L4'T5, 2018-2019	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1102	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019	98.28%	86.01%	98.41%	92.63%	99.38%	100.00%	97.36%	99.21%	100.00%	100.00%	100.00%	100%
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1112	Upstream 4L4' LED Tube, 2018-2019	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1113	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019 (Base Upstrea	98.28%	86.01%	98.41%	92.63%	99.38%	100.00%	97.36%	99.21%	100.00%	100.00%	100.00%	100%
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020 (New)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1151	NEW 3L4'T5, 2020	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1152	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020	98.28%	86.01%	98.41%	92.63%	99.38%	100.00%	97.36%	99.21%	100.00%	100.00%	100.00%	100%
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1162	Upstream 4L4' LED Tube, 2020	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1163	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020 (Base Upstream)	98.28%	86.01%	98.41%	92.63%	99.38%	100.00%	97.36%	99.21%	100.00%	100.00%	100.00%	100%
1200	Base Other Fluorescent Fixture (New)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1201	NEW T5	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1202	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings	98.28%	86.01%	98.41%	92.63%	99.38%	100.00%	97.36%	99.21%	100.00%	100.00%	100.00%	100%
1210	Base Other Fluorescent Fixture--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1211	Upstream Low Watt High Performance T8	98.64%	98.64%	98.29%	100.00%	100.00%	100.00%	97.70%	99.58%	100.00%	78.24%	78.24%	78%
1212	Upstream LED Tube	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1213	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings (Base Upstream)	98.28%	86.01%	98.41%	92.63%	99.38%	100.00%	97.36%	99.21%	100.00%	100.00%	100.00%	100%
1300	Base Incandescent Lamp, 72W 2015--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1301	New LEDs (base incandescent 72W) 2015	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62%
1310	Base Incandescent Lamp, 72W 2015--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1311	Upstream LEDs (base incandescent 72W) 2015	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62%
1320	Base Incandescent Lamp, 72W 2016-2017--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1321	New LEDs (base incandescent 72W) 2016-2017	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62%
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1331	Upstream LEDs (base incandescent 72W) 2016-2017	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62%
1340	Base Incandescent Lamp, 72W 2018-2019--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1341	New LEDs (base incandescent 72W) 2018-2019	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62%
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%

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Commercial Electric Measure Inputs		Incomplete Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
1351	Upstream LEDs (base incandescent 72W) 2018-2019	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62%
1360	Base Incandescent Lamp, 72W 2020--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1361	New LEDs (base incandescent 72W) 2020	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62%
1370	Base Incandescent Lamp, 72W 2020--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1371	Upstream LEDs (base incandescent 72W) 2020	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62.17%	62%
1400	Base CFL Lamp, 23W 2015--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1401	New LEDs (base CFL spiral 23W) 2015	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1410	Base CFL Lamp, 23W 2015--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1411	Upstream LEDs (base CFL spiral 23W) 2015	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1420	Base CFL Lamp, 23W 2016-2017--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1421	New LEDs (base CFL spiral 23W) 2016-2017	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1430	Base CFL Lamp, 23W 2016-2017--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1440	Base CFL Lamp, 23W 2018-2019--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1441	New LEDs (base CFL spiral 23W) 2018-2019	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1450	Base CFL Lamp, 23W 2018-2019--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1460	Base CFL Lamp, 23W 2020--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1461	New LEDs (base CFL spiral 23W) 2020	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1470	Base CFL Lamp, 23W 2020--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1471	Upstream LEDs (base CFL spiral 23W) 2020	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1500	Base Metal Halide, 400W	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1501	High Bay T5 HO (240W)	5.09%	47.39%	100.00%	91.11%	100.00%	100.00%	98.96%	2.62%	68.04%	53.62%	25.49%	100%
1502	High Bay Induction Lighting	100.00%	99.93%	100.00%	100.00%	100.00%	100.00%	100.00%	97.38%	100.00%	100.00%	100.00%	100%
1600	Base HID Parking Garage Lighting	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1601	LED Parking Garage Fixtures	100.00%	100.00%	100.00%	100.00%	0.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1602	Bi-Level LED Parking Garage Fixtures	90.00%	90.00%	90.00%	90.00%	-10.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90%
1700	Base CFL Exit Sign	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1800	Base Outdoor High Pressure Sodium 250W Lamp	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1801	LED Outdoor Area Lighting (other than pole-mounted)	98.58%	31.58%	100.00%	100.00%	100.00%	85.91%	95.18%	96.72%	100.00%	92.83%	97.74%	21%
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	68.00%	68.00%	68.00%	68.00%	68.00%	68.00%	68.00%	68.00%	68.00%	68.00%	68.00%	68%
2002	Chilled Beams	66.89%	61.21%	100.00%	0.00%	87.80%	100.00%	33.77%	100.00%	0.00%	0.00%	0.00%	0%
2003	Cool Roof - Chiller	100.00%	48.70%	100.00%	0.00%	87.80%	87.80%	100.00%	33.80%	100.00%	100.00%	0.00%	0%
2005	VSD for Chiller Pumps and Towers	100.00%	99.55%	100.00%	100.00%	93.12%	100.00%	96.72%	83.72%	99.05%	39.10%	99.53%	100%
2100	Base DX Packaged System, EER=10.0, 30 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2101	ROB DX Packaged System, EER=10.8, 30 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2102	ROB DX Packaged System, EER=11.7, 30 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2103	Automated Fault Detection	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2104	RTU VSD	100.00%	99.55%	100.00%	100.00%	93.12%	100.00%	96.72%	83.72%	99.05%	39.10%	99.53%	100%
2106	Aerosol Duct Sealing	37.10%	100.00%	100.00%	91.60%	100.00%	100.00%	100.00%	100.00%	96.00%	96.00%	100.00%	97%
2107	VRF Conditioning Systems	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2201	Air Source Heat Pump, EER=11.3, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2202	Geothermal Heat Pump, EER=18, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2203	VRF Conditioning Systems	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2300	Base PTAC, EER=8.3, 1 ton	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2301	Occupancy Sensor (hotels)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3001	Variable Speed Drive Control, 5 HP	100.00%	99.73%	100.00%	100.00%	100.00%	80.56%	100.00%	96.00%	100.00%	100.00%	100.00%	100%
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3101	Variable Speed Drive Control, 15 HP	100.00%	27.66%	100.00%	100.00%	100.00%	100.00%	100.00%	41.36%	54.91%	100.00%	100.00%	100%
3102	Air Handler Optimization, 15 HP	81.00%	100.00%	100.00%	100.00%	0.00%	0.00%	100.00%	95.00%	100.00%	100.00%	100.00%	100%
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	71.06%	97.81%	100.00%	100.00%	100.00%	100.00%	100.00%	42.12%	100.00%	100.00%	100.00%	100%
3104	Separate Makeup Air / Exhaust Hoods AC	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3201	Variable Speed Drive Control, 40 HP	0.00%	81.50%	100.00%	100.00%	0.00%	0.00%	100.00%	33.80%	1.60%	1.60%	100.00%	7%
3202	Air Handler Optimization, 40 HP	81.00%	100.00%	100.00%	100.00%	0.00%	0.00%	100.00%	95.00%	100.00%	100.00%	100.00%	100%

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Commercial Electric Measure Inputs		Incomplete Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
3203	Demand Controlled Ventilation (40 HP fan motor)	100.00%	90.20%	100.00%	100.00%	65.20%	65.20%	100.00%	42.10%	12.60%	12.60%	100.00%	7%
4000	Base Built-Up Refrigeration System	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4001	Auto-closer on main door to walk-in freezer (built-up)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
4002	Evaporator fan controller for MT walk-ins	43.80%	20.81%	22.03%	26.40%	37.28%	29.56%	29.60%	60.40%	56.60%	65.80%	51.30%	5%
4003	Efficient compressor motor	0.00%	0.00%	2.65%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
4004	Refrigeration Commissioning	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50%
4500	Base Self-Contained Refrigeration	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4501	Auto-closer on main door to walk-in freezer (self-contained)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
4502	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64%
4503	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66%
4504	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64%
4505	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64%
4506	ENERGY STAR Ice Machines	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64.00%	64%
4507	Hydraulic-type door closer on reach-in cooler glass doors	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50%
6000	Base Water Heating	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6001	Demand controlled circulating systems	100.00%	100.00%	97.10%	100.00%	100.00%	100.00%	100.00%	78.90%	100.00%	100.00%	39.80%	51%
6003	Tankless Water Heater	100.00%	87.13%	100.00%	100.00%	100.00%	100.00%	90.04%	98.39%	98.98%	100.00%	99.21%	95%
6004	Heat Pump Water Heater (air source)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6005	Solar Water Heater	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
7000	Base Refrigerated Vending Machines	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
7500	Base Non-Refrigerated Vending Machines	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8000	Base Oven	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8001	Convection Oven	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	59.78%	100.00%	100.00%	100.00%	100.00%	100%
8100	Base Fryer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8101	Efficient Fryer	100.00%	100.00%	100.00%	83.12%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8200	Base Steamer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8201	Efficient Steamer	100.00%	98.78%	100.00%	100.00%	100.00%	100.00%	100.00%	26.11%	100.00%	100.00%	100.00%	100%
8300	Base Hot Food Holding Cabinet	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8301	ENERGY STAR Hot Food Holding Cabinets	100.00%	97.42%	100.00%	91.36%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8500	Base Compressed Air	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8700	Base Heating	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8701	Air Source Heat Pump, EER=11.3, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8702	Geothermal Heat Pump, EER=18, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8703	VRF Conditioning Systems	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9000	Base Miscellaneous	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9500	Base Building Design - Standard Code	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9501	15% better than code - Campuses	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9502	15% better than code - Education	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9503	15% better than code - Food Sales	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9504	15% better than code - Food Service	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9505	15% better than code - Healthcare	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9506	15% better than code - Lodging	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0%
9507	15% better than code - Office	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0%
9508	15% better than code - Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0%
9509	15% better than code - Public Assembly	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0%
9510	15% better than code - Retail	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0%
9511	15% better than code - Warehouse	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
9512	Commissioning	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9600	Base Building Design - Standard Code	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9601	30% better than code - Campuses	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9602	30% better than code - Education	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9603	30% better than code - Food Sales	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9604	30% better than code - Food Service	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9605	30% better than code - Healthcare	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9606	30% better than code - Lodging	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0%
9607	30% better than code - Office	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0%
9608	30% better than code - Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0%
9609	30% better than code - Public Assembly	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0%

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Commercial Electric Measure Inputs		**Incomplete Factor (percent)**											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
9610	30% better than code - Retail	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0%
9611	30% better than code - Warehouse	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
9612	Commissioning	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9700	Base Building Design - Standard Code	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9701	50% better than code - Campuses	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9702	50% better than code - Education	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9703	50% better than code - Food Sales	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9704	50% better than code - Food Service	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9705	50% better than code - Healthcare	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9706	50% better than code - Lodging	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0%
9707	50% better than code - Office	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0%
9708	50% better than code - Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0%
9709	50% better than code - Public Assembly	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0%
9710	50% better than code - Retail	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0%
9711	50% better than code - Warehouse	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
9712	Commissioning	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9800	Base Building Design - Standard Code	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9801	70% better than code - Campuses	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9802	70% better than code - Education	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9803	70% better than code - Food Sales	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9804	70% better than code - Food Service	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9805	70% better than code - Healthcare	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9806	70% better than code - Lodging	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0%
9807	70% better than code - Office	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0%
9808	70% better than code - Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0%
9809	70% better than code - Public Assembly	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0%
9810	70% better than code - Retail	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0%
9811	70% better than code - Warehouse	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
9812	Commissioning	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%

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Commercial Electric Measure Inputs		**FEASIBILITY FACTOR (percent)**											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--RET	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1001	RET 4L4' Low Watt High Performance T8 (83 W), 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1002	RET 4L4' LED Tube, 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1003	RET LED Troffer (base 4L4'T8), 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1004	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base RET)	80%	70%	20%	15%	50%	40%	50%	90%	60%	50%	20%	95%
1005	Advanced Lighting Controls (2015 Base RET)	40%	20%	7%	7%	14%	35%	28%	20%	7%	14%	7%	14%
1006	Daylight Dimming Controls (2015 Base RET)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1007	Custom Lighting, Base 4L4'T8, 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--ROB	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1011	ROB 4L4' Low Watt High Performance T8 (83 W), 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1012	ROB 4L4' LED Tube, 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1013	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base ROB)	80%	70%	20%	15%	50%	40%	50%	90%	60%	50%	20%	95%
1014	Advanced Lighting Controls (2015 Base ROB)	40%	20%	7%	7%	14%	35%	28%	20%	7%	14%	7%	14%
1015	Daylight Dimming Controls (2015 Base ROB)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1020	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1021	Upstream 4L4' Low Watt High Performance T8 (83 W), 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1022	Upstream 4L4' LED Tube, 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1023	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base Upstream)	80%	70%	20%	15%	50%	40%	50%	90%	60%	50%	20%	95%
1024	Advanced Lighting Controls (2015 Base Up)	40%	20%	7%	7%	14%	35%	28%	20%	7%	14%	7%	14%
1025	Daylight Dimming Controls (2015 Base Up)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--RET	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1051	RET 4L4' Low Watt High Performance T8 (83 W), 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1052	RET 4L4' LED Tube, 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1053	RET LED Troffer (base 4L4'T8), 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1054	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base RET)	80%	70%	20%	15%	50%	40%	50%	90%	60%	50%	20%	95%
1055	Advanced Lighting Controls (2016-2017 Base RET)	40%	20%	7%	7%	14%	35%	28%	20%	7%	14%	7%	14%
1056	Daylight Dimming Controls (2016-2017 Base RET)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1057	Custom Lighting, Base 4L4'T8, 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--ROB	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1061	ROB 4L4' Low Watt High Performance T8 (83 W), 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1062	ROB 4L4' LED Tube, 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1063	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base ROB)	80%	70%	20%	15%	50%	40%	50%	90%	60%	50%	20%	95%
1064	Advanced Lighting Controls (2016-2017 Base ROB)	40%	20%	7%	7%	14%	35%	28%	20%	7%	14%	7%	14%
1065	Daylight Dimming Controls (2016-2017 Base ROB)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1070	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1071	Upstream 4L4' Low Watt High Performance T8 (83 W), 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1072	Upstream 4L4' LED Tube, 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1073	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base Upstream)	80%	70%	20%	15%	50%	40%	50%	90%	60%	50%	20%	95%
1074	Advanced Lighting Controls (2016-2017 Base Up)	40%	20%	7%	7%	14%	35%	28%	20%	7%	14%	7%	14%
1075	Daylight Dimming Controls (2016-2017 Base Up)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1080	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--RET	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1081	RET 4L4' Low Watt High Performance T8 (83 W), 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1082	RET 4L4' LED Tube, 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1083	RET LED Troffer (base 4L4'T8), 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1084	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base RET)	80%	70%	20%	15%	50%	40%	50%	90%	60%	50%	20%	95%
1085	Advanced Lighting Controls (2018-2019 Base RET)	40%	20%	7%	7%	14%	35%	28%	20%	7%	14%	7%	14%
1086	Daylight Dimming Controls (2018-2019 Base RET)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1087	Custom Lighting, Base 4L4'T8, 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--ROB	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1101	ROB 4L4' Low Watt High Performance T8 (83 W), 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1102	ROB 4L4' LED Tube, 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1103	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base ROB)	80%	70%	20%	15%	50%	40%	50%	90%	60%	50%	20%	95%
1104	Advanced Lighting Controls (2018-2019 Base ROB)	40%	20%	7%	7%	14%	35%	28%	20%	7%	14%	7%	14%
1105	Daylight Dimming Controls (2018-2019 Base ROB)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

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Commercial Electric Measure Inputs		FEASIBILITY FACTOR (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1111	Upstream 4L4' Low Watt High Performance T8 (83 W), 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1112	Upstream 4L4' LED Tube, 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1113	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base Upstream)	80%	70%	20%	15%	50%	40%	50%	90%	60%	50%	20%	95%
1114	Advanced Lighting Controls (2018-2019 Base Up)	40%	20%	7%	7%	14%	35%	28%	20%	7%	14%	7%	14%
1115	Daylight Dimming Controls (2018-2019 Base Up)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1120	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--RET	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1121	RET 4L4' Low Watt High Performance T8 (83 W), 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1122	RET 4L4' LED Tube, 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1123	RET LED Troffer (base 4L4'T8), 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1124	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base RET)	80%	70%	20%	15%	50%	40%	50%	90%	60%	50%	20%	95%
1125	Advanced Lighting Controls (2020 Base RET)	40%	20%	7%	7%	14%	35%	28%	20%	7%	14%	7%	14%
1126	Daylight Dimming Controls (2020 Base RET)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1127	Custom Lighting, Base 4L4'T8, 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--ROB	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1151	ROB 4L4' Low Watt High Performance T8 (83 W), 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1152	ROB 4L4' LED Tube, 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1153	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base ROB)	80%	70%	20%	15%	50%	40%	50%	90%	60%	50%	20%	95%
1154	Advanced Lighting Controls (2020 Base ROB)	40%	20%	7%	7%	14%	35%	28%	20%	7%	14%	7%	14%
1155	Daylight Dimming Controls (2020 Base ROB)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1161	Upstream 4L4' Low Watt High Performance T8 (83 W), 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1162	Upstream 4L4' LED Tube, 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1163	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base Upstream)	80%	70%	20%	15%	50%	40%	50%	90%	60%	50%	20%	95%
1164	Advanced Lighting Controls (2020 Base Up)	40%	20%	7%	7%	14%	35%	28%	20%	7%	14%	7%	14%
1165	Daylight Dimming Controls (2020 Base Up)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1200	Base Other Fluorescent Fixture--RET	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1201	RET Low Watt High Performance T8	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1202	RET LED Tube	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1203	RET LED Troffer	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1204	Occupancy Sensor (Base Other Fluor RET)	80%	70%	20%	15%	50%	40%	50%	90%	60%	50%	20%	95%
1205	Advanced Lighting Controls (Base Other Fluor RET)	40%	20%	7%	7%	14%	35%	28%	20%	7%	14%	7%	14%
1206	Daylight Dimming Controls (Base Other Fluor RET)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1207	Custom Lighting, Base Other Fluorescent	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1210	Base Other Fluorescent Fixture--ROB	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1211	ROB Low Watt High Performance T8	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1212	ROB LED Tube	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1213	Occupancy Sensor (Base Other Fluor ROB)	80%	70%	20%	15%	50%	40%	50%	90%	60%	50%	20%	95%
1214	Advanced Lighting Controls (Base Other Fluor ROB)	40%	20%	7%	7%	14%	35%	28%	20%	7%	14%	7%	14%
1215	Daylight Dimming Controls (Base Other Fluor ROB)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1220	Base Other Fluorescent Fixture--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1221	Upstream Low Watt High Performance T8	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1222	Upstream LED Tube	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
1223	Occupancy Sensor (Base Other Fluor Upstream)	80%	70%	20%	15%	50%	40%	50%	90%	60%	50%	20%	95%
1224	Advanced Lighting (Base Other Fluor Upstream)	40%	20%	7%	7%	14%	35%	28%	20%	7%	14%	7%	14%
1225	Daylight Dimming Controls (Base Other Fluor Upstream)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1300	Base Incandescent Lamp, 72W 2015--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1301	LED Track Lighting (base Incandescent 72W) 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1310	Base Incandescent Lamp, 72W 2015--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1311	Upstream LEDs (base Incandescent 72W) 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1320	Base Incandescent Lamp, 72W 2016-2017--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1321	LED Track Lighting (base Incandescent 72W) 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1331	Upstream LEDs (base Incandescent 72W) 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1340	Base Incandescent Lamp, 72W 2018-2019--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1341	LED Track Lighting (base Incandescent 72W) 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Commercial Electric Measure Inputs — **FEASIBILITY FACTOR (percent)**

Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1351	Upstream LEDs (base Incandescent 72W) 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1360	Base Incandescent Lamp, 72W 2020--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1361	LED Track Lighting (base Incandescent 72W) 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1370	Base Incandescent Lamp, 72W 2020--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1371	Upstream LEDs (base Incandescent 72W) 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1400	Base CFL Lamp, 23W 2015--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1401	LED Track Lighting (base CFL spiral 23W) 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1410	Base CFL Lamp, 23W 2015--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1411	Upstream LEDs (base CFL spiral 23W) 2015	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1420	Base CFL Lamp, 23W 2016-2017--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1421	LED Track Lighting (base CFL spiral 23W) 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1430	Base CFL Lamp, 23W 2016-2017--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1440	Base CFL Lamp, 23W 2018-2019--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1441	LED Track Lighting (base CFL spiral 23W) 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1450	Base CFL Lamp, 23W 2018-2019--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1460	Base CFL Lamp, 23W 2020--Hardwired	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1461	LED Track Lighting (base CFL spiral 23W) 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1470	Base CFL Lamp, 23W 2020--Upstream	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1471	Upstream LEDs (base CFL spiral 23W) 2020	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1500	Base Metal Halide, 400W	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1501	High Bay T5 HO (240W)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1502	High Bay Induction Lighting	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1503	PSMH with electronic ballast	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1504	High Bay LED Lighting	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1600	Base HPS (high pressure sodium) Parking Garage Lighting	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1601	High-efficiency fluorescent parking garage fixture	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1602	LED Parking Garage Fixtures	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1603	Bi-Level LED Parking Garage Fixtures	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80%
1700	Base CFL Exit Sign	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1701	LED Exit Sign	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1800	Base Outdoor High Pressure Sodium 250W Lamp	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1801	LED Outdoor Area Lighting (other than pole-mounted)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2002	Chiller VSD	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2003	EMS - Chiller	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2004	Cool Roof - Chiller	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50%
2006	VSD for Chiller Pumps and Towers	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2008	Ceiling/roof Insulation - Chiller	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10%
2009	Custom HVAC--Base Chiller	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2010	Custom Shell--Base Chiller	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2100	Base DX Packaged System, EER=10.0, 30 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2101	ROB DX Packaged System, EER=10.8, 30 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2102	ROB DX Packaged System, EER=11.7, 30 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2104	Automated Fault Detection	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5%
2106	Advanced Controllers for RTUs	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2107	Programmable Communicating Thermostat	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2108	Prog. Thermostat - DX	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2109	Cool Roof - DX	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50%
2110	RTU VSD	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%	20%
2111	Dual Enthalpy Economizer Controls	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5%
2113	Aerosol Duct Sealing	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%	32%
2114	Ceiling/roof Insulation - DX	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5%

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Commercial Electric Measure Inputs		FEASIBILITY FACTOR (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
2115	Duct/Pipe Insulation - DX	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75%
2116	Custom HVAC--DX	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2117	Custom Shell--DX	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2201	Air Source Heat Pump, EER=11.3, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2300	Base PTAC, EER=8.3, 1 ton	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2301	Occupancy Sensor (hotels)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	75.00%	0.00%	0.00%	0.00%	0.00%	0%
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3001	Variable Speed Drive Control, 5 HP	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3002	Custom HVAC--Base Fan Motor, 5hp	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3101	Variable Speed Drive Control, 15 HP	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3102	Air Handler Optimization, 15 HP	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3104	Separate Makeup Air / Exhaust Hoods AC	20.00%	15.00%	10.00%	15.00%	10.00%	15.00%	5.00%	0.00%	10.00%	5.00%	5.00%	5%
3105	Custom HVAC--Base Fan Motor, 15hp	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3201	Variable Speed Drive Control, 40 HP	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	82.57%	100.00%	100.00%	100.00%	100.00%	100%
3202	Air Handler Optimization, 40 HP	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3203	Demand Controlled Ventilation (40 HP fan motor)	85.00%	85.00%	85.00%	90.00%	80.00%	80.00%	80.00%	80.00%	70.00%	80.00%	80.00%	80%
3204	Custom HVAC--Base Fan Motor, 40hp	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4000	Base Built-Up Refrigeration System	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4001	Strip curtains for walk-ins (built-up)	100.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
4002	Auto-closer on main door to walk-in freezer (built-up)	100.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
4003	Night covers for display cases	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
4004	Evaporator fan controller for MT walk-ins	100.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
4005	Electronically commutated evaporator fan motor	100.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
4006	Efficient compressor motor	100.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100%
4007	Floating head pressure controls	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100%
4008	Refrigeration Commissioning	100.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100%
4009	Demand Hot Gas Defrost	100.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
4010	Demand Defrost Electric	100.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
4011	Anti-sweat (humidistat) controls	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
4012	Freezer-Cooler Replacement Gaskets	100.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
4013	High R-Value Glass Doors	0.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
4014	LED Display Lighting (Base T8 Lighting)	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
4016	Multiplex Compressor System	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100%
4017	Oversized Air Cooled Condenser	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100%
4018	Custom Refrigeration	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100%
4500	Base Self-Contained Refrigeration	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4501	Strip curtains for walk-ins (self-contained)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4502	Auto-closer on main door to walk-in freezer (self-contained)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4503	Night covers for display cases (self-contained)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4504	LED Display Lighting (Base T8 Lighting)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4506	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4507	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4508	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4509	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4510	ENERGY STAR Ice Machines	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4511	Hydraulic-type door closer on reach-in cooler glass doors	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4512	Doors for open cases	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6000	Base Water Heating	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6001	Demand controlled circulating systems	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75%
6003	Hot Water Pipe Insulation	78.81%	54.54%	100.00%	100.00%	100.00%	100.00%	57.99%	99.63%	82.14%	99.30%	82.14%	99%
6004	Tankless Water Heater	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75%
6005	Heat Pump Water Heater (air source)	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80%
6006	Heat Recovery Unit	7.50%	15.00%	80.00%	80.00%	80.00%	20.00%	10.00%	5.00%	5.00%	10.00%	5.00%	10%
6007	Heat Trap	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75%

DNV·GL

Commercial Electric Measure Inputs		**FEASIBILITY FACTOR (percent)**											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
6008	Solar Water Heater	38.00%	10.00%	20.00%	20.00%	20.00%	20.00%	76.00%	0.00%	4.00%	49.00%	4.00%	49%
6009	High Temperature Dishwasher	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75%
7000	Base Refrigerated Vending Machines	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
7001	Vending Misers (Refrigerated units)	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70%
7002	Vending Misers (Refrigerated glass-front units)	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70%
7003	Refrigerated Vending Low Watt High Performance T8	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70%
7500	Base Non-Refrigerated Vending Machines	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
7501	Vending Misers (Non-Refrigerated)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
7502	Non-refrigerated Vending Low Watt High Performance T8	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8000	Base Oven	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8001	Convection Oven	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8100	Base Fryer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8101	Efficient Fryer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8200	Base Steamer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8201	Efficient Steamer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8300	Base Hot Food Holding Cabinet	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8301	ENERGY STAR Hot Food Holding Cabinets	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8500	Base Compressed Air	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8700	Base Heating	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9000	Base Miscellaneous	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9500	Base Whole Building	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9501	NEMA Premium Efficiency Transformer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9502	Retrocommissioning/Building tune up	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9503	Custom O&M	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015 (New)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1001	NEW 3L4'T5, 2015	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1002	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1012	Upstream 4L4' LED Tube, 2015	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1013	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015 (Base Upstream)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017 (New)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1051	NEW 3L4'T5, 2016-2017	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1052	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1062	Upstream 4L4' LED Tube, 2016-2017	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1063	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017 (Base Upstrea	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019 (New)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1101	NEW 3L4'T5, 2018-2019	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1102	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1112	Upstream 4L4' LED Tube, 2018-2019	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1113	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019 (Base Upstrea	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020 (New)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1151	NEW 3L4'T5, 2020	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1152	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1162	Upstream 4L4' LED Tube, 2020	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1163	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020 (Base Upstream)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1200	Base Other Fluorescent Fixture (New)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1201	NEW T5	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1202	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1210	Base Other Fluorescent Fixture--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1211	Upstream Low Watt High Performance T8	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1212	Upstream LED Tube	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1213	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings (Base Upstream)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1300	Base Incandescent Lamp, 72W 2015--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1301	New LEDs (base incandescent 72W) 2015	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1310	Base Incandescent Lamp, 72W 2015--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%

DNV·GL

Commercial Electric Measure Inputs		FEASIBILITY FACTOR (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1311	Upstream LEDs (base incandescent 72W) 2015	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1320	Base Incandescent Lamp, 72W 2016-2017--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1321	New LEDs (base incandescent 72W) 2016-2017	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1331	Upstream LEDs (base incandescent 72W) 2016-2017	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1340	Base Incandescent Lamp, 72W 2018-2019--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1341	New LEDs (base incandescent 72W) 2018-2019	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1351	Upstream LEDs (base incandescent 72W) 2018-2019	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1360	Base Incandescent Lamp, 72W 2020--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1361	New LEDs (base incandescent 72W) 2020	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1370	Base Incandescent Lamp, 72W 2020--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1371	Upstream LEDs (base incandescent 72W) 2020	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1400	Base CFL Lamp, 23W 2015--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1401	New LEDs (base CFL spiral 23W) 2015	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1410	Base CFL Lamp, 23W 2015--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1411	Upstream LEDs (base CFL spiral 23W) 2015	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1420	Base CFL Lamp, 23W 2016-2017--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1421	New LEDs (base CFL spiral 23W) 2016-2017	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1430	Base CFL Lamp, 23W 2016-2017--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1440	Base CFL Lamp, 23W 2018-2019--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1441	New LEDs (base CFL spiral 23W) 2018-2019	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1450	Base CFL Lamp, 23W 2018-2019--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1460	Base CFL Lamp, 23W 2020--New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1461	New LEDs (base CFL spiral 23W) 2020	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1470	Base CFL Lamp, 23W 2020--Upstream New	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1471	Upstream LEDs (base CFL spiral 23W) 2020	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1500	Base Metal Halide, 400W	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1501	High Bay T5 HO (240W)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1502	High Bay Induction Lighting	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1600	Base HID Parking Garage Lighting	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1601	LED Parking Garage Fixtures	100.00%	100.00%	100.00%	100.00%	0.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1602	Bi-Level LED Parking Garage Fixtures	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80%
1700	Base CFL Exit Sign	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1800	Base Outdoor High Pressure Sodium 250W Lamp	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
1801	LED Outdoor Area Lighting (other than pole-mounted)	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90%
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2002	Chilled Beams	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50%
2003	Cool Roof - Chiller	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%	50%
2005	VSD for Chiller Pumps and Towers	38.80%	16.54%	100.00%	0.00%	14.69%	3.79%	15.99%	61.60%	50.00%	50.00%	50.00%	50%
2100	Base DX Packaged System, EER=10.0, 30 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2101	ROB DX Packaged System, EER=10.8, 30 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2102	ROB DX Packaged System, EER=11.7, 30 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2103	Automated Fault Detection	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5%
2104	RTU VSD	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%	20%
2106	Aerosol Duct Sealing	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%	32%
2107	VRF Conditioning Systems	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2201	Air Source Heat Pump, EER=11.3, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2202	Geothermal Heat Pump, EER=18, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2203	VRF Conditioning Systems	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2300	Base PTAC, EER=8.3, 1 ton	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2301	Occupancy Sensor (hotels)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	75.00%	0.00%	0.00%	0.00%	0.00%	0%
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3001	Variable Speed Drive Control, 5 HP	97.21%	100.00%	100.00%	100.00%	100.00%	100.00%	94.42%	100.00%	91.81%	100.00%	91.81%	100%

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Commercial Electric Measure Inputs		**FEASIBILITY FACTOR (percent)**											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3101	Variable Speed Drive Control, 15 HP	91.29%	100.00%	100.00%	100.00%	100.00%	100.00%	82.57%	100.00%	100.00%	100.00%	100.00%	100%
3102	Air Handler Optimization, 15 HP	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3104	Separate Makeup Air / Exhaust Hoods AC	71.38%	84.65%	100.00%	100.00%	100.00%	100.00%	55.16%	87.60%	100.00%	100.00%	100.00%	100%
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3201	Variable Speed Drive Control, 40 HP	91.29%	100.00%	100.00%	100.00%	100.00%	100.00%	82.57%	100.00%	100.00%	100.00%	100.00%	100%
3202	Air Handler Optimization, 40 HP	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
3203	Demand Controlled Ventilation (40 HP fan motor)	84.89%	100.00%	100.00%	92.21%	100.00%	100.00%	78.56%	91.23%	70.00%	100.00%	70.00%	100%
4000	Base Built-Up Refrigeration System	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4001	Auto-closer on main door to walk-in freezer (built-up)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4002	Evaporator fan controller for MT walk-ins	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4003	Efficient compressor motor	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4004	Refrigeration Commissioning	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%	20.00%	60.00%	20.00%	60.00%	20%
4500	Base Self-Contained Refrigeration	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4501	Auto-closer on main door to walk-in freezer (self-contained)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4502	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4503	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4504	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4505	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4506	ENERGY STAR Ice Machines	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
4507	Hydraulic-type door closer on reach-in cooler glass doors	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6000	Base Water Heating	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
6001	Demand controlled circulating systems	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75%
6003	Tankless Water Heater	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75%
6004	Heat Pump Water Heater (air source)	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80%
6005	Solar Water Heater	38.00%	10.00%	20.00%	20.00%	20.00%	20.00%	76.00%	0.00%	4.00%	49.00%	4.00%	49%
7000	Base Refrigerated Vending Machines	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
7500	Base Non-Refrigerated Vending Machines	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8000	Base Oven	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8001	Convection Oven	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8100	Base Fryer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8101	Efficient Fryer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8200	Base Steamer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8201	Efficient Steamer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8300	Base Hot Food Holding Cabinet	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8301	ENERGY STAR Hot Food Holding Cabinets	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8500	Base Compressed Air	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8700	Base Heating	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8701	Air Source Heat Pump, EER=11.3, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8702	Geothermal Heat Pump, EER=18, 10 tons	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
8703	VRF Conditioning Systems	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9000	Base Miscellaneous	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9500	Base Building Design - Standard Code	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9501	15% better than code - Campuses	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9502	15% better than code - Education	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9503	15% better than code - Food Sales	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9504	15% better than code - Food Service	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9505	15% better than code - Healthcare	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9506	15% better than code - Lodging	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0%
9507	15% better than code - Office	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0%
9508	15% better than code - Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0%
9509	15% better than code - Public Assembly	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0%
9510	15% better than code - Retail	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0%
9511	15% better than code - Warehouse	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
9512	Commissioning	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9600	Base Building Design - Standard Code	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9601	30% better than code - Campuses	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%

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Commercial Electric Measure Inputs		FEASIBILITY FACTOR (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
9602	30% better than code - Education	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9603	30% better than code - Food Sales	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9604	30% better than code - Food Service	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9605	30% better than code - Healthcare	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9606	30% better than code - Lodging	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0%
9607	30% better than code - Office	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0%
9608	30% better than code - Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0%
9609	30% better than code - Public Assembly	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0%
9610	30% better than code - Retail	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0%
9611	30% better than code - Warehouse	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
9612	Commissioning	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9700	Base Building Design - Standard Code	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9701	50% better than code - Campuses	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9702	50% better than code - Education	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9703	50% better than code - Food Sales	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9704	50% better than code - Food Service	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9705	50% better than code - Healthcare	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9706	50% better than code - Lodging	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0%
9707	50% better than code - Office	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0%
9708	50% better than code - Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0%
9709	50% better than code - Public Assembly	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0%
9710	50% better than code - Retail	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0%
9711	50% better than code - Warehouse	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
9712	Commissioning	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9800	Base Building Design - Standard Code	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
9801	70% better than code - Campuses	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9802	70% better than code - Education	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9803	70% better than code - Food Sales	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9804	70% better than code - Food Service	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9805	70% better than code - Healthcare	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
9806	70% better than code - Lodging	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0%
9807	70% better than code - Office	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0%
9808	70% better than code - Other	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0%
9809	70% better than code - Public Assembly	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0%
9810	70% better than code - Retail	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0%
9811	70% better than code - Warehouse	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%
9812	Commissioning	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%

DNV·GL

Commercial Electric Measure Inputs	TECHNOLOGY SATURATION (units/square foot)											
Measure # Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
1000 Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--RET	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1001 RET 4L4' Low Watt High Performance T8 (83 W), 2015	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1002 RET 4L4' LED Tube, 2015	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1003 RET LED Troffer (base 4L4'T8), 2015	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1004 Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base RET)	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1005 Advanced Lighting Controls (2015 Base RET)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1006 Daylight Dimming Controls (2015 Base RET)	0.0053	0.0043	0.0032	0.0011	0.0023	0.0013	0.0023	0.0015	0.0031	0.0021	0.0037	0.0003
1007 Custom Lighting, Base 4L4'T8, 2015	1.1947	0.7821	1.3652	0.4100	0.5731	0.7524	0.9458	0.3446	0.8628	0.2818	1.0646	0.0842
1010 Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--ROB	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1011 ROB 4L4' Low Watt High Performance T8 (83 W), 2015	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1012 ROB 4L4' LED Tube, 2015	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1013 Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base ROB)	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1014 Advanced Lighting Controls (2015 Base ROB)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1015 Daylight Dimming Controls (2015 Base ROB)	0.0053	0.0043	0.0032	0.0011	0.0023	0.0013	0.0023	0.0015	0.0031	0.0021	0.0037	0.0003
1020 Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1021 Upstream 4L4' Low Watt High Performance T8 (83 W), 2015	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1022 Upstream 4L4' LED Tube, 2015	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1023 Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base Upstream)	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1024 Advanced Lighting Controls (2015 Base Up)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1025 Daylight Dimming Controls (2015 Base Up)	0.0053	0.0043	0.0032	0.0011	0.0023	0.0013	0.0023	0.0015	0.0031	0.0021	0.0037	0.0003
1050 Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--RET	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1051 RET 4L4' Low Watt High Performance T8 (83 W), 2016-2017	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1052 RET 4L4' LED Tube, 2016-2017	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1053 RET LED Troffer (base 4L4'T8), 2016-2017	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1054 Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base RET)	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1055 Advanced Lighting Controls (2016-2017 Base RET)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1056 Daylight Dimming Controls (2016-2017 Base RET)	0.0053	0.0043	0.0032	0.0011	0.0023	0.0013	0.0023	0.0015	0.0031	0.0021	0.0037	0.0003
1057 Custom Lighting, Base 4L4'T8, 2016-2017	1.1947	0.7821	1.3652	0.4100	0.5731	0.7524	0.9458	0.3446	0.8628	0.2818	1.0646	0.0842
1060 Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--ROB	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1061 ROB 4L4' Low Watt High Performance T8 (83 W), 2016-2017	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1062 ROB 4L4' LED Tube, 2016-2017	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1063 Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base ROB)	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1064 Advanced Lighting Controls (2016-2017 Base ROB)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1065 Daylight Dimming Controls (2016-2017 Base ROB)	0.0053	0.0043	0.0032	0.0011	0.0023	0.0013	0.0023	0.0015	0.0031	0.0021	0.0037	0.0003
1070 Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1071 Upstream 4L4' Low Watt High Performance T8 (83 W), 2016-2017	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1072 Upstream 4L4' LED Tube, 2016-2017	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1073 Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base Upstream)	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1074 Advanced Lighting Controls (2016-2017 Base Up)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1075 Daylight Dimming Controls (2016-2017 Base Up)	0.0053	0.0043	0.0032	0.0011	0.0023	0.0013	0.0023	0.0015	0.0031	0.0021	0.0037	0.0003
1080 Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--RET	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1081 RET 4L4' Low Watt High Performance T8 (83 W), 2018-2019	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1082 RET 4L4' LED Tube, 2018-2019	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1083 RET LED Troffer (base 4L4'T8), 2018-2019	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1084 Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base RET)	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1085 Advanced Lighting Controls (2018-2019 Base RET)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1086 Daylight Dimming Controls (2018-2019 Base RET)	0.0053	0.0043	0.0032	0.0011	0.0023	0.0013	0.0023	0.0015	0.0031	0.0021	0.0037	0.0003
1087 Custom Lighting, Base 4L4'T8, 2018-2019	1.1947	0.7821	1.3652	0.4100	0.5731	0.7524	0.9458	0.3446	0.8628	0.2818	1.0646	0.0842
1100 Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--ROB	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1101 ROB 4L4' Low Watt High Performance T8 (83 W), 2018-2019	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1102 ROB 4L4' LED Tube, 2018-2019	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1103 Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base ROB)	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1104 Advanced Lighting Controls (2018-2019 Base ROB)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1105 Daylight Dimming Controls (2018-2019 Base ROB)	0.0053	0.0043	0.0032	0.0011	0.0023	0.0013	0.0023	0.0015	0.0031	0.0021	0.0037	0.0003

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Commercial Electric Measure Inputs	TECHNOLOGY SATURATION (units/square foot)											
Measure # Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
1110 Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1111 Upstream 4L4' Low Watt High Performance T8 (83 W), 2018-2019	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1112 Upstream 4L4' LED Tube, 2018-2019	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1113 Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base Upstream)	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1114 Advanced Lighting Controls (2018-2019 Base Up)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1115 Daylight Dimming Controls (2018-2019 Base Up)	0.0053	0.0043	0.0032	0.0011	0.0023	0.0013	0.0023	0.0015	0.0031	0.0021	0.0037	0.0003
1120 Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--RET	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1121 RET 4L4' Low Watt High Performance T8 (83 W), 2020	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1122 RET 4L4' LED Tube, 2020	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1123 RET LED Troffer (base 4L4'T8), 2020	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1124 Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base RET)	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1125 Advanced Lighting Controls (2020 Base RET)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1126 Daylight Dimming Controls (2020 Base RET)	0.0053	0.0043	0.0032	0.0011	0.0023	0.0013	0.0023	0.0015	0.0031	0.0021	0.0037	0.0003
1127 Custom Lighting, Base 4L4'T8, 2020	1.1947	0.7821	1.3652	0.4100	0.5731	0.7524	0.9458	0.3446	0.8628	0.2818	1.0646	0.0842
1150 Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--ROB	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1151 ROB 4L4' Low Watt High Performance T8 (83 W), 2020	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1152 ROB 4L4' LED Tube, 2020	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1153 Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base ROB)	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1154 Advanced Lighting Controls (2020 Base ROB)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1155 Daylight Dimming Controls (2020 Base ROB)	0.0053	0.0043	0.0032	0.0011	0.0023	0.0013	0.0023	0.0015	0.0031	0.0021	0.0037	0.0003
1160 Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1161 Upstream 4L4' Low Watt High Performance T8 (83 W), 2020	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1162 Upstream 4L4' LED Tube, 2020	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1163 Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base Upstream)	0.0175	0.0144	0.0107	0.0038	0.0076	0.0045	0.0075	0.0050	0.0104	0.0069	0.0124	0.0011
1164 Advanced Lighting Controls (2020 Base Up)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1165 Daylight Dimming Controls (2020 Base Up)	0.0053	0.0043	0.0032	0.0011	0.0023	0.0013	0.0023	0.0015	0.0031	0.0021	0.0037	0.0003
1200 Base Other Fluorescent Fixture--RET	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1201 RET Low Watt High Performance T8	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1202 RET LED Tube	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1203 RET LED Troffer	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1204 Occupancy Sensor (Base Other Fluor RET)	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1205 Advanced Lighting Controls (Base Other Fluor RET)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1206 Daylight Dimming Controls (Base Other Fluor RET)	0.0053	0.0043	0.0032	0.0011	0.0023	0.0013	0.0023	0.0015	0.0031	0.0021	0.0037	0.0003
1207 Custom Lighting, Base Other Fluorescent	0.0311	0.0136	0.0044	0.1720	0.0241	0.0298	0.0728	0.1706	0.0027	0.0923	0.6669	0.0046
1210 Base Other Fluorescent Fixture--ROB	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1211 ROB Low Watt High Performance T8	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1212 ROB LED Tube	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1213 Occupancy Sensor (Base Other Fluor ROB)	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1214 Advanced Lighting Controls (Base Other Fluor ROB)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1215 Daylight Dimming Controls (Base Other Fluor ROB)	0.0053	0.0043	0.0032	0.0011	0.0023	0.0013	0.0023	0.0015	0.0031	0.0021	0.0037	0.0003
1220 Base Other Fluorescent Fixture--Upstream	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1221 Upstream Low Watt High Performance T8	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1222 Upstream LED Tube	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1223 Occupancy Sensor (Base Other Fluor Upstream)	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1224 Advanced Lighting (Base Other Fluor Upstream)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1225 Daylight Dimming Controls (Base Other Fluor Upstream)	0.0053	0.0043	0.0032	0.0011	0.0023	0.0013	0.0023	0.0015	0.0031	0.0021	0.0037	0.0003
1300 Base Incandescent Lamp, 72W 2015--Hardwired	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1301 LED Track Lighting (base Incandescent 72W) 2015	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1310 Base Incandescent Lamp, 72W 2015--Upstream	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1311 Upstream LEDs (base Incandescent 72W) 2015	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1320 Base Incandescent Lamp, 72W 2016-2017--Hardwired	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1321 LED Track Lighting (base Incandescent 72W) 2016-2017	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1330 Base Incandescent Lamp, 72W 2016-2017--Upstream	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1331 Upstream LEDs (base Incandescent 72W) 2016-2017	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1340 Base Incandescent Lamp, 72W 2018-2019--Hardwired	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010

Commercial Electric Measure Inputs

Measure #	Measure Description	TECHNOLOGY SATURATION (units/square foot) College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
1341	LED Track Lighting (base Incandescent 72W) 2018-2019	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1351	Upstream LEDs (base Incandescent 72W) 2018-2019	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1360	Base Incandescent Lamp, 72W 2020--Hardwired	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1361	LED Track Lighting (base Incandescent 72W) 2020	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1370	Base Incandescent Lamp, 72W 2020--Upstream	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1371	Upstream LEDs (base Incandescent 72W) 2020	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1400	Base CFL Lamp, 23W 2015--Hardwired	0.0533	0.0007	0.0023	0.0458	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1401	LED Track Lighting (base CFL spiral 23W) 2015	0.0533	0.0007	0.0023	0.0458	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1410	Base CFL Lamp, 23W 2015--Upstream	0.0533	0.0007	0.0023	0.0458	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1411	Upstream LEDs (base CFL spiral 23W) 2015	0.0533	0.0007	0.0023	0.0458	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1420	Base CFL Lamp, 23W 2016-2017--Hardwired	0.0533	0.0007	0.0023	0.0458	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1421	LED Track Lighting (base CFL spiral 23W) 2016-2017	0.0533	0.0007	0.0023	0.0458	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1430	Base CFL Lamp, 23W 2016-2017--Upstream	0.0533	0.0007	0.0023	0.0458	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	0.0533	0.0007	0.0023	0.0458	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1440	Base CFL Lamp, 23W 2018-2019--Hardwired	0.0533	0.0007	0.0023	0.0458	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1441	LED Track Lighting (base CFL spiral 23W) 2018-2019	0.0533	0.0007	0.0023	0.0458	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1450	Base CFL Lamp, 23W 2018-2019--Upstream	0.0533	0.0007	0.0023	0.0458	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	0.0533	0.0007	0.0023	0.0046	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1460	Base CFL Lamp, 23W 2020--Hardwired	0.0533	0.0007	0.0023	0.0458	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1461	LED Track Lighting (base CFL spiral 23W) 2020	0.0533	0.0007	0.0023	0.0458	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1470	Base CFL Lamp, 23W 2020--Upstream	0.0533	0.0007	0.0023	0.0458	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1471	Upstream LEDs (base CFL spiral 23W) 2020	0.0533	0.0007	0.0023	0.0458	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1500	Base Metal Halide, 400W	0.0091	0.0008	0.0001	0.0018	0.0000	0.0028	0.0013	0.0017	0.0011	0.0004	0.0040	0.0014
1501	High Bay T5 HO (240W)	0.0182	0.0016	0.0002	0.0036	0.0001	0.0055	0.0025	0.0033	0.0023	0.0008	0.0079	0.0029
1502	High Bay Induction Lighting	0.0182	0.0016	0.0002	0.0036	0.0001	0.0055	0.0025	0.0033	0.0023	0.0008	0.0079	0.0029
1503	PSMH with electronic ballast	0.0182	0.0016	0.0002	0.0036	0.0001	0.0055	0.0025	0.0033	0.0023	0.0008	0.0079	0.0029
1504	High Bay LED Lighting	0.0182	0.0016	0.0002	0.0036	0.0001	0.0055	0.0025	0.0033	0.0023	0.0008	0.0079	0.0029
1600	Base HPS (high pressure sodium) Parking Garage Lighting	0.0001	0.0000	0.0000	0.0000	0.0002	0.0002	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000
1601	High-efficiency fluorescent parking garage fixture	0.0001	0.0000	0.0000	0.0000	0.0002	0.0002	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000
1602	LED Parking Garage Fixtures	0.0001	0.0000	0.0000	0.0000	0.0002	0.0002	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000
1603	Bi-Level LED Parking Garage Fixtures	0.0001	0.0000	0.0000	0.0000	0.0002	0.0002	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000
1700	Base CFL Exit Sign	0.0002	0.0003	0.0003	0.0013	0.0010	0.0005	0.0006	0.0007	0.0004	0.0010	0.0003	0.0001
1701	LED Exit Sign	0.0002	0.0003	0.0003	0.0013	0.0010	0.0005	0.0006	0.0007	0.0004	0.0010	0.0003	0.0001
1800	Base Outdoor High Pressure Sodium 250W Lamp	0.0054	0.0044	0.0016	0.0032	0.0020	0.0007	0.0025	0.0010	0.0017	0.0018	0.0032	0.0098
1801	LED Outdoor Area Lighting (other than pole-mounted)	0.0054	0.0044	0.0016	0.0032	0.0020	0.0007	0.0025	0.0010	0.0017	0.0018	0.0032	0.0098
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	0.0124	0.0007	0.0000	0.0000	0.0057	0.0059	0.0027	0.0016	0.0005	0.0012	0.0016	0.0000
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	0.0124	0.0007	0.0000	0.0000	0.0057	0.0059	0.0027	0.0016	0.0005	0.0012	0.0016	0.0000
2002	Chiller VSD	0.0124	0.0007	0.0000	0.0000	0.0057	0.0059	0.0027	0.0016	0.0005	0.0012	0.0016	0.0000
2003	EMS - Chiller	0.0012	0.0001	0.0000	0.0000	0.0006	0.0006	0.0003	0.0002	0.0001	0.0001	0.0002	0.0000
2004	Cool Roof - Chiller	0.4333	0.5000	1.0000	1.0000	0.2500	0.2500	0.2500	0.3315	0.5000	0.5000	0.8973	1.0000
2006	VSD for Chiller Pumps and Towers	0.0004	0.0000	0.0001	0.0030	0.0025	0.0003	0.0003	0.0000	0.0020	0.0020	0.0030	0.0189
2008	Ceiling/roof Insulation - Chiller	0.4333	0.5000	1.0000	1.0000	0.2500	0.2500	0.2500	0.3315	0.5000	0.5000	0.8973	1.0000
2009	Custom HVAC--Base Chiller	0.0941	0.0539	0.0000	0.0000	0.4285	0.4438	0.0255	0.1223	0.0414	0.0924	0.1182	0.0000
2010	Custom Shell--Base Chiller	0.0941	0.0539	0.0000	0.0000	0.4285	0.4438	0.0255	0.1223	0.0414	0.0924	0.1182	0.0000
2100	Base DX Packaged System, EER=10.0, 30 tons	0.0014	0.0005	0.0019	0.0024	0.0412	0.0023	0.0017	0.0020	0.0017	0.0040	0.0018	0.0002
2101	ROB DX Packaged System, EER=10.8, 30 tons	0.0014	0.0005	0.0019	0.0024	0.0412	0.0023	0.0017	0.0020	0.0017	0.0040	0.0018	0.0002
2102	ROB DX Packaged System, EER=11.7, 30 tons	0.0014	0.0005	0.0019	0.0024	0.0412	0.0023	0.0017	0.0020	0.0017	0.0040	0.0018	0.0002
2104	Automated Fault Detection	0.0026	0.0025	0.0025	0.0030	0.0025	0.0025	0.0035	0.0030	0.0020	0.0020	0.0030	0.0189
2106	Advanced Controllers for RTUs	0.0006	0.0004	0.0002	0.0007	0.0103	0.0013	0.0008	0.0001	0.0006	0.0011	0.0007	0.0000
2107	Programmable Communicating Thermostat	0.0002	0.0002	0.0004	0.0016	0.0011	0.0006	0.0012	0.0014	0.0014	0.0004	0.0009	0.0004
2108	Prog. Thermostat - DX	0.0002	0.0002	0.0004	0.0016	0.0011	0.0006	0.0012	0.0014	0.0014	0.0004	0.0009	0.0004
2109	Cool Roof - DX	0.4333	0.5000	1.0000	1.0000	0.2500	0.2500	0.2500	0.3315	0.5000	0.5000	0.8973	1.0000
2110	RTU VSD	0.0006	0.0004	0.0001	0.0007	0.0103	0.0013	0.0008	0.0002	0.0006	0.0011	0.0007	0.0000
2111	Dual Enthalpy Economizer Controls	0.0009	0.0004	0.0016	0.0030	0.0025	0.0025	0.0035	0.0030	0.0020	0.0020	0.0030	0.0016
2113	Aerosol Duct Sealing	0.0014	0.0005	0.0019	0.0024	0.0412	0.0023	0.0017	0.0020	0.0017	0.0040	0.0018	0.0002

DNV·GL

Commercial Electric Measure Inputs		TECHNOLOGY SATURATION (units/square foot)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
2114	Ceiling/roof Insulation - DX	0.4333	0.5000	1.0000	1.0000	0.2500	0.2500	0.2500	0.3315	0.5000	0.5000	0.8973	1.0000
2115	Duct/Pipe Insulation - DX	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500
2116	Custom HVAC--DX	0.2492	0.0843	0.3406	0.4333	0.3290	0.4008	0.3063	0.3557	0.0428	0.0913	0.3175	0.0421
2117	Custom Shell--DX	0.2492	0.0843	0.3406	0.4333	0.3290	0.4008	0.3063	0.3557	0.0428	0.0913	0.3175	0.0421
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	0.0014	0.0005	0.0019	0.0024	0.0412	0.0023	0.0017	0.0020	0.0017	0.0040	0.0018	0.0002
2201	Air Source Heat Pump, EER=11.3, 10 tons	0.0014	0.0005	0.0019	0.0024	0.0412	0.0023	0.0017	0.0020	0.0017	0.0040	0.0018	0.0002
2300	Base PTAC, EER=8.3, 1 ton	0.0002	0.0003	0.0001	0.0001	0.0013	0.0013	0.0051	0.0009	0.0003	0.0025	0.0003	0.0008
2301	Occupancy Sensor (hotels)	0.0002	0.0003	0.0001	0.0001	0.0013	0.0013	0.0051	0.0009	0.0003	0.0025	0.0003	0.0008
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	0.0001	0.0000	0.0003	0.0030	0.0001	0.0002	0.0002	0.0002	0.0001	0.0007	0.0001	0.0000
3001	Variable Speed Drive Control, 5 HP	0.0001	0.0001	0.0003	0.0030	0.0001	0.0002	0.0002	0.0002	0.0001	0.0007	0.0001	0.0002
3002	Custom HVAC--Base Fan Motor, 5hp	0.3420	0.3849	0.1200	0.2250	0.3600	0.4200	0.2400	0.4650	0.2250	0.3300	0.1050	0.1050
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	0.0006	0.0005	0.0000	0.0000	0.0001	0.0002	0.0032	0.0012	0.0006	0.0003	0.0001	0.0000
3101	Variable Speed Drive Control, 15 HP	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0004	0.0002	0.0001	0.0000	0.0000	0.0000
3102	Air Handler Optimization, 15 HP	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	0.0020	0.0026	0.0035	0.0037	0.0042	0.0042	0.0017	0.0024	0.0014	0.0014	0.0016	0.0004
3104	Separate Makeup Air / Exhaust Hoods AC	0.0338	0.0732	0.0000	0.1000	0.0175	0.0748	0.0000	0.0160	0.0901	0.0901	0.1333	0.0000
3105	Custom HVAC--Base Fan Motor, 15hp	0.3420	0.3849	0.1200	0.2250	0.3600	0.4200	0.2400	0.4650	0.2250	0.3300	0.1050	0.1050
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	0.0022	0.0009	0.0006	0.0000	0.0000	0.0018	0.0000	0.0006	0.0024	0.0000	0.0009	0.0238
3201	Variable Speed Drive Control, 40 HP	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0006
3202	Air Handler Optimization, 40 HP	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3203	Demand Controlled Ventilation (40 HP fan motor)	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0006
3204	Custom HVAC--Base Fan Motor, 40hp	0.3420	0.3849	0.1200	0.2250	0.3600	0.4200	0.2400	0.4650	0.2250	0.3300	0.1050	0.1050
4000	Base Built-Up Refrigeration System	0.0000	0.0000	0.0008	0.0005	0.0000	0.0000	0.0001	0.0000	0.0000	0.0002	0.0003	0.0000
4001	Strip curtains for walk-ins (built-up)	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4002	Auto-closer on main door to walk-in freezer (built-up)	0.0002	0.0000	0.0001	0.0001	0.0003	0.0003	0.0000	0.0001	0.0001	0.0001	0.0001	0.0000
4003	Night covers for display cases	0.0003	0.0002	0.0145	0.0027	0.0003	0.0003	0.0002	0.0007	0.0002	0.0002	0.0006	0.0000
4004	Evaporator fan controller for MT walk-ins	0.0002	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4005	Electronically commutated evaporator fan motor	0.0050	0.0003	0.0050	0.0050	0.0008	0.0007	0.0012	0.0002	0.0005	0.0005	0.0004	0.0050
4006	Efficient compressor motor	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4007	Floating head pressure controls	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4008	Refrigeration Commissioning	0.0000	0.0002	0.0016	0.0008	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0002	0.0002
4009	Demand Hot Gas Defrost	0.0000	0.0001	0.0013	0.0006	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001
4010	Demand Defrost Electric	0.0000	0.0001	0.0013	0.0006	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001
4011	Anti-sweat (humidistat) controls	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4012	Freezer-Cooler Replacement Gaskets	0.0003	0.0002	0.0145	0.0027	0.0003	0.0003	0.0002	0.0007	0.0002	0.0002	0.0006	0.0000
4013	High R-Value Glass Doors	0.0003	0.0002	0.0145	0.0027	0.0003	0.0003	0.0002	0.0007	0.0002	0.0002	0.0006	0.0000
4014	LED Display Lighting (Base T8 Lighting)	0.0007	0.0002	0.0145	0.0027	0.0003	0.0003	0.0002	0.0007	0.0002	0.0002	0.0006	0.0000
4016	Multiplex Compressor System	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
4017	Oversized Air Cooled Condenser	0.0000	0.0002	0.0016	0.0008	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0002	0.0002
4018	Custom Refrigeration	0.0480	0.0270	1.5000	0.4500	0.0465	0.0660	0.0225	0.0123	0.0458	0.0375	0.0351	0.9300
4500	Base Self-Contained Refrigeration	0.0001	0.0001	0.0005	0.0021	0.0003	0.0001	0.0007	0.0002	0.0000	0.0007	0.0001	0.0000
4501	Strip curtains for walk-ins (self-contained)	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4502	Auto-closer on main door to walk-in freezer (self-contained)	0.0001	0.0001	0.0005	0.0021	0.0003	0.0001	0.0007	0.0002	0.0000	0.0007	0.0001	0.0000
4503	Night covers for display cases (self-contained)	0.0000	0.0000	0.0001	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000
4504	LED Display Lighting (Base T8 Lighting)	0.0001	0.0001	0.0005	0.0021	0.0003	0.0001	0.0007	0.0002	0.0000	0.0007	0.0001	0.0000
4506	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	0.0001	0.0001	0.0005	0.0021	0.0003	0.0001	0.0007	0.0002	0.0000	0.0007	0.0001	0.0000
4507	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	0.0001	0.0001	0.0005	0.0021	0.0003	0.0001	0.0007	0.0002	0.0000	0.0007	0.0001	0.0000
4508	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	0.0001	0.0001	0.0005	0.0021	0.0003	0.0001	0.0007	0.0002	0.0000	0.0007	0.0001	0.0000
4509	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	0.0001	0.0001	0.0005	0.0021	0.0003	0.0001	0.0007	0.0002	0.0000	0.0007	0.0001	0.0000
4510	ENERGY STAR Ice Machines	0.0001	0.0001	0.0005	0.0021	0.0003	0.0001	0.0007	0.0002	0.0000	0.0007	0.0001	0.0000
4511	Hydraulic-type door closer on reach-in cooler glass doors	0.0001	0.0001	0.0005	0.0021	0.0003	0.0001	0.0007	0.0002	0.0000	0.0007	0.0001	0.0000
4512	Doors for open cases	0.0000	0.0000	0.0001	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000
6000	Base Water Heating	0.0060	0.0001	0.0034	0.0079	0.0023	0.0058	0.0023	0.0014	0.0025	0.0030	0.0123	0.0054
6001	Demand controlled circulating systems	0.0000	0.0001	0.0001	0.0002	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002
6003	Hot Water Pipe Insulation	0.0019	0.0019	0.0016	0.0021	0.0020	0.0020	0.0029	0.0011	0.0012	0.0012	0.0010	0.0061
6004	Tankless Water Heater	0.0060	0.0001	0.0034	0.0079	0.0023	0.0058	0.0023	0.0014	0.0025	0.0030	0.0123	0.0054
6005	Heat Pump Water Heater (air source)	0.0060	0.0001	0.0034	0.0079	0.0023	0.0058	0.0023	0.0014	0.0025	0.0030	0.0123	0.0054
6006	Heat Recovery Unit	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

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Commercial Electric Measure Inputs		TECHNOLOGY SATURATION (units/square foot)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
6007	Heat Trap	0.0060	0.0001	0.0034	0.0079	0.0023	0.0058	0.0023	0.0014	0.0025	0.0030	0.0123	0.0054
6008	Solar Water Heater	0.0060	0.0001	0.0034	0.0079	0.0023	0.0058	0.0023	0.0014	0.0025	0.0030	0.0123	0.0054
6009	High Temperature Dishwasher	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000
7000	Base Refrigerated Vending Machines	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
7001	Vending Misers (Refrigerated units)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
7002	Vending Misers (Refrigerated glass-front units)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
7003	Refrigerated Vending Low Watt High Performance T8	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
7500	Base Non-Refrigerated Vending Machines	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
7501	Vending Misers (Non-Refrigerated)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
7502	Non-refrigerated Vending Low Watt High Performance T8	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
8000	Base Oven	0.0000	0.0001	0.0001	0.0014	0.0000	0.0000	0.0002	0.0001	0.0000	0.0001	0.0000	0.0000
8001	Convection Oven	0.0000	0.0001	0.0001	0.0014	0.0000	0.0000	0.0002	0.0001	0.0000	0.0001	0.0000	0.0000
8100	Base Fryer	0.0000	0.0000	0.0002	0.0027	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
8101	Efficient Fryer	0.0000	0.0000	0.0002	0.0027	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
8200	Base Steamer	0.0000	0.0000	0.0000	0.0025	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000
8201	Efficient Steamer	0.0000	0.0000	0.0000	0.0025	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000
8300	Base Hot Food Holding Cabinet	0.0000	0.0001	0.0000	0.0029	0.0000	0.0000	0.0001	0.0000	0.0000	0.0004	0.0000	0.0000
8301	ENERGY STAR Hot Food Holding Cabinets	0.0000	0.0001	0.0000	0.0029	0.0000	0.0000	0.0001	0.0000	0.0000	0.0004	0.0000	0.0000
8500	Base Compressed Air	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8700	Base Heating	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9000	Base Miscellaneous	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9500	Base Whole Building	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9501	NEMA Premium Efficiency Transformer	0.0328	0.0339	0.0877	0.0901	0.0390	0.0768	0.0363	0.0404	0.0778	0.0233	0.0395	0.0207
9502	Retrocommissioning/Building tune up	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9503	Custom O&M	0.5143	0.5319	1.3740	1.4122	0.6118	1.2039	0.5696	0.6328	1.2189	0.3649	0.6196	0.3240
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015 (New)	0.0131	0.0108	0.0080	0.0029	0.0057	0.0033	0.0056	0.0037	0.0078	0.0052	0.0093	0.0008
1001	NEW 3L4'T5, 2015	0.0131	0.0108	0.0080	0.0029	0.0057	0.0033	0.0056	0.0037	0.0078	0.0052	0.0093	0.0008
1002	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream New	0.0131	0.0108	0.0080	0.0029	0.0057	0.0033	0.0056	0.0037	0.0078	0.0052	0.0093	0.0008
1012	Upstream 4L4' LED Tube, 2015	0.0131	0.0108	0.0080	0.0029	0.0057	0.0033	0.0056	0.0037	0.0078	0.0052	0.0093	0.0008
1013	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015 (Base Upstream)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017 (New)	0.0131	0.0108	0.0080	0.0029	0.0057	0.0033	0.0056	0.0037	0.0078	0.0052	0.0093	0.0008
1051	NEW 3L4'T5, 2016-2017	0.0131	0.0108	0.0080	0.0029	0.0057	0.0033	0.0056	0.0037	0.0078	0.0052	0.0093	0.0008
1052	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream New	0.0131	0.0108	0.0080	0.0029	0.0057	0.0033	0.0056	0.0037	0.0078	0.0052	0.0093	0.0008
1062	Upstream 4L4' LED Tube, 2016-2017	0.0131	0.0108	0.0080	0.0029	0.0057	0.0033	0.0056	0.0037	0.0078	0.0052	0.0093	0.0008
1063	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017 (Base Upstream)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019 (New)	0.0131	0.0108	0.0080	0.0029	0.0057	0.0033	0.0056	0.0037	0.0078	0.0052	0.0093	0.0008
1101	NEW 3L4'T5, 2018-2019	0.0131	0.0108	0.0080	0.0029	0.0057	0.0033	0.0056	0.0037	0.0078	0.0052	0.0093	0.0008
1102	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream New	0.0131	0.0108	0.0080	0.0029	0.0057	0.0033	0.0056	0.0037	0.0078	0.0052	0.0093	0.0008
1112	Upstream 4L4' LED Tube, 2018-2019	0.0131	0.0108	0.0080	0.0029	0.0057	0.0033	0.0056	0.0037	0.0078	0.0052	0.0093	0.0008
1113	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019 (Base Upstream)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020 (New)	0.0131	0.0108	0.0080	0.0029	0.0057	0.0033	0.0056	0.0037	0.0078	0.0052	0.0093	0.0008
1151	NEW 3L4'T5, 2020	0.0131	0.0108	0.0080	0.0029	0.0057	0.0033	0.0056	0.0037	0.0078	0.0052	0.0093	0.0008
1152	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream New	0.0131	0.0108	0.0080	0.0029	0.0057	0.0033	0.0056	0.0037	0.0078	0.0052	0.0093	0.0008
1162	Upstream 4L4' LED Tube, 2020	0.0131	0.0108	0.0080	0.0029	0.0057	0.0033	0.0056	0.0037	0.0078	0.0052	0.0093	0.0008
1163	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020 (Base Upstream)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1200	Base Other Fluorescent Fixture (New)	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1201	NEW T5	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1202	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1210	Base Other Fluorescent Fixture--Upstream New	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1211	Upstream Low Watt High Performance T8	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1212	Upstream LED Tube	0.0008	0.0004	0.0001	0.0029	0.0006	0.0003	0.0010	0.0044	0.0001	0.0041	0.0140	0.0001
1213	Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings (Base Upstream)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1300	Base Incandescent Lamp, 72W 2015--New	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1301	New LEDs (base incandescent 72W) 2015	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010

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Commercial Electric Measure Inputs		TECHNOLOGY SATURATION (units/square foot)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
1310	Base Incandescent Lamp, 72W 2015--Upstream New	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1311	Upstream LEDs (base incandescent 72W) 2015	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1320	Base Incandescent Lamp, 72W 2016-2017--New	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1321	New LEDs (base incandescent 72W) 2016-2017	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream New	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1331	Upstream LEDs (base incandescent 72W) 2016-2017	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1340	Base Incandescent Lamp, 72W 2018-2019--New	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1341	New LEDs (base incandescent 72W) 2018-2019	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream New	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1351	Upstream LEDs (base incandescent 72W) 2018-2019	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1360	Base Incandescent Lamp, 72W 2020--New	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1361	New LEDs (base incandescent 72W) 2020	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1370	Base Incandescent Lamp, 72W 2020--Upstream New	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1371	Upstream LEDs (base incandescent 72W) 2020	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1400	Base CFL Lamp, 23W 2015--New	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1401	New LEDs (base CFL spiral 23W) 2015	0.0533	0.0007	0.0023	0.0046	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1410	Base CFL Lamp, 23W 2015--Upstream New	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1411	Upstream LEDs (base CFL spiral 23W) 2015	0.0533	0.0007	0.0023	0.0046	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1420	Base CFL Lamp, 23W 2016-2017--New	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1421	New LEDs (base CFL spiral 23W) 2016-2017	0.0533	0.0007	0.0023	0.0046	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1430	Base CFL Lamp, 23W 2016-2017--Upstream New	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	0.0533	0.0007	0.0023	0.0046	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1440	Base CFL Lamp, 23W 2018-2019--New	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1441	New LEDs (base CFL spiral 23W) 2018-2019	0.0533	0.0007	0.0023	0.0046	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1450	Base CFL Lamp, 23W 2018-2019--Upstream New	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	0.0533	0.0007	0.0023	0.0046	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1460	Base CFL Lamp, 23W 2020--New	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1461	New LEDs (base CFL spiral 23W) 2020	0.0533	0.0007	0.0023	0.0046	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1470	Base CFL Lamp, 23W 2020--Upstream New	0.0014	0.0005	0.0021	0.0208	0.0047	0.0007	0.0052	0.0021	0.0031	0.0134	0.0200	0.0010
1471	Upstream LEDs (base CFL spiral 23W) 2020	0.0533	0.0007	0.0023	0.0046	0.0116	0.0028	0.0050	0.0035	0.0099	0.0094	0.0139	0.0035
1500	Base Metal Halide, 400W	0.0091	0.0008	0.0001	0.0018	0.0000	0.0028	0.0013	0.0017	0.0011	0.0004	0.0040	0.0014
1501	High Bay T5 HO (240W)	0.0182	0.0016	0.0002	0.0036	0.0001	0.0055	0.0025	0.0033	0.0023	0.0008	0.0079	0.0029
1502	High Bay Induction Lighting	0.0182	0.0016	0.0002	0.0036	0.0001	0.0055	0.0025	0.0033	0.0023	0.0008	0.0079	0.0029
1600	Base HID Parking Garage Lighting	0.0001	0.0000	0.0000	0.0000	0.0002	0.0002	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000
1601	LED Parking Garage Fixtures	0.0001	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000
1602	Bi-Level LED Parking Garage Fixtures	0.0001	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000
1700	Base CFL Exit Sign	0.0002	0.0003	0.0003	0.0013	0.0010	0.0005	0.0006	0.0007	0.0004	0.0010	0.0003	0.0001
1800	Base Outdoor High Pressure Sodium 250W Lamp	0.0054	0.0002	0.0016	0.0032	0.0020	0.0007	0.0025	0.0010	0.0017	0.0018	0.0032	0.0002
1801	LED Outdoor Area Lighting (other than pole-mounted)	0.0054	0.0044	0.0016	0.0032	0.0020	0.0007	0.0025	0.0010	0.0017	0.0018	0.0032	0.0098
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	0.0124	0.0007	0.0000	0.0000	0.0057	0.0059	0.0027	0.0016	0.0005	0.0012	0.0016	0.0000
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	0.0124	0.0007	0.0000	0.0000	0.0057	0.0059	0.0027	0.0016	0.0005	0.0012	0.0016	0.0000
2002	Chilled Beams	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001
2003	Cool Roof - Chiller	0.4333	0.5000	1.0000	1.0000	0.2500	0.2500	0.2500	0.3315	0.5000	0.5000	0.8973	1.0000
2005	VSD for Chiller Pumps and Towers	0.0000	0.0000	0.0001	0.0030	0.0025	0.0000	0.0000	0.0000	0.0020	0.0020	0.0030	0.0189
2100	Base DX Packaged System, EER=10.0, 30 tons	0.0014	0.0005	0.0019	0.0024	0.0412	0.0023	0.0017	0.0020	0.0017	0.0040	0.0018	0.0002
2101	ROB DX Packaged System, EER=10.8, 30 tons	0.0014	0.0005	0.0019	0.0024	0.0412	0.0023	0.0017	0.0020	0.0017	0.0040	0.0018	0.0002
2102	ROB DX Packaged System, EER=11.7, 30 tons	0.0014	0.0005	0.0019	0.0024	0.0412	0.0023	0.0017	0.0020	0.0017	0.0040	0.0018	0.0002
2103	Automated Fault Detection	0.0026	0.0025	0.0025	0.0030	0.0025	0.0025	0.0035	0.0030	0.0020	0.0020	0.0030	0.0189
2104	RTU VSD	0.0006	0.0004	0.0001	0.0007	0.0103	0.0013	0.0008	0.0002	0.0006	0.0011	0.0007	0.0000
2106	Aerosol Duct Sealing	0.0014	0.0005	0.0019	0.0024	0.0412	0.0023	0.0017	0.0020	0.0017	0.0040	0.0018	0.0002
2107	VRF Conditioning Systems	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	0.0014	0.0005	0.0019	0.0024	0.0412	0.0023	0.0017	0.0020	0.0017	0.0040	0.0018	0.0002
2201	Air Source Heat Pump, EER=11.3, 10 tons	0.0014	0.0005	0.0019	0.0024	0.0412	0.0023	0.0017	0.0020	0.0017	0.0040	0.0018	0.0002
2202	Geothermal Heat Pump, EER=18, 10 tons	0.0014	0.0005	0.0019	0.0024	0.0412	0.0023	0.0017	0.0020	0.0017	0.0040	0.0018	0.0002
2203	VRF Conditioning Systems	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2300	Base PTAC, EER=8.3, 1 ton	0.0002	0.0003	0.0001	0.0001	0.0013	0.0013	0.0051	0.0009	0.0003	0.0025	0.0003	0.0008
2301	Occupancy Sensor (hotels)	0.0002	0.0003	0.0001	0.0001	0.0013	0.0013	0.0051	0.0009	0.0003	0.0025	0.0003	0.0008
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	0.0001	0.0000	0.0003	0.0030	0.0001	0.0002	0.0002	0.0002	0.0001	0.0007	0.0001	0.0000

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Commercial Electric Measure Inputs		TECHNOLOGY SATURATION (units/square foot)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
3001	Variable Speed Drive Control, 5 HP	0.0001	0.0001	0.0003	0.0030	0.0001	0.0002	0.0002	0.0002	0.0001	0.0007	0.0001	0.0002
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	0.0006	0.0005	0.0000	0.0000	0.0001	0.0002	0.0032	0.0012	0.0006	0.0003	0.0001	0.0000
3101	Variable Speed Drive Control, 15 HP	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0004	0.0002	0.0001	0.0000	0.0000	0.0000
3102	Air Handler Optimization, 15 HP	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	0.0020	0.0026	0.0035	0.0037	0.0042	0.0042	0.0017	0.0024	0.0014	0.0014	0.0016	0.0004
3104	Separate Makeup Air / Exhaust Hoods AC	0.0338	0.0732	0.0000	0.1000	0.0175	0.0748	0.0000	0.0160	0.0901	0.0901	0.1333	0.0000
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	0.0022	0.0009	0.0006	0.0000	0.0000	0.0018	0.0000	0.0006	0.0024	0.0000	0.0009	0.0238
3201	Variable Speed Drive Control, 40 HP	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0006
3202	Air Handler Optimization, 40 HP	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3203	Demand Controlled Ventilation (40 HP fan motor)	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0006
4000	Base Built-Up Refrigeration System	0.0000	0.0000	0.0008	0.0005	0.0000	0.0000	0.0001	0.0000	0.0000	0.0002	0.0003	0.0000
4001	Auto-closer on main door to walk-in freezer (built-up)	0.0002	0.0000	0.0001	0.0001	0.0003	0.0003	0.0000	0.0001	0.0001	0.0001	0.0001	0.0000
4002	Evaporator fan controller for MT walk-ins	0.0002	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4003	Efficient compressor motor	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4004	Refrigeration Commissioning	0.0000	0.0002	0.0016	0.0008	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0002	0.0002
4500	Base Self-Contained Refrigeration	0.0001	0.0001	0.0005	0.0021	0.0003	0.0001	0.0007	0.0002	0.0000	0.0007	0.0001	0.0000
4501	Auto-closer on main door to walk-in freezer (self-contained)	0.0001	0.0001	0.0005	0.0021	0.0003	0.0001	0.0007	0.0002	0.0000	0.0007	0.0001	0.0000
4502	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	0.0001	0.0001	0.0005	0.0021	0.0003	0.0001	0.0007	0.0002	0.0000	0.0007	0.0001	0.0000
4503	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	0.0001	0.0001	0.0005	0.0021	0.0003	0.0001	0.0007	0.0002	0.0000	0.0007	0.0001	0.0000
4504	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	0.0001	0.0001	0.0005	0.0021	0.0003	0.0001	0.0007	0.0002	0.0000	0.0007	0.0001	0.0000
4505	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	0.0001	0.0001	0.0005	0.0021	0.0003	0.0001	0.0007	0.0002	0.0000	0.0007	0.0001	0.0000
4506	ENERGY STAR Ice Machines	0.0001	0.0001	0.0005	0.0021	0.0003	0.0001	0.0007	0.0002	0.0000	0.0007	0.0001	0.0000
4507	Hydraulic-type door closer on reach-in cooler glass doors	0.0001	0.0001	0.0005	0.0021	0.0003	0.0001	0.0007	0.0002	0.0000	0.0007	0.0001	0.0000
6000	Base Water Heating	0.0060	0.0001	0.0034	0.0079	0.0023	0.0058	0.0023	0.0014	0.0012	0.0030	0.0123	0.0054
6001	Demand controlled circulating systems	0.0000	0.0001	0.0001	0.0002	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002
6003	Tankless Water Heater	0.0060	0.0001	0.0034	0.0079	0.0023	0.0058	0.0023	0.0014	0.0012	0.0030	0.0123	0.0054
6004	Heat Pump Water Heater (air source)	0.0060	0.0001	0.0034	0.0079	0.0023	0.0058	0.0023	0.0014	0.0012	0.0030	0.0123	0.0054
6005	Solar Water Heater	0.0060	0.0001	0.0034	0.0079	0.0023	0.0058	0.0023	0.0014	0.0012	0.0030	0.0123	0.0054
7000	Base Refrigerated Vending Machines	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
7500	Base Non-Refrigerated Vending Machines	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
8000	Base Oven	0.0000	0.0001	0.0001	0.0014	0.0000	0.0000	0.0002	0.0001	0.0000	0.0001	0.0000	0.0000
8001	Convection Oven	0.0000	0.0001	0.0001	0.0014	0.0000	0.0000	0.0002	0.0001	0.0000	0.0001	0.0000	0.0000
8100	Base Fryer	0.0000	0.0000	0.0002	0.0027	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
8101	Efficient Fryer	0.0000	0.0000	0.0002	0.0027	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
8200	Base Steamer	0.0000	0.0000	0.0000	0.0025	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000
8201	Efficient Steamer	0.0000	0.0000	0.0000	0.0025	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000
8300	Base Hot Food Holding Cabinet	0.0000	0.0001	0.0000	0.0029	0.0000	0.0000	0.0001	0.0000	0.0000	0.0004	0.0000	0.0000
8301	ENERGY STAR Hot Food Holding Cabinets	0.0000	0.0001	0.0000	0.0029	0.0000	0.0000	0.0001	0.0000	0.0000	0.0004	0.0000	0.0000
8500	Base Compressed Air	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8700	Base Heating	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8701	Air Source Heat Pump, EER=11.3, 10 tons	0.0010	0.0011	0.0002	0.0031	0.0001	0.0008	0.0000	0.0006	0.0001	0.0009	0.0001	0.0017
8702	Geothermal Heat Pump, EER=18, 10 tons	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8703	VRF Conditioning Systems	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9000	Base Miscellaneous	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9500	Base Building Design - Standard Code	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9501	15% better than code - Campuses	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9502	15% better than code - Education	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9503	15% better than code - Food Sales	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9504	15% better than code - Food Service	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9505	15% better than code - Healthcare	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9506	15% better than code - Lodging	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9507	15% better than code - Office	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9508	15% better than code - Other	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9509	15% better than code - Public Assembly	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9510	15% better than code - Retail	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9511	15% better than code - Warehouse	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9512	Commissioning	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9600	Base Building Design - Standard Code	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

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Commercial Electric Measure Inputs		TECHNOLOGY SATURATION (units/square foot)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	blic Assem	Retail	Warehouse
9601	30% better than code - Campuses	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9602	30% better than code - Education	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9603	30% better than code - Food Sales	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9604	30% better than code - Food Service	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9605	30% better than code - Healthcare	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9606	30% better than code - Lodging	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9607	30% better than code - Office	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9608	30% better than code - Other	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9609	30% better than code - Public Assembly	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9610	30% better than code - Retail	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9611	30% better than code - Warehouse	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9612	Commissioning	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9700	Base Building Design - Standard Code	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9701	50% better than code - Campuses	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9702	50% better than code - Education	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9703	50% better than code - Food Sales	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9704	50% better than code - Food Service	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9705	50% better than code - Healthcare	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9706	50% better than code - Lodging	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9707	50% better than code - Office	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9708	50% better than code - Other	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9709	50% better than code - Public Assembly	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9710	50% better than code - Retail	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9711	50% better than code - Warehouse	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9712	Commissioning	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9800	Base Building Design - Standard Code	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9801	70% better than code - Campuses	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9802	70% better than code - Education	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9803	70% better than code - Food Sales	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9804	70% better than code - Food Service	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9805	70% better than code - Healthcare	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9806	70% better than code - Lodging	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9807	70% better than code - Office	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9808	70% better than code - Other	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9809	70% better than code - Public Assembly	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9810	70% better than code - Retail	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9811	70% better than code - Warehouse	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9812	Commissioning	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

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Commercial Electric Measure Inputs		APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1000	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--RET	13%	46%	43%	34%	41%	31%	36%	46%	12%	24%	48%	47%
1001	RET 4L4' Low Watt High Performance T8 (83 W), 2015	8%	45%	34%	33%	33%	25%	36%	42%	10%	22%	13%	18%
1002	RET 4L4' LED Tube, 2015	13%	46%	43%	34%	41%	31%	33%	46%	12%	24%	48%	47%
1003	RET LED Troffer (base 4L4'T8), 2015	13%	46%	43%	34%	41%	31%	36%	46%	12%	24%	48%	47%
1004	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base RET)	8%	29%	5%	5%	14%	10%	15%	35%	6%	11%	8%	40%
1005	Advanced Lighting Controls (2015 Base RET)	5%	9%	2%	2%	6%	11%	10%	9%	1%	3%	1%	7%
1006	Daylight Dimming Controls (2015 Base RET)	2%	14%	13%	10%	9%	8%	10%	13%	3%	6%	4%	14%
1007	Custom Lighting, Base 4L4'T8, 2015	13%	46%	43%	34%	41%	31%	36%	46%	12%	24%	48%	47%
1010	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--ROB	5%	18%	17%	13%	16%	13%	14%	19%	5%	9%	19%	19%
1011	ROB 4L4' Low Watt High Performance T8 (83 W), 2015	3%	18%	14%	13%	13%	10%	14%	17%	4%	9%	5%	7%
1012	ROB 4L4' LED Tube, 2015	5%	18%	17%	13%	16%	13%	13%	19%	5%	9%	19%	19%
1013	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base ROB)	3%	11%	2%	2%	6%	4%	6%	14%	2%	5%	3%	16%
1014	Advanced Lighting Controls (2015 Base ROB)	2%	4%	1%	1%	2%	4%	4%	3%	0%	1%	0%	3%
1015	Daylight Dimming Controls (2015 Base ROB)	1%	5%	5%	4%	4%	3%	4%	5%	1%	2%	2%	6%
1020	Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream	8%	28%	26%	20%	24%	19%	21%	28%	7%	14%	29%	28%
1021	Upstream 4L4' Low Watt High Performance T8 (83 W), 2015	5%	27%	20%	20%	20%	15%	21%	25%	6%	13%	8%	11%
1022	Upstream 4L4' LED Tube, 2015	8%	28%	26%	20%	24%	19%	20%	28%	7%	14%	29%	28%
1023	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2015 (Base Upstream)	5%	17%	3%	3%	8%	6%	9%	21%	3%	7%	5%	24%
1024	Advanced Lighting Controls (2015 Base Up)	3%	5%	1%	1%	3%	7%	6%	5%	1%	2%	1%	4%
1025	Daylight Dimming Controls (2015 Base Up)	1%	8%	8%	6%	6%	5%	6%	8%	2%	4%	3%	8%
1050	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--RET	13%	46%	43%	34%	41%	31%	36%	46%	12%	24%	48%	47%
1051	RET 4L4' Low Watt High Performance T8 (83 W), 2016-2017	8%	45%	34%	33%	33%	25%	36%	42%	10%	22%	13%	18%
1052	RET 4L4' LED Tube, 2016-2017	13%	46%	43%	34%	41%	31%	33%	46%	12%	24%	48%	47%
1053	RET LED Troffer (base 4L4'T8), 2016-2017	13%	46%	43%	34%	41%	31%	36%	46%	12%	24%	48%	47%
1054	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base RET)	8%	29%	5%	5%	14%	10%	15%	35%	6%	11%	8%	40%
1055	Advanced Lighting Controls (2016-2017 Base RET)	5%	9%	2%	2%	6%	11%	10%	9%	1%	3%	1%	7%
1056	Daylight Dimming Controls (2016-2017 Base RET)	2%	14%	13%	10%	9%	8%	10%	13%	3%	6%	4%	14%
1057	Custom Lighting, Base 4L4'T8, 2016-2017	13%	46%	43%	34%	41%	31%	36%	46%	12%	24%	48%	47%
1060	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--ROB	5%	18%	17%	13%	16%	13%	14%	19%	5%	9%	19%	19%
1061	ROB 4L4' Low Watt High Performance T8 (83 W), 2016-2017	3%	18%	14%	13%	13%	10%	14%	17%	4%	9%	5%	7%
1062	ROB 4L4' LED Tube, 2016-2017	5%	18%	17%	13%	16%	13%	13%	19%	5%	9%	19%	19%
1063	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base ROB)	3%	11%	2%	2%	6%	4%	6%	14%	2%	5%	3%	16%
1064	Advanced Lighting Controls (2016-2017 Base ROB)	2%	4%	1%	1%	2%	4%	4%	3%	0%	1%	0%	3%
1065	Daylight Dimming Controls (2016-2017 Base ROB)	1%	5%	5%	4%	4%	3%	4%	5%	1%	2%	2%	6%
1070	Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream	8%	28%	26%	20%	24%	19%	21%	28%	7%	14%	29%	28%
1071	Upstream 4L4' Low Watt High Performance T8 (83 W), 2016-2017	5%	27%	20%	20%	20%	15%	21%	25%	6%	13%	8%	11%
1072	Upstream 4L4' LED Tube, 2016-2017	8%	28%	26%	20%	24%	19%	20%	28%	7%	14%	29%	28%
1073	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2016-2017 (Base Upstream)	5%	17%	3%	3%	8%	6%	9%	21%	3%	7%	5%	24%
1074	Advanced Lighting Controls (2016-2017 Base Up)	3%	5%	1%	1%	3%	7%	6%	5%	1%	2%	1%	4%
1075	Daylight Dimming Controls (2016-2017 Base Up)	1%	8%	8%	6%	6%	5%	6%	8%	2%	4%	3%	8%
1080	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--RET	13%	46%	43%	34%	41%	31%	36%	46%	12%	24%	48%	47%
1081	RET 4L4' Low Watt High Performance T8 (83 W), 2018-2019	8%	45%	34%	33%	33%	25%	36%	42%	10%	22%	13%	18%
1082	RET 4L4' LED Tube, 2018-2019	13%	46%	43%	34%	41%	31%	33%	46%	12%	24%	48%	47%
1083	RET LED Troffer (base 4L4'T8), 2018-2019	13%	46%	43%	34%	41%	31%	36%	46%	12%	24%	48%	47%
1084	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base RET)	8%	29%	5%	5%	14%	10%	15%	35%	6%	11%	8%	40%
1085	Advanced Lighting Controls (2018-2019 Base RET)	5%	9%	2%	2%	6%	11%	10%	9%	1%	3%	1%	7%
1086	Daylight Dimming Controls (2018-2019 Base RET)	2%	14%	13%	10%	9%	8%	10%	13%	3%	6%	4%	14%
1087	Custom Lighting, Base 4L4'T8, 2018-2019	13%	46%	43%	34%	41%	31%	36%	46%	12%	24%	48%	47%
1100	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--ROB	5%	18%	17%	13%	16%	13%	14%	19%	5%	9%	19%	19%
1101	ROB 4L4' Low Watt High Performance T8 (83 W), 2018-2019	3%	18%	14%	13%	13%	10%	14%	17%	4%	9%	5%	7%
1102	ROB 4L4' LED Tube, 2018-2019	5%	18%	17%	13%	16%	13%	13%	19%	5%	9%	19%	19%
1103	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base ROB)	3%	11%	2%	2%	6%	4%	6%	14%	2%	5%	3%	16%
1104	Advanced Lighting Controls (2018-2019 Base ROB)	2%	4%	1%	1%	2%	4%	4%	3%	0%	1%	0%	3%
1105	Daylight Dimming Controls (2018-2019 Base ROB)	1%	5%	5%	4%	4%	3%	4%	5%	1%	2%	2%	6%
1110	Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream	8%	28%	26%	20%	24%	19%	21%	28%	7%	14%	29%	28%
1111	Upstream 4L4' Low Watt High Performance T8 (83 W), 2018-2019	5%	27%	20%	20%	20%	15%	21%	25%	6%	13%	8%	11%
1112	Upstream 4L4' LED Tube, 2018-2019	8%	28%	26%	20%	24%	19%	20%	28%	7%	14%	29%	28%
1113	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2018-2019 (Base Upstream)	5%	17%	3%	3%	8%	6%	9%	21%	3%	7%	5%	24%

Commercial Electric Measure Inputs

Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
		APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)											
1114	Advanced Lighting Controls (2018-2019 Base Up)	3%	5%	1%	1%	3%	7%	6%	5%	1%	2%	1%	4%
1115	Daylight Dimming Controls (2018-2019 Base Up)	1%	8%	8%	6%	6%	5%	6%	8%	2%	4%	3%	8%
1120	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--RET	13%	46%	43%	34%	41%	31%	36%	46%	12%	24%	48%	47%
1121	RET 4L4' Low Watt High Performance T8 (83 W), 2020	8%	45%	34%	33%	33%	25%	36%	42%	10%	22%	13%	18%
1122	RET 4L4' LED Tube, 2020	13%	46%	43%	34%	41%	31%	33%	46%	12%	24%	48%	47%
1123	RET LED Troffer (base 4L4'T8), 2020	13%	46%	43%	34%	41%	31%	36%	46%	12%	24%	48%	47%
1124	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base RET)	8%	29%	5%	5%	14%	10%	15%	35%	6%	11%	8%	40%
1125	Advanced Lighting Controls (2020 Base RET)	5%	9%	2%	2%	6%	11%	10%	9%	1%	3%	1%	7%
1126	Daylight Dimming Controls (2020 Base RET)	2%	14%	13%	10%	9%	8%	10%	13%	3%	6%	4%	14%
1127	Custom Lighting, Base 4L4'T8, 2020	13%	46%	43%	34%	41%	31%	36%	46%	12%	24%	48%	47%
1150	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--ROB	5%	18%	17%	13%	16%	13%	14%	19%	5%	9%	19%	19%
1151	ROB 4L4' Low Watt High Performance T8 (83 W), 2020	3%	18%	14%	13%	13%	10%	14%	17%	4%	9%	5%	7%
1152	ROB 4L4' LED Tube, 2020	5%	18%	17%	13%	16%	13%	13%	19%	5%	9%	19%	19%
1153	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base ROB)	3%	11%	2%	2%	6%	4%	6%	14%	2%	5%	3%	16%
1154	Advanced Lighting Controls (2020 Base ROB)	2%	4%	1%	1%	2%	4%	4%	3%	0%	1%	0%	3%
1155	Daylight Dimming Controls (2020 Base ROB)	1%	5%	5%	4%	4%	3%	4%	5%	1%	2%	2%	6%
1160	Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream	8%	28%	26%	20%	24%	19%	21%	28%	7%	14%	29%	28%
1161	Upstream 4L4' Low Watt High Performance T8 (83 W), 2020	5%	27%	20%	20%	20%	15%	21%	25%	6%	13%	8%	11%
1162	Upstream 4L4' LED Tube, 2020	8%	28%	26%	20%	24%	19%	20%	28%	7%	14%	29%	28%
1163	Occupancy Sensor, 4L4' Fluorescent Fixtures, 2020 (Base Upstream)	5%	17%	3%	3%	8%	6%	9%	21%	3%	7%	5%	24%
1164	Advanced Lighting Controls (2020 Base Up)	3%	5%	1%	1%	3%	7%	6%	5%	1%	2%	1%	4%
1165	Daylight Dimming Controls (2020 Base Up)	1%	8%	8%	6%	6%	5%	6%	8%	2%	4%	3%	8%
1200	Base Other Fluorescent Fixture--RET	8%	18%	16%	6%	2%	23%	12%	17%	0%	7%	4%	2%
1201	RET Low Watt High Performance T8	7%	15%	16%	6%	2%	23%	12%	12%	0%	7%	4%	2%
1202	RET LED Tube	2%	5%	5%	2%	1%	7%	4%	5%	0%	2%	1%	1%
1203	RET LED Troffer	2%	5%	5%	2%	1%	7%	4%	5%	0%	2%	1%	1%
1204	Occupancy Sensor (Base Other Fluor RET)	6%	12%	3%	1%	1%	9%	6%	15%	0%	3%	1%	2%
1205	Advanced Lighting Controls (Base Other Fluor RET)	3%	3%	1%	0%	0%	8%	3%	3%	0%	1%	0%	0%
1206	Daylight Dimming Controls (Base Other Fluor RET)	2%	5%	5%	2%	1%	7%	3%	5%	0%	1%	1%	1%
1207	Custom Lighting, Base Other Fluorescent	8%	18%	16%	6%	2%	23%	12%	17%	0%	7%	4%	2%
1210	Base Other Fluorescent Fixture--ROB	3%	7%	6%	2%	1%	9%	5%	7%	0%	3%	1%	1%
1211	ROB Low Watt High Performance T8	3%	6%	6%	2%	1%	9%	5%	5%	0%	3%	1%	1%
1212	ROB LED Tube	3%	7%	6%	2%	1%	9%	5%	7%	0%	3%	1%	1%
1213	Occupancy Sensor (Base Other Fluor ROB)	2%	5%	1%	0%	0%	4%	2%	6%	0%	1%	0%	1%
1214	Advanced Lighting Controls (Base Other Fluor ROB)	1%	1%	0%	0%	0%	3%	1%	1%	0%	0%	0%	0%
1215	Daylight Dimming Controls (Base Other Fluor ROB)	1%	2%	2%	1%	0%	3%	1%	2%	0%	1%	0%	0%
1220	Base Other Fluorescent Fixture--Upstream	5%	11%	10%	4%	1%	14%	7%	10%	0%	4%	2%	1%
1221	Upstream Low Watt High Performance T8	4%	9%	10%	4%	1%	14%	7%	7%	0%	4%	2%	1%
1222	Upstream LED Tube	1%	2%	2%	1%	0%	3%	1%	2%	0%	1%	0%	0%
1223	Occupancy Sensor (Base Other Fluor Upstream)	4%	7%	2%	0%	1%	5%	4%	9%	0%	2%	0%	1%
1224	Advanced Lighting (Base Other Fluor Upstream)	2%	2%	1%	0%	0%	5%	2%	2%	0%	0%	0%	0%
1225	Daylight Dimming Controls (Base Other Fluor Upstream)	1%	3%	3%	1%	0%	4%	2%	3%	0%	1%	1%	0%
1300	Base Incandescent Lamp, 72W 2015--Hardwired	0%	1%	1%	2%	1%	1%	1%	1%	0%	1%	0%	1%
1301	LED Track Lighting (base Incandescent 72W) 2015	0%	1%	1%	2%	1%	1%	1%	1%	0%	1%	0%	1%
1310	Base Incandescent Lamp, 72W 2015--Upstream	19%	47%	45%	87%	62%	56%	52%	47%	11%	68%	16%	30%
1311	Upstream LEDs (base Incandescent 72W) 2015	12%	29%	28%	54%	39%	35%	32%	29%	7%	43%	10%	18%
1320	Base Incandescent Lamp, 72W 2016-2017--Hardwired	0%	1%	1%	2%	1%	1%	1%	1%	0%	1%	0%	1%
1321	LED Track Lighting (base Incandescent 72W) 2016-2017	0%	1%	1%	2%	1%	1%	1%	1%	0%	1%	0%	1%
1330	Base Incandescent Lamp, 72W 2016-2017--Upstream	19%	47%	45%	87%	62%	56%	52%	47%	11%	68%	16%	30%
1331	Upstream LEDs (base Incandescent 72W) 2016-2017	12%	29%	28%	54%	39%	35%	32%	29%	7%	43%	10%	18%
1340	Base Incandescent Lamp, 72W 2018-2019--Hardwired	0%	1%	1%	2%	1%	1%	1%	1%	0%	1%	0%	1%
1341	LED Track Lighting (base Incandescent 72W) 2018-2019	0%	1%	1%	2%	1%	1%	1%	1%	0%	1%	0%	1%
1350	Base Incandescent Lamp, 72W 2018-2019--Upstream	19%	47%	45%	87%	62%	56%	52%	47%	11%	68%	16%	30%
1351	Upstream LEDs (base Incandescent 72W) 2018-2019	12%	29%	28%	54%	39%	35%	32%	29%	7%	43%	10%	18%
1360	Base Incandescent Lamp, 72W 2020--Hardwired	0%	1%	1%	2%	1%	1%	1%	1%	0%	1%	0%	1%
1361	LED Track Lighting (base Incandescent 72W) 2020	0%	1%	1%	2%	1%	1%	1%	1%	0%	1%	0%	1%
1370	Base Incandescent Lamp, 72W 2020--Upstream	19%	47%	45%	87%	62%	56%	52%	47%	11%	68%	16%	30%
1371	Upstream LEDs (base Incandescent 72W) 2020	12%	29%	28%	54%	39%	35%	32%	29%	7%	43%	10%	18%

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Commercial Electric Measure Inputs		APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1400	Base CFL Lamp, 23W 2015--Hardwired	0%	1%	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%
1401	LED Track Lighting (base CFL spiral 23W) 2015	0%	1%	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%
1410	Base CFL Lamp, 23W 2015--Upstream	18%	36%	12%	36%	68%	46%	60%	63%	54%	38%	12%	3%
1411	Upstream LEDs (base CFL spiral 23W) 2015	18%	36%	12%	36%	68%	46%	60%	63%	54%	38%	12%	3%
1420	Base CFL Lamp, 23W 2016-2017--Hardwired	0%	1%	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%
1421	LED Track Lighting (base CFL spiral 23W) 2016-2017	0%	1%	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%
1430	Base CFL Lamp, 23W 2016-2017--Upstream	18%	36%	12%	36%	68%	46%	60%	63%	54%	38%	12%	3%
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	18%	36%	12%	36%	68%	46%	60%	63%	54%	38%	12%	3%
1440	Base CFL Lamp, 23W 2018-2019--Hardwired	0%	1%	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%
1441	LED Track Lighting (base CFL spiral 23W) 2018-2019	0%	1%	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%
1450	Base CFL Lamp, 23W 2018-2019--Upstream	18%	36%	12%	36%	68%	46%	60%	63%	54%	38%	12%	3%
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	18%	36%	12%	36%	68%	46%	60%	63%	54%	38%	12%	3%
1460	Base CFL Lamp, 23W 2020--Hardwired	0%	1%	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%
1461	LED Track Lighting (base CFL spiral 23W) 2020	0%	1%	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%
1470	Base CFL Lamp, 23W 2020--Upstream	18%	36%	12%	36%	68%	46%	60%	63%	54%	38%	12%	3%
1471	Upstream LEDs (base CFL spiral 23W) 2020	18%	36%	12%	36%	68%	46%	60%	63%	54%	38%	12%	3%
1500	Base Metal Halide, 400W	7%	67%	32%	20%	4%	45%	7%	16%	7%	21%	5%	63%
1501	High Bay T5 HO (240W)	0%	32%	32%	18%	4%	45%	7%	0%	5%	11%	1%	63%
1502	High Bay Induction Lighting	7%	67%	32%	20%	4%	45%	7%	15%	7%	21%	5%	63%
1503	PSMH with electronic ballast	7%	23%	31%	20%	4%	45%	7%	16%	7%	21%	5%	63%
1504	High Bay LED Lighting	7%	67%	32%	20%	4%	45%	7%	16%	7%	21%	5%	63%
1600	Base HPS (high pressure sodium) Parking Garage Lighting	18%	0%	0%	0%	7%	7%	2%	50%	7%	7%	0%	0%
1601	High-efficiency fluorescent parking garage fixture	18%	0%	0%	0%	7%	7%	2%	50%	7%	7%	0%	0%
1602	LED Parking Garage Fixtures	18%	0%	0%	0%	7%	7%	2%	50%	7%	7%	0%	0%
1603	Bi-Level LED Parking Garage Fixtures	13%	0%	0%	0%	5%	5%	1%	36%	5%	5%	0%	0%
1700	Base CFL Exit Sign	100%	96%	88%	98%	76%	97%	89%	93%	24%	55%	96%	89%
1701	LED Exit Sign	20%	38%	30%	65%	61%	41%	18%	12%	14%	27%	77%	5%
1800	Base Outdoor High Pressure Sodium 250W Lamp	19%	27%	10%	24%	42%	44%	32%	38%	10%	77%	1%	73%
1801	LED Outdoor Area Lighting (other than pole-mounted)	19%	8%	10%	24%	42%	38%	30%	37%	10%	71%	1%	16%
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	77%	11%	11%	0%	4%	100%	19%	6%	11%	16%	4%	0%
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	53%	7%	8%	0%	3%	68%	13%	4%	7%	11%	3%	0%
2002	Chiller VSD	31%	4%	4%	0%	1%	40%	8%	2%	4%	6%	2%	0%
2003	EMS - Chiller	63%	10%	4%	0%	4%	51%	19%	5%	1%	6%	1%	0%
2004	Cool Roof - Chiller	39%	3%	6%	0%	2%	44%	10%	1%	5%	8%	0%	0%
2006	VSD for Chiller Pumps and Towers	77%	11%	11%	0%	3%	100%	19%	5%	11%	6%	4%	0%
2008	Ceiling/roof Insulation - Chiller	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2009	Custom HVAC--Base Chiller	77%	11%	11%	0%	4%	100%	19%	6%	11%	16%	4%	0%
2010	Custom Shell--Base Chiller	77%	11%	11%	0%	4%	100%	19%	6%	11%	16%	4%	0%
2100	Base DX Packaged System, EER=10.0, 30 tons	8%	29%	68%	77%	57%	60%	9%	80%	3%	55%	68%	53%
2101	ROB DX Packaged System, EER=10.8, 30 tons	8%	29%	68%	77%	57%	60%	9%	80%	3%	55%	68%	53%
2102	ROB DX Packaged System, EER=11.7, 30 tons	8%	29%	68%	77%	57%	60%	9%	80%	3%	55%	68%	53%
2104	Automated Fault Detection	0%	1%	3%	4%	3%	3%	0%	4%	0%	3%	3%	3%
2106	Advanced Controllers for RTUs	1%	1%	1%	2%	1%	16%	0%	1%	0%	0%	0%	0%
2107	Programmable Communicating Thermostat	8%	29%	68%	77%	57%	60%	9%	80%	3%	55%	68%	53%
2108	Prog. Thermostat - DX	1%	22%	2%	24%	16%	16%	3%	10%	0%	5%	42%	34%
2109	Cool Roof - DX	4%	13%	34%	35%	29%	30%	4%	38%	2%	28%	22%	21%
2110	RTU VSD	2%	6%	14%	15%	11%	12%	2%	13%	1%	4%	13%	11%
2111	Dual Enthalpy Economizer Controls	0%	1%	2%	2%	2%	2%	0%	2%	0%	1%	2%	1%
2113	Aerosol Duct Sealing	1%	9%	22%	22%	18%	19%	3%	26%	1%	17%	22%	17%
2114	Ceiling/roof Insulation - DX	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
2115	Duct/Pipe Insulation - DX	2%	21%	51%	47%	31%	33%	5%	26%	1%	17%	25%	5%
2116	Custom HVAC--DX	8%	29%	68%	77%	57%	60%	9%	80%	3%	55%	68%	53%
2117	Custom Shell--DX	8%	29%	68%	77%	57%	60%	9%	80%	3%	55%	68%	53%
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	7%	2%	1%	2%	19%	1%	11%	9%	0%	0%	0%	1%
2201	Air Source Heat Pump, EER=11.3, 10 tons	7%	2%	1%	2%	19%	1%	11%	9%	0%	0%	0%	1%
2300	Base PTAC, EER=8.3, 1 ton	0%	77%	11%	12%	29%	4%	41%	4%	2%	18%	8%	0%
2301	Occupancy Sensor (hotels)	0%	0%	0%	0%	0%	0%	31%	0%	0%	0%	0%	0%
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	81%	88%	43%	40%	40%	100%	62%	70%	12%	46%	36%	25%
3001	Variable Speed Drive Control, 5 HP	81%	88%	43%	40%	40%	81%	62%	67%	12%	46%	36%	25%
3002	Custom HVAC--Base Fan Motor, 5hp	81%	88%	43%	40%	40%	100%	62%	70%	12%	46%	36%	25%
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	6%	4%	0%	0%	7%	40%	1%	4%	0%	2%	4%	0%

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Commercial Electric Measure Inputs — **APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)**

Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
3101	Variable Speed Drive Control, 15 HP	6%	1%	0%	0%	7%	40%	1%	2%	0%	2%	4%	0%
3102	Air Handler Optimization, 15 HP	5%	4%	0%	0%	0%	0%	1%	4%	0%	2%	4%	0%
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	4%	4%	0%	0%	7%	40%	1%	2%	0%	2%	4%	0%
3104	Separate Makeup Air / Exhaust Hoods AC	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%
3105	Custom HVAC--Base Fan Motor, 15hp	6%	4%	0%	0%	7%	40%	1%	4%	0%	2%	4%	0%
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	1%	1%	9%	0%	0%	1%	0%	1%	0%	0%	4%	0%
3201	Variable Speed Drive Control, 40 HP	0%	1%	9%	0%	0%	0%	0%	0%	0%	0%	4%	0%
3202	Air Handler Optimization, 40 HP	1%	1%	9%	0%	0%	0%	0%	1%	0%	0%	4%	0%
3203	Demand Controlled Ventilation (40 HP fan motor)	1%	1%	8%	0%	0%	0%	0%	0%	0%	0%	3%	0%
3204	Custom HVAC--Base Fan Motor, 40hp	1%	1%	9%	0%	0%	1%	0%	1%	0%	0%	4%	0%
4000	Base Built-Up Refrigeration System	0%	60%	52%	91%	31%	68%	53%	18%	3%	62%	2%	26%
4001	Strip curtains for walk-ins (built-up)	0%	0%	52%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4002	Auto-closer on main door to walk-in freezer (built-up)	0%	0%	26%	45%	0%	0%	0%	0%	0%	0%	0%	13%
4003	Night covers for display cases	0%	0%	47%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4004	Evaporator fan controller for MT walk-ins	0%	0%	12%	24%	0%	0%	0%	0%	0%	0%	0%	1%
4005	Electronically commutated evaporator fan motor	0%	0%	12%	36%	0%	0%	0%	0%	0%	0%	0%	5%
4006	Efficient compressor motor	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4007	Floating head pressure controls	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4008	Refrigeration Commissioning	0%	0%	26%	45%	0%	0%	0%	0%	2%	0%	0%	13%
4009	Demand Hot Gas Defrost	0%	0%	52%	91%	0%	0%	0%	0%	0%	0%	0%	0%
4010	Demand Defrost Electric	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4011	Anti-sweat (humidistat) controls	0%	0%	14%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4012	Freezer-Cooler Replacement Gaskets	0%	0%	26%	45%	0%	0%	0%	0%	0%	0%	0%	13%
4013	High R-Value Glass Doors	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4014	LED Display Lighting (Base T8 Lighting)	0%	0%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4016	Multiplex Compressor System	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4017	Oversized Air Cooled Condenser	0%	0%	26%	0%	0%	0%	0%	0%	2%	0%	0%	13%
4018	Custom Refrigeration	0%	0%	52%	0%	0%	0%	0%	0%	3%	0%	0%	26%
4500	Base Self-Contained Refrigeration	98%	97%	100%	100%	96%	94%	99%	75%	92%	96%	24%	69%
4501	Strip curtains for walk-ins (self-contained)	14%	25%	6%	18%	21%	20%	14%	20%	11%	29%	6%	2%
4502	Auto-closer on main door to walk-in freezer (self-contained)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4503	Night covers for display cases (self-contained)	20%	29%	27%	29%	28%	27%	29%	16%	26%	29%	7%	0%
4504	LED Display Lighting (Base T8 Lighting)	10%	10%	8%	8%	10%	6%	9%	7%	9%	9%	2%	7%
4506	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	31%	31%	32%	32%	31%	30%	32%	24%	29%	31%	8%	22%
4507	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	32%	32%	33%	33%	32%	31%	33%	25%	30%	32%	8%	23%
4508	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	31%	31%	32%	32%	31%	30%	32%	24%	29%	31%	8%	22%
4509	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	31%	31%	32%	32%	31%	30%	32%	24%	29%	31%	8%	22%
4510	ENERGY STAR Ice Machines	31%	31%	32%	32%	31%	30%	32%	24%	29%	31%	8%	22%
4511	Hydraulic-type door closer on reach-in cooler glass doors	49%	49%	50%	50%	48%	47%	49%	38%	46%	48%	12%	35%
4512	Doors for open cases	25%	29%	29%	30%	29%	28%	30%	23%	17%	29%	7%	21%
6000	Base Water Heating	90%	4%	17%	27%	22%	12%	55%	85%	10%	32%	92%	73%
6001	Demand controlled circulating systems	67%	3%	13%	20%	16%	9%	41%	50%	7%	24%	27%	28%
6003	Hot Water Pipe Insulation	67%	0%	17%	0%	22%	12%	32%	24%	6%	25%	76%	71%
6004	Tankless Water Heater	67%	3%	13%	20%	16%	9%	37%	63%	7%	24%	69%	52%
6005	Heat Pump Water Heater (air source)	72%	3%	14%	22%	17%	9%	44%	68%	8%	26%	74%	58%
6006	Heat Recovery Unit	7%	1%	14%	22%	17%	2%	6%	4%	0%	3%	5%	7%
6007	Heat Trap	51%	2%	10%	15%	12%	6%	31%	48%	5%	18%	52%	41%
6008	Solar Water Heater	34%	0%	3%	5%	4%	2%	42%	0%	0%	16%	4%	36%
6009	High Temperature Dishwasher	2%	0%	3%	10%	0%	0%	0%	2%	0%	0%	1%	1%
7000	Base Refrigerated Vending Machines	81%	33%	50%	21%	32%	69%	40%	28%	10%	49%	71%	76%
7001	Vending Misers (Refrigerated units)	40%	14%	24%	9%	16%	16%	19%	10%	3%	24%	35%	9%
7002	Vending Misers (Refrigerated glass-front units)	17%	6%	10%	4%	7%	7%	8%	4%	1%	10%	15%	4%
7003	Refrigerated Vending Low Watt High Performance T8	48%	21%	30%	15%	21%	44%	25%	19%	6%	19%	28%	30%
7500	Base Non-Refrigerated Vending Machines	81%	33%	50%	21%	32%	69%	40%	28%	10%	49%	71%	76%
7501	Vending Misers (Non-Refrigerated)	81%	28%	50%	18%	32%	32%	39%	20%	7%	49%	71%	18%
7502	Non-refrigerated Vending Low Watt High Performance T8	69%	31%	43%	21%	31%	63%	36%	28%	8%	28%	40%	43%
8000	Base Oven	76%	45%	25%	10%	38%	0%	24%	11%	9%	75%	3%	0%
8001	Convection Oven	76%	45%	25%	10%	38%	0%	14%	11%	9%	75%	3%	0%
8100	Base Fryer	0%	5%	7%	4%	0%	0%	4%	0%	0%	41%	0%	0%
8101	Efficient Fryer	0%	5%	7%	3%	0%	0%	4%	0%	0%	41%	0%	0%
8200	Base Steamer	0%	41%	3%	21%	21%	0%	15%	3%	3%	42%	0%	0%
8201	Efficient Steamer	0%	41%	3%	21%	21%	0%	15%	1%	3%	42%	0%	0%

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Commercial Electric Measure Inputs	APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)											
Measure # Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembl	Retail	Warehouse
8300 Base Hot Food Holding Cabinet	0%	66%	22%	30%	8%	37%	13%	9%	0%	49%	0%	0%
8301 ENERGY STAR Hot Food Holding Cabinets	0%	64%	22%	28%	8%	37%	13%	9%	0%	49%	0%	0%
8500 Base Compressed Air	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
8700 Base Heating	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
9000 Base Miscellaneous	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
9500 Base Whole Building	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
9501 NEMA Premium Efficiency Transformer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
9502 Retrocommissioning/Building tune up	64%	64%	0%	0%	64%	64%	64%	64%	24%	40%	40%	0%
9503 Custom O&M	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
1000 Base Fluorescent Fixture, 4L4'T8, 1EB, 2015 (New)	8%	28%	26%	20%	24%	19%	21%	28%	7%	14%	29%	28%
1001 NEW 3L4'T5, 2015	8%	28%	26%	20%	24%	19%	21%	28%	7%	14%	29%	28%
1002 Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015	7%	24%	25%	19%	24%	19%	21%	28%	7%	14%	29%	28%
1010 Base Fluorescent Fixture, 4L4'T8, 1EB, 2015--Upstream New	18%	64%	60%	47%	57%	44%	50%	65%	17%	33%	67%	65%
1012 Upstream 4L4' LED Tube, 2015	18%	64%	60%	47%	57%	44%	50%	65%	17%	33%	67%	65%
1013 Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2015 (Base Upstream)	17%	55%	59%	44%	56%	44%	49%	65%	17%	33%	67%	65%
1050 Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017 (New)	8%	28%	26%	20%	24%	19%	21%	28%	7%	14%	29%	28%
1051 NEW 3L4'T5, 2016-2017	8%	28%	26%	20%	24%	19%	21%	28%	7%	14%	29%	28%
1052 Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017	7%	24%	25%	19%	24%	19%	21%	28%	7%	14%	29%	28%
1060 Base Fluorescent Fixture, 4L4'T8, 1EB, 2016-2017--Upstream New	18%	64%	60%	47%	57%	44%	50%	65%	17%	33%	67%	65%
1062 Upstream 4L4' LED Tube, 2016-2017	18%	64%	60%	47%	57%	44%	50%	65%	17%	33%	67%	65%
1063 Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2016-2017 (Base Upstream)	17%	55%	59%	44%	56%	44%	49%	65%	17%	33%	67%	65%
1100 Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019 (New)	8%	28%	26%	20%	24%	19%	21%	28%	7%	14%	29%	28%
1101 NEW 3L4'T5, 2018-2019	8%	28%	26%	20%	24%	19%	21%	28%	7%	14%	29%	28%
1102 Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019	7%	24%	25%	19%	24%	19%	21%	28%	7%	14%	29%	28%
1110 Base Fluorescent Fixture, 4L4'T8, 1EB, 2018-2019--Upstream New	18%	64%	60%	47%	57%	44%	50%	65%	17%	33%	67%	65%
1112 Upstream 4L4' LED Tube, 2018-2019	18%	64%	60%	47%	57%	44%	50%	65%	17%	33%	67%	65%
1113 Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2018-2019 (Base Upstream)	17%	55%	59%	44%	56%	44%	49%	65%	17%	33%	67%	65%
1150 Base Fluorescent Fixture, 4L4'T8, 1EB, 2020 (New)	8%	28%	26%	20%	24%	19%	21%	28%	7%	14%	29%	28%
1151 NEW 3L4'T5, 2020	8%	28%	26%	20%	24%	19%	21%	28%	7%	14%	29%	28%
1152 Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020	7%	24%	25%	19%	24%	19%	21%	28%	7%	14%	29%	28%
1160 Base Fluorescent Fixture, 4L4'T8, 1EB, 2020--Upstream New	18%	64%	60%	47%	57%	44%	50%	65%	17%	33%	67%	65%
1162 Upstream 4L4' LED Tube, 2020	18%	64%	60%	47%	57%	44%	50%	65%	17%	33%	67%	65%
1163 Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings, 2020 (Base Upstream)	17%	55%	59%	44%	56%	44%	49%	65%	17%	33%	67%	65%
1200 Base Other Fluorescent Fixture (New)	5%	11%	10%	4%	1%	14%	7%	10%	0%	4%	2%	1%
1201 NEW T5	5%	11%	10%	4%	1%	14%	7%	10%	0%	4%	2%	1%
1202 Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings	5%	9%	10%	3%	1%	14%	7%	10%	0%	4%	2%	1%
1210 Base Other Fluorescent Fixture--Upstream New	11%	25%	23%	8%	2%	32%	17%	24%	0%	10%	5%	3%
1211 Upstream Low Watt High Performance T8	11%	25%	22%	8%	2%	32%	16%	24%	0%	8%	4%	2%
1212 Upstream LED Tube	11%	25%	23%	8%	2%	32%	17%	24%	0%	10%	5%	3%
1213 Advanced Lighting Design (High Performance Lighting R/R) - 25% Savings (Base Upstream)	11%	22%	22%	8%	2%	32%	16%	24%	0%	10%	5%	3%
1300 Base Incandescent Lamp, 72W 2015--New	0%	1%	1%	2%	1%	1%	1%	1%	0%	1%	0%	1%
1301 New LEDs (base incandescent 72W) 2015	0%	1%	1%	1%	1%	1%	1%	1%	0%	1%	0%	0%
1310 Base Incandescent Lamp, 72W 2015--Upstream New	19%	47%	45%	87%	62%	56%	52%	47%	11%	68%	16%	30%
1311 Upstream LEDs (base incandescent 72W) 2015	12%	29%	28%	54%	39%	35%	32%	29%	7%	43%	10%	18%
1320 Base Incandescent Lamp, 72W 2016-2017--New	0%	1%	1%	2%	1%	1%	1%	1%	0%	1%	0%	1%
1321 New LEDs (base incandescent 72W) 2016-2017	0%	1%	1%	1%	1%	1%	1%	1%	0%	1%	0%	0%
1330 Base Incandescent Lamp, 72W 2016-2017--Upstream New	19%	47%	45%	87%	62%	56%	52%	47%	11%	68%	16%	30%
1331 Upstream LEDs (base incandescent 72W) 2016-2017	12%	29%	28%	54%	39%	35%	32%	29%	7%	43%	10%	18%
1340 Base Incandescent Lamp, 72W 2018-2019--New	0%	1%	1%	2%	1%	1%	1%	1%	0%	1%	0%	1%
1341 New LEDs (base incandescent 72W) 2018-2019	0%	1%	1%	1%	1%	1%	1%	1%	0%	1%	0%	0%
1350 Base Incandescent Lamp, 72W 2018-2019--Upstream New	19%	47%	45%	87%	62%	56%	52%	47%	11%	68%	16%	30%
1351 Upstream LEDs (base incandescent 72W) 2018-2019	12%	29%	28%	54%	39%	35%	32%	29%	7%	43%	10%	18%
1360 Base Incandescent Lamp, 72W 2020--New	0%	1%	1%	2%	1%	1%	1%	1%	0%	1%	0%	1%
1361 New LEDs (base incandescent 72W) 2020	0%	1%	1%	1%	1%	1%	1%	1%	0%	1%	0%	0%
1370 Base Incandescent Lamp, 72W 2020--Upstream New	19%	47%	45%	87%	62%	56%	52%	47%	11%	68%	16%	30%
1371 Upstream LEDs (base incandescent 72W) 2020	12%	29%	28%	54%	39%	35%	32%	29%	7%	43%	10%	18%
1400 Base CFL Lamp, 23W 2015--New	0%	1%	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%
1401 New LEDs (base CFL spiral 23W) 2015	0%	1%	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%
1410 Base CFL Lamp, 23W 2015--Upstream New	18%	36%	12%	36%	68%	46%	60%	63%	54%	38%	12%	3%
1411 Upstream LEDs (base CFL spiral 23W) 2015	18%	36%	12%	36%	68%	46%	60%	63%	54%	38%	12%	3%
1420 Base CFL Lamp, 23W 2016-2017--New	0%	1%	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%
1421 New LEDs (base CFL spiral 23W) 2016-2017	0%	1%	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%

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Commercial Electric Measure Inputs		APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembl	Retail	Warehouse
1430	Base CFL Lamp, 23W 2016-2017--Upstream New	18%	36%	12%	36%	68%	46%	60%	63%	54%	38%	12%	3%
1431	Upstream LEDs (base CFL spiral 23W) 2016-2017	18%	36%	12%	36%	68%	46%	60%	63%	54%	38%	12%	3%
1440	Base CFL Lamp, 23W 2018-2019--New	0%	1%	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%
1441	New LEDs (base CFL spiral 23W) 2018-2019	0%	1%	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%
1450	Base CFL Lamp, 23W 2018-2019--Upstream New	18%	36%	12%	36%	68%	46%	60%	63%	54%	38%	12%	3%
1451	Upstream LEDs (base CFL spiral 23W) 2018-2019	18%	36%	12%	36%	68%	46%	60%	63%	54%	38%	12%	3%
1460	Base CFL Lamp, 23W 2020--New	0%	1%	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%
1461	New LEDs (base CFL spiral 23W) 2020	0%	1%	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%
1470	Base CFL Lamp, 23W 2020--Upstream New	18%	36%	12%	36%	68%	46%	60%	63%	54%	38%	12%	3%
1471	Upstream LEDs (base CFL spiral 23W) 2020	18%	36%	12%	36%	68%	46%	60%	63%	54%	38%	12%	3%
1500	Base Metal Halide, 400W	7%	67%	32%	20%	4%	45%	7%	16%	7%	21%	5%	63%
1501	High Bay T5 HO (240W)	0%	32%	32%	18%	4%	45%	7%	0%	5%	11%	1%	63%
1502	High Bay Induction Lighting	7%	67%	32%	20%	4%	45%	7%	15%	7%	21%	5%	63%
1600	Base HID Parking Garage Lighting	18%	0%	0%	0%	7%	7%	2%	50%	7%	7%	0%	0%
1601	LED Parking Garage Fixtures	18%	0%	0%	0%	0%	7%	2%	50%	7%	7%	0%	0%
1602	Bi-Level LED Parking Garage Fixtures	13%	0%	0%	0%	-1%	5%	1%	36%	5%	5%	0%	0%
1700	Base CFL Exit Sign	100%	96%	88%	98%	76%	97%	89%	93%	24%	55%	96%	89%
1800	Base Outdoor High Pressure Sodium 250W Lamp	19%	27%	10%	24%	42%	44%	32%	38%	10%	77%	1%	73%
1801	LED Outdoor Area Lighting (other than pole-mounted)	17%	8%	9%	22%	38%	34%	27%	33%	9%	64%	1%	14%
2000	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	77%	11%	11%	0%	4%	100%	19%	6%	11%	16%	4%	0%
2001	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	53%	7%	8%	0%	3%	68%	13%	4%	7%	11%	3%	0%
2002	Chilled Beams	26%	3%	6%	0%	2%	50%	3%	3%	0%	0%	0%	0%
2003	Cool Roof - Chiller	39%	3%	6%	0%	2%	44%	10%	1%	5%	8%	0%	0%
2005	VSD for Chiller Pumps and Towers	30%	2%	11%	0%	1%	4%	3%	3%	5%	3%	2%	0%
2100	Base DX Packaged System, EER=10.0, 30 tons	8%	29%	68%	77%	57%	60%	9%	80%	3%	55%	68%	53%
2101	ROB DX Packaged System, EER=10.8, 30 tons	8%	29%	68%	77%	57%	60%	9%	80%	3%	55%	68%	53%
2102	ROB DX Packaged System, EER=11.7, 30 tons	8%	29%	68%	77%	57%	60%	9%	80%	3%	55%	68%	53%
2103	Automated Fault Detection	0%	1%	3%	4%	3%	3%	0%	4%	0%	3%	3%	3%
2104	RTU VSD	2%	6%	14%	15%	11%	12%	2%	13%	1%	4%	13%	11%
2106	Aerosol Duct Sealing	1%	9%	22%	22%	18%	19%	3%	26%	1%	17%	22%	17%
2107	VRF Conditioning Systems	7%	2%	1%	2%	19%	1%	11%	9%	0%	0%	0%	1%
2200	Base Air Source Heat Pump, EER=9.9, 10 tons	7%	2%	1%	2%	19%	1%	11%	9%	0%	0%	0%	1%
2201	Air Source Heat Pump, EER=11.3, 10 tons	7%	2%	1%	2%	19%	1%	11%	9%	0%	0%	0%	1%
2202	Geothermal Heat Pump, EER=18, 10 tons	7%	2%	1%	2%	19%	1%	11%	9%	0%	0%	0%	1%
2203	VRF Conditioning Systems	7%	2%	1%	2%	19%	1%	11%	9%	0%	0%	0%	1%
2300	Base PTAC, EER=8.3, 1 ton	0%	77%	11%	12%	29%	4%	41%	4%	2%	18%	8%	0%
2301	Occupancy Sensor (hotels)	0%	0%	0%	0%	0%	0%	31%	0%	0%	0%	0%	0%
3000	Base Fan Motor, 5hp, 1800rpm, 87.5%	81%	88%	43%	40%	40%	100%	62%	44%	12%	46%	36%	25%
3001	Variable Speed Drive Control, 5 HP	79%	88%	43%	40%	40%	81%	59%	42%	11%	46%	33%	25%
3100	Base Fan Motor, 15hp, 1800rpm, 91.0%	6%	4%	0%	0%	7%	40%	1%	4%	0%	2%	4%	0%
3101	Variable Speed Drive Control, 15 HP	6%	1%	0%	0%	7%	40%	1%	2%	0%	2%	4%	0%
3102	Air Handler Optimization, 15 HP	5%	4%	0%	0%	0%	0%	1%	4%	0%	2%	4%	0%
3103	Electronically Commutated Motors (ECM) on an Air Handler Unit	4%	4%	0%	0%	7%	40%	1%	2%	0%	2%	4%	0%
3104	Separate Makeup Air / Exhaust Hoods AC	0%	0%	0%	0%	1%	8%	0%	0%	0%	0%	0%	0%
3200	Base Fan Motor, 40hp, 1800rpm, 93.0%	1%	1%	9%	0%	0%	1%	0%	1%	0%	0%	4%	0%
3201	Variable Speed Drive Control, 40 HP	0%	1%	9%	0%	0%	0%	0%	0%	0%	0%	4%	0%
3202	Air Handler Optimization, 40 HP	1%	1%	9%	0%	0%	0%	0%	1%	0%	0%	4%	0%
3203	Demand Controlled Ventilation (40 HP fan motor)	1%	1%	9%	0%	0%	0%	0%	1%	0%	0%	3%	0%
4000	Base Built-Up Refrigeration System	0%	60%	52%	91%	31%	68%	53%	18%	3%	62%	2%	26%
4001	Auto-closer on main door to walk-in freezer (built-up)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4002	Evaporator fan controller for MT walk-ins	0%	12%	12%	24%	12%	20%	16%	11%	2%	41%	1%	1%
4003	Efficient compressor motor	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4004	Refrigeration Commissioning	0%	6%	5%	9%	3%	7%	5%	2%	1%	6%	1%	3%
4500	Base Self-Contained Refrigeration	98%	97%	100%	100%	96%	94%	99%	75%	92%	96%	24%	69%
4501	Auto-closer on main door to walk-in freezer (self-contained)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4502	ENERGY STAR Refrigerator, solid door (Base existing solid door refrigerator)	63%	62%	64%	64%	62%	60%	63%	48%	59%	62%	15%	44%
4503	ENERGY STAR Freezer, solid door (Base exisiting solid door freezer)	65%	64%	66%	66%	64%	62%	65%	50%	61%	64%	16%	46%
4504	ENERGY STAR Refrigerator, glass door (Base exisiting glass door refrigerator)	63%	62%	64%	64%	62%	60%	63%	48%	59%	62%	15%	44%
4505	ENERGY STAR Freezer, glass door (Base exisiting glass door freezer)	63%	62%	64%	64%	62%	60%	63%	48%	59%	62%	15%	44%
4506	ENERGY STAR Ice Machines	63%	62%	64%	64%	62%	60%	63%	48%	59%	62%	15%	44%
4507	Hydraulic-type door closer on reach-in cooler glass doors	49%	49%	50%	50%	48%	47%	49%	38%	46%	48%	12%	35%
6000	Base Water Heating	90%	4%	17%	27%	22%	12%	55%	85%	10%	32%	92%	73%

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Commercial Electric Measure Inputs		APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
6001	Demand controlled circulating systems	67%	3%	13%	20%	16%	9%	41%	50%	7%	24%	27%	28%
6003	Tankless Water Heater	67%	3%	13%	20%	16%	9%	37%	63%	7%	24%	69%	52%
6004	Heat Pump Water Heater (air source)	72%	3%	14%	22%	17%	9%	44%	68%	8%	26%	74%	58%
6005	Solar Water Heater	34%	0%	3%	5%	4%	2%	42%	0%	0%	16%	4%	36%
7000	Base Refrigerated Vending Machines	81%	33%	50%	21%	32%	69%	40%	28%	10%	49%	71%	76%
7500	Base Non-Refrigerated Vending Machines	81%	33%	50%	21%	32%	69%	40%	28%	10%	49%	71%	76%
8000	Base Oven	76%	45%	25%	10%	38%	0%	24%	11%	9%	75%	3%	0%
8001	Convection Oven	76%	45%	25%	10%	38%	0%	14%	11%	9%	75%	3%	0%
8100	Base Fryer	0%	5%	7%	4%	0%	0%	4%	0%	0%	41%	0%	0%
8101	Efficient Fryer	0%	5%	7%	3%	0%	0%	4%	0%	0%	41%	0%	0%
8200	Base Steamer	0%	41%	3%	21%	21%	0%	15%	3%	3%	42%	0%	0%
8201	Efficient Steamer	0%	41%	3%	21%	21%	0%	15%	1%	3%	42%	0%	0%
8300	Base Hot Food Holding Cabinet	0%	66%	22%	30%	8%	37%	13%	9%	0%	49%	0%	0%
8301	ENERGY STAR Hot Food Holding Cabinets	0%	64%	22%	28%	8%	37%	13%	9%	0%	49%	0%	0%
8500	Base Compressed Air	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
8700	Base Heating	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
8701	Air Source Heat Pump, EER=11.3, 10 tons	7%	2%	1%	2%	19%	1%	11%	9%	0%	0%	0%	1%
8702	Geothermal Heat Pump, EER=18, 10 tons	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
8703	VRF Conditioning Systems	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
9000	Base Miscellaneous	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
9500	Base Building Design - Standard Code	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
9501	15% better than code - Campuses	15%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9502	15% better than code - Education	0%	15%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9503	15% better than code - Food Sales	0%	0%	15%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9504	15% better than code - Food Service	0%	0%	0%	15%	0%	0%	0%	0%	0%	0%	0%	0%
9505	15% better than code - Healthcare	0%	0%	0%	0%	15%	15%	0%	0%	0%	0%	0%	0%
9506	15% better than code - Lodging	0%	0%	0%	0%	0%	0%	15%	0%	0%	0%	0%	0%
9507	15% better than code - Office	0%	0%	0%	0%	0%	0%	0%	15%	0%	0%	0%	0%
9508	15% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	15%	0%	0%	0%
9509	15% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	15%	0%	0%
9510	15% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15%	0%
9511	15% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15%
9512	Commissioning	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
9600	Base Building Design - Standard Code	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
9601	30% better than code - Campuses	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9602	30% better than code - Education	0%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9603	30% better than code - Food Sales	0%	0%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9604	30% better than code - Food Service	0%	0%	0%	6%	0%	0%	0%	0%	0%	0%	0%	0%
9605	30% better than code - Healthcare	0%	0%	0%	0%	6%	6%	0%	0%	0%	0%	0%	0%
9606	30% better than code - Lodging	0%	0%	0%	0%	0%	0%	6%	0%	0%	0%	0%	0%
9607	30% better than code - Office	0%	0%	0%	0%	0%	0%	0%	6%	0%	0%	0%	0%
9608	30% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	6%	0%	0%	0%
9609	30% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	0%	0%
9610	30% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	0%
9611	30% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%
9612	Commissioning	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
9700	Base Building Design - Standard Code	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
9701	50% better than code - Campuses	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9702	50% better than code - Education	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9703	50% better than code - Food Sales	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9704	50% better than code - Food Service	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%
9705	50% better than code - Healthcare	0%	0%	0%	0%	3%	3%	0%	0%	0%	0%	0%	0%
9706	50% better than code - Lodging	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%
9707	50% better than code - Office	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%
9708	50% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%
9709	50% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%
9710	50% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%
9711	50% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%
9712	Commissioning	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
9800	Base Building Design - Standard Code	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
9801	70% better than code - Campuses	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9802	70% better than code - Education	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

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Commercial Electric Measure Inputs		APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
9803	70% better than code - Food Sales	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9804	70% better than code - Food Service	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%
9805	70% better than code - Healthcare	0%	0%	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%
9806	70% better than code - Lodging	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%
9807	70% better than code - Office	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%
9808	70% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%
9809	70% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%
9810	70% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%
9811	70% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
9812	Commissioning	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%

DNV·GL

Commercial Gas Measure Inputs

BASE TECHNOLOGY EUIs (therm/square foot)

Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1000	Base Boiler	0.4	0.3	0.8	0.2	0.2	0.3	0.2	0.7	0.9	0.1	0.4	0.1
1200	Base Furnace	0.4	0.3	0.8	0.2	0.2	0.3	0.2	0.7	0.9	0.1	0.4	0.1
1400	Base Other Heat	0.4	0.3	0.8	0.2	0.2	0.3	0.2	0.7	0.9	0.1	0.4	0.1
1500	Base Water Heating - high standby loss (as % of load)	0.1	0.0	0.0	0.4	0.1	0.4	0.2	0.2	0.3	0.2	0.1	
1600	Base Water Heating - low standby loss (as % of load)	0.1	0.0	0.0	0.4	0.1	0.4	0.2	0.2	0.3	0.2	0.1	
1700	Base Cooking - Fryer			0.0	0.7	0.0	0.0	0.0	0.0	0.2	0.1	0.0	
1800	Base Cooking - Steamer		0.0		0.4	0.0	0.0	0.0	0.0	0.0	0.1		
1900	Base Cooking - Convection Oven		0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.1	0.1	0.4	
2000	Base Cooking - Griddle			0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.0	
2010	Base Cooking - Range		0.0	0.1	1.1	0.0	0.1	0.1	0.0	0.3	0.1	0.0	
2020	Base Misc	0.2	0.0	0.0	0.0		0.2		0.1	0.1	0.1		
2030	Base Whole Building	0.5	0.5	0.7	1.7	0.4	0.6	0.5	0.6	0.7	0.4	0.4	0.3
2100	Base Building Design - Standard Code	0.5	0.5	0.7	1.7	0.4	0.6	0.5	0.6	0.7	0.4	0.4	0.3
2120	Base Building Design - Standard Code	0.5	0.5	0.7	1.7	0.4	0.6	0.5	0.6	0.7	0.4	0.4	0.3
2140	Base Building Design - Standard Code	0.5	0.5	0.7	1.7	0.4	0.6	0.5	0.6	0.7	0.4	0.4	0.3
2160	Base Building Design - Standard Code	0.5	0.5	0.7	1.7	0.4	0.6	0.5	0.6	0.7	0.4	0.4	0.3
2200	Base Boiler	0.4	0.3	0.8	0.2	0.2	0.3	0.2	0.7	0.9	0.1	0.4	0.1
2220	Base Furnace	0.4	0.3	0.8	0.2	0.2	0.3	0.2	0.7	0.9	0.1	0.4	0.1
2240	Base Other Heat	0.4	0.3	0.8	0.2	0.2	0.3	0.2	0.7	0.9	0.1	0.4	0.1
2250	Base Water Heating - high standby loss (as % of load)	0.1	0.0	0.0	0.4	0.1	0.4	0.2	0.2	0.3	0.2	0.1	
2260	Base Water Heating - low standby loss (as % of load)	0.1	0.0	0.0	0.4	0.1	0.4	0.2	0.2	0.3	0.2	0.1	
2270	Base Cooking - Fryer			0.0	0.7	0.0	0.0	0.0	0.0	0.2	0.1	0.0	
2280	Base Cooking - Steamer		0.0		0.4	0.0	0.0	0.0	0.0	0.0	0.1		
2290	Base Cooking - Convection Oven		0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.1	0.1	0.4	
2300	Base Cooking - Griddle			0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.0	
2310	Base Cooking - Range		0.0	0.1	1.1	0.0	0.1	0.1	0.0	0.3	0.1	0.0	
2320	Base Misc	0.2	0.0	0.0	0.0		0.2		0.1	0.1	0.1		

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Commercial Gas Measure Costs

Measure #	Measure Description	First Year	End Year	Savings Units	Cost Units	Unit Equipment Cost	Unit Labor Costs	NPV of Lifetime O&M Cost	Implementation Cost Factor	Implementation Type (RET/ROB)	Initial Cost	Replacement Cost	Measure File Service Life (Yrs)	Full Per Unit Cost
1000	Base Boiler	2015	2054	sq ft	kBtuhr	$0.00	$0.00	$0.00	$0.00	ROB	1	1	$20.00	$0.00
1001	High Efficiency Windows (Multiple Glazed, Low Emissivity)	2015	2054	sq ft	sf-window	$54.70	$0.00	$0.00	$54.70	ROB	1	1	$20.00	$54.70
1002	Insulation (ceiling)	2015	2054	sq ft	sf-ceiling	$2.40	$0.00	$0.00	$2.40	RET	1	1	$25.00	$2.40
1003	Insulation (wall)	2015	2054	sq ft	sf-wall	$2.40	$0.00	$0.00	$2.40	RET	1	1	$25.00	$2.40
1004	Insulation of Pipes	2015	2054	sq ft	MMBTU saved	$27.20	$0.00	($13.46)	$27.20	RET	1	1	$15.00	$13.74
1005	Boiler Tune-Up	2015	2054	sq ft	MBtu/hr	$0.00	$0.83	$0.00	$0.83	RET	1	1	$3.00	$0.83
1006	Clock / Programmable Thermostat	2015	2054	sq ft	unit	$37.50	$100.00	($103.67)	$137.50	RET	1	1	$15.00	$33.83
1007	Programmable communicating thermostat	2015	2054	sq ft	unit	$150.00	$0.00	($103.67)	$150.00	RET	1	1	$15.00	$46.33
1008	Installation of Energy Management Systems (EMS)	2015	2054	sq ft	point	$800.00	$0.00	($13.04)	$800.00	RET	1	1	$10.00	$786.96
1009	Installation of Air Side Heat Recovery Systems	2015	2054	sq ft	O-A CFM	$1.00	$0.00	$0.00	$1.00	RET	1	1	$20.00	$1.00
1010	High Efficiency Non-Condensing Boiler 89% efficiency	2015	2054	sq ft	kBtuhr	$3.23	$0.00	$0.00	$3.23	ROB	1	1	$25.00	$3.23
1011	High Efficiency Condensing Boiler 95% efficiency	2015	2054	sq ft	kBtuhr	$7.09	$0.00	$0.00	$7.09	ROB	1	1	$25.00	$7.09
1012	Stack Heat Exchanger	2015	2054	sq ft	MMBtu saved	$10.10	$0.00	$0.00	$10.10	RET	1	1	$20.00	$10.10
1013	Boiler Controls	2015	2054	sq ft	unit	$17,900.00	$0.00	$0.00	$17,900.00	RET	1	1	$10.00	$17,900.00
1014	Hot water temperature reset	2015	2054	sq ft	MMBtu saved	$27.95		($13.50)	$27.95	RET	1	1	$15.00	$14.45
1015	Demand controlled ventilation (DCV)	2015	2054	sq ft	zone	$500.00	$1,000.00	$0.00	$1,500.00	RET	1	1	$10.00	$1,500.00
1018	Refrigeration heat recovery - space conditioning	2015	2054	sq ft	bldg	$0.00	$40,000.00	$0.00	$40,000.00	RET	1	1	$15.00	$40,000.00
1019	Custom Boiler	2015	2054	sq ft	MMBTU saved	$8.38	$0.00	($1.69)	$8.38	ROB	1	1	$20.00	$6.69
1020	Steam traps	2015	2054	sq ft	MMBTU saved	$7.77		($1.69)	$7.77	RET	1	1	$3.00	$6.07
1200	Base Furnace	2015	2054	sq ft	kBtuhr	$0.00	$0.00	$0.00	$0.00	ROB	1	1	$20.00	$0.00
1201	High Efficiency Windows (Multiple Glazed, Low Emissivity)	2015	2054	sq ft	sf-window	$54.70	$0.00	$0.00	$54.70	ROB	1	1	$20.00	$54.70
1202	Insulation (ceiling)	2015	2054	sq ft	sf-ceiling	$1.36	$0.00	$0.00	$1.36	RET	1	1	$25.00	$1.36
1203	Insulation (wall)	2015	2054	sq ft	sf-wall	$2.40		$0.00	$2.40	RET	1	1	$25.00	$2.40
1204	Duct Repair and Sealing	2015	2054	sq ft	sf building	$0.16	$0.00	$0.00	$0.16	RET	1	1	$18.00	$0.16
1205	Duct Insulation	2015	2054	sq ft	sf insulation	$0.68	$2.40	$0.00	$3.08	RET	1	1	$20.00	$3.08
1206	Clock / Programmable Thermostat	2015	2054	sq ft	unit	$37.50	$100.00	($103.67)	$137.50	RET	1	1	$15.00	$33.83
1207	Programmable communicating thermostat	2015	2054	sq ft	unit	$150.00	$0.00	($103.67)	$150.00	RET	1	1	$15.00	$46.33
1208	Installation of Energy Management Systems (EMS)	2015	2054	sq ft	point	$800.00	$0.00	($13.04)	$800.00	RET	1	1	$10.00	$786.96
1209	Installation of Air Side Heat Recovery Systems	2015	2054	sq ft	O-A CFM	$1.00	$0.00	$0.00	$1.00	RET	1	1	$20.00	$1.00
1210	High Efficiency (Power Burner/ Premium) Furnace 95% efficiency	2015	2054	sq ft	kBtuhr	$9.00	$0.00	$0.00	$9.00	ROB	1	1	$18.00	$9.00
1211	Stack Heat Exchanger	2015	2054	sq ft	MMBtu saved	$10.10	$0.00	$0.00	$10.10	RET	1	1	$20.00	$10.10
1212	Demand controlled ventilation (DCV)	2015	2054	sq ft	zone	$500.00	$1,000.00	$0.00	$1,500.00	RET	1	1	$10.00	$1,500.00
1213	Refrigeration heat recovery - space conditioning	2015	2054	sq ft	bldg	$0.00	$40,000.00	$0.00	$40,000.00	RET	1	1	$15.00	$40,000.00
1214	Custom Furnace	2015	2054	sq ft	MMBTU saved	$67.52	$0.00	($1.69)	$67.52	ROB	1	1	$20.00	$65.83
1400	Base Other Heat	2015	2054	sq ft	kBtuhr	$0.00	$0.00	$0.00	$0.00	ROB	1	1	$20.00	$0.00
1401	Condensing unit heaters	2015	2054	sq ft	unit	$1,000.00	$0.00	$0.00	$1,000.00	ROB	1	1	$18.00	$1,000.00
1402	Radiant heater	2015	2054	sq ft	unit	$1,938.00	$0.00	$0.00	$1,938.00	ROB	1	1	$20.00	$1,938.00
1403	Custom Other Heat	2015	2054	sq ft	MMBTU saved	$30.27	$0.00	($1.69)	$30.27	ROB	1	1	$20.00	$28.58
1500	Base Water Heating - high standby loss (as % of load)	2015	2054	sq ft	kBtuhr	$0.00	$0.00	$0.00	$0.00	RET	1	1	$15.00	$0.00
1501	DHW Pipe Insulation - high standby loss (as % of load)	2015	2054	sq ft	MMBTU saved	$27.20	$0.00	($13.46)	$27.20	RET	1	1	$15.00	$13.74
1502	Demand controlled circulating systems - high standby loss (as % of load)	2015	2054	sq ft	unit	$59.00	$165.00	$0.00	$224.00	RET	1	1	$15.00	$224.00
1503	Tankless Water Heater - high standby loss applications	2015	2054	sq ft	unit	$3,255.00	$0.00	$1,986.65	$3,255.00	ROB	1	1	$20.00	$5,241.65
1504	Custom Water Heating-high stanby loss	2015	2054	sq ft	MMBTU saved	$10.40	$0.00	($1.69)	$10.40	ROB	1	1	$15.00	$8.71
1600	Base Water Heating - low standby loss (as % of load)	2015	2054	sq ft	kBtuhr	$0.00	$0.00	$0.00	$0.00	RET	1	1	$15.00	$0.00
1601	DHW Pipe Insulation - low standby loss (as % of load)	2015	2054	sq ft	MMBTU saved	$27.20	$0.00	($13.46)	$27.20	RET	1	1	$15.00	$13.74
1602	Demand controlled circulating systems - low standby loss (as % of load)	2015	2054	sq ft	unit	$59.00	$165.28	$0.00	$224.28	RET	1	1	$15.00	$224.28
1603	Condensing Water Heater (gas, 95% thermal efficiency)	2015	2054	sq ft	unit	$1,000.00	$0.00	$68.48	$1,000.00	ROB	1	1	$15.00	$1,068.48
1604	Pre-Rinse Spray Valve, 1.28 gpm or less (base 1.6 gpm)	2015	2054	unit	unit	$65.00	$0.00	$0.00	$65.00	RET	1	1	$5.00	$65.00
1605	Custom Water Heating-low stanby loss	2015	2054	sq ft	MMBTU saved	$10.40	$0.00	($1.69)	$10.40	ROB	1	1	$15.00	$8.71
1700	Base Cooking - Fryer	2015	2054	unit	unit	$0.00	$0.00	$0.00	$0.00	ROB	1	1	$12.00	$0.00
1701	Energy Star Fryer	2015	2054	unit	40 lb unit	$1,816.80	$0.00	$0.00	$1,816.80	ROB	1	1	$12.00	$1,816.80
1800	Base Cooking - Steamer	2015	2054	unit	unit	$0.00	$0.00	$0.00	$0.00	ROB	1	1	$12.00	$0.00
1801	Energy Star Steamer	2015	2054	unit	unit	$998.00	$0.00	$0.00	$998.00	ROB	1	1	$12.00	$998.00
1900	Base Cooking - Oven	2015	2054	unit	unit	$0.00	$0.00	$0.00	$0.00	ROB	1	1	$12.00	$0.00
1901	High-Efficiency Convection Oven	2015	2054	unit	unit	$209.50	$0.00	$0.00	$209.50	ROB	1	1	$12.00	$209.50
1902	Conveyor Oven	2015	2054	unit	unit	$1,800.00	$0.00	$0.00	$1,800.00	ROB	1	1	$12.00	$1,800.00
1903	Combination Oven	2015	2054	unit	unit	$4,300.00	$0.00	$0.00	$4,300.00	ROB	1	1	$12.00	$4,300.00
2000	Base Cooking - Griddle	2015	2054	unit	unit	$0.00	$0.00	$0.00	$0.00	ROB	1	1	$12.00	$0.00
2001	High-Efficiency Griddle	2015	2054	unit	unit	$60.00	$0.00	$0.00	$60.00	ROB	1	1	$12.00	$60.00
2010	Base Cooking - Range	2015	2054	unit	unit	$0.00	$0.00	$0.00	$0.00	ROB	1	1	$12.00	$0.00

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Commercial Gas Measure Costs

Measure #	Measure Description	First Year	End Year	Savings Units	Cost Units	Unit Equipment Cost	Unit Labor Costs	NPV of Lifetime O&M Cost	Implementation Cost Factor	Implementation Type (RET/ROB)	Initial Cost	Replacement Cost	Measure File Service Life (Yrs)	Full Per Unit Cost
2011	High-Efficiency Range	2015	2054	unit	unit	$2,493.00	$0.00	$0.00	$2,493.00	ROB	1	1	$12.00	$2,493.00
2020	Base Miscellaneous	2015	2054	unit	unit				$0.00	RET	1	1		
2030	Base Whole Building	2015	2054	unit	unit				$0.00	RET	1	1		$0.00
2031	Retrocommissioning	2015	2054	sqft	sqft	$0.30			$0.30	RET	1	1	$5.00	$0.30
2100	Base Building Design - Standard Code	2015	2054	sq ft	sqft				$0.00	NEW	1	1	$20.00	
2101	15% better than code - Campuses	2015	2054	sq ft	sqft	$0.85	$0.00	$0.00	$0.85	NEW	1	1	$20.00	$0.85
2102	15% better than code - Education	2015	2054	sq ft	sqft	$0.75	$0.00	$0.00	$0.75	NEW	1	1	$20.00	$0.75
2103	15% better than code - Food Sales	2015	2054	sq ft	sqft	$0.48	$0.00	$0.00	$0.48	NEW	1	1	$20.00	$0.48
2104	15% better than code - Food Service	2015	2054	sq ft	sqft	$0.96	$0.00	$0.00	$0.96	NEW	1	1	$20.00	$0.96
2105	15% better than code - Healthcare	2015	2054	sq ft	sqft	$1.37	$0.00	$0.00	$1.37	NEW	1	1	$20.00	$1.37
2106	15% better than code - Lodging	2015	2054	sq ft	sqft	$0.79	$0.00	$0.00	$0.79	NEW	1	1	$20.00	$0.79
2107	15% better than code - Office	2015	2054	sq ft	sqft	$0.79	$0.00	$0.00	$0.79	NEW	1	1	$20.00	$0.79
2108	15% better than code - Other	2015	2054	sq ft	sqft	$0.77	$0.00	$0.00	$0.77	NEW	1	1	$20.00	$0.77
2109	15% better than code - Public Assembly	2015	2054	sq ft	sqft	$0.70	$0.00	$0.00	$0.70	NEW	1	1	$20.00	$0.70
2110	15% better than code - Retail	2015	2054	sq ft	sqft	$0.56	$0.00	$0.00	$0.56	NEW	1	1	$20.00	$0.56
2111	15% better than code - Warehouse	2015	2054	sq ft	sqft	$0.43	$0.00	$0.00	$0.43	NEW	1	1	$20.00	$0.43
2112	Commissioning	2015	2054	sq ft	sqft	$0.66	$0.00	$0.00	$0.66	NEW	1	1	$5.00	$0.66
2120	Base Building Design - Standard Code	2015	2054	sq ft	sqft	$0.00			$0.00	NEW	1	1	$20.00	$0.01
2121	30% better than code - Campuses	2015	2054	sq ft	sqft	$1.21	$0.00	$0.00	$1.21	NEW	1	1	$20.00	$1.21
2122	30% better than code - Education	2015	2054	sq ft	sqft	$1.07	$0.00	$0.00	$1.07	NEW	1	1	$20.00	$1.07
2123	30% better than code - Food Sales	2015	2054	sq ft	sqft	$0.69	$0.00	$0.00	$0.69	NEW	1	1	$20.00	$0.69
2124	30% better than code - Food Service	2015	2054	sq ft	sqft	$1.37	$0.00	$0.00	$1.37	NEW	1	1	$20.00	$1.37
2125	30% better than code - Healthcare	2015	2054	sq ft	sqft	$1.95	$0.00	$0.00	$1.95	NEW	1	1	$20.00	$1.95
2126	30% better than code - Lodging	2015	2054	sq ft	sqft	$1.12	$0.00	$0.00	$1.12	NEW	1	1	$20.00	$1.12
2127	30% better than code - Office	2015	2054	sq ft	sqft	$1.13	$0.00	$0.00	$1.13	NEW	1	1	$20.00	$1.13
2128	30% better than code - Other	2015	2054	sq ft	sqft	$1.10	$0.00	$0.00	$1.10	NEW	1	1	$20.00	$1.10
2129	30% better than code - Public Assembly	2015	2054	sq ft	sqft	$1.01	$0.00	$0.00	$1.01	NEW	1	1	$20.00	$1.01
2130	30% better than code - Retail	2015	2054	sq ft	sqft	$0.80	$0.00	$0.00	$0.80	NEW	1	1	$20.00	$0.80
2131	30% better than code - Warehouse	2015	2054	sq ft	sqft	$0.62	$0.00	$0.00	$0.62	NEW	1	1	$20.00	$0.62
2132	Commissioning	2015	2054	sq ft	sqft	$0.66	$0.00	$0.00	$0.66	NEW	1	1	$5.00	$0.66
2140	Base Building Design - Standard Code	2015	2054	sq ft	sqft	$0.00			$0.00	NEW	1	1	$20.00	$0.01
2141	50% better than code - Campuses	2015	2054	sq ft	sqft	$2.13	$0.00	$0.00	$2.13	NEW	1	1	$20.00	$2.13
2142	50% better than code - Education	2015	2054	sq ft	sqft	$1.87	$0.00	$0.00	$1.87	NEW	1	1	$20.00	$1.87
2143	50% better than code - Food Sales	2015	2054	sq ft	sqft	$1.21	$0.00	$0.00	$1.21	NEW	1	1	$20.00	$1.21
2144	50% better than code - Food Service	2015	2054	sq ft	sqft	$2.40	$0.00	$0.00	$2.40	NEW	1	1	$20.00	$2.40
2145	50% better than code - Healthcare	2015	2054	sq ft	sqft	$3.41	$0.00	$0.00	$3.41	NEW	1	1	$20.00	$3.41
2146	50% better than code - Lodging	2015	2054	sq ft	sqft	$1.96	$0.00	$0.00	$1.96	NEW	1	1	$20.00	$1.96
2147	50% better than code - Office	2015	2054	sq ft	sqft	$1.97	$0.00	$0.00	$1.97	NEW	1	1	$20.00	$1.97
2148	50% better than code - Other	2015	2054	sq ft	sqft	$1.92	$0.00	$0.00	$1.92	NEW	1	1	$20.00	$1.92
2149	50% better than code - Public Assembly	2015	2054	sq ft	sqft	$1.76	$0.00	$0.00	$1.76	NEW	1	1	$20.00	$1.76
2150	50% better than code - Retail	2015	2054	sq ft	sqft	$1.40	$0.00	$0.00	$1.40	NEW	1	1	$20.00	$1.40
2151	50% better than code - Warehouse	2015	2054	sq ft	sqft	$1.08	$0.00	$0.00	$1.08	NEW	1	1	$20.00	$1.08
2152	Commissioning	2015	2054	sq ft	sqft	$0.66	$0.00	$0.00	$0.66	NEW	1	1	$5.00	$0.66
2160	Base Building Design - Standard Code	2015	2054	sq ft	sqft	$0.00			$0.00	NEW	1	1	$20.00	$0.01
2161	70% better than code - Campuses	2015	2054	sq ft	sqft	$3.34	$0.00	$0.00	$3.34	NEW	1	1	$20.00	$3.34
2162	70% better than code - Education	2015	2054	sq ft	sqft	$2.93	$0.00	$0.00	$2.93	NEW	1	1	$20.00	$2.93
2163	70% better than code - Food Sales	2015	2054	sq ft	sqft	$1.90	$0.00	$0.00	$1.90	NEW	1	1	$20.00	$1.90
2164	70% better than code - Food Service	2015	2054	sq ft	sqft	$3.77	$0.00	$0.00	$3.77	NEW	1	1	$20.00	$3.77
2165	70% better than code - Healthcare	2015	2054	sq ft	sqft	$5.36	$0.00	$0.00	$5.36	NEW	1	1	$20.00	$5.36
2166	70% better than code - Lodging	2015	2054	sq ft	sqft	$3.09	$0.00	$0.00	$3.09	NEW	1	1	$20.00	$3.09
2167	70% better than code - Office	2015	2054	sq ft	sqft	$3.10	$0.00	$0.00	$3.10	NEW	1	1	$20.00	$3.10
2168	70% better than code - Other	2015	2054	sq ft	sqft	$3.02	$0.00	$0.00	$3.02	NEW	1	1	$20.00	$3.02
2169	70% better than code - Public Assembly	2015	2054	sq ft	sqft	$2.77	$0.00	$0.00	$2.77	NEW	1	1	$20.00	$2.77
2170	70% better than code - Retail	2015	2054	sq ft	sqft	$2.20	$0.00	$0.00	$2.20	NEW	1	1	$20.00	$2.20
2171	70% better than code - Warehouse	2015	2054	sq ft	sqft	$1.70	$0.00	$0.00	$1.70	NEW	1	1	$20.00	$1.70
2172	Commissioning	2015	2054	sq ft	sqft	$0.66	$0.00	$0.00	$0.66	NEW	1	1	$5.00	$0.66
2200	Base Boiler	2015	2054	sq ft	kBtuhr	$0.00	$0.00	$0.00	$0.00	NEW	1	1	$20.00	$0.00
2201	High Efficiency Windows (Multiple Glazed, Low Emissivity)	2015	2054	sq ft	sf-window	$54.70	$0.00	$0.00	$54.70	NEW	1	1	$20.00	$54.70
2207	Programmable communicating thermostat	2015	2054	sq ft	unit	$112.50	$100.00	$0.00	$212.50	NEW	1	1	$15.00	$212.50
2208	Installation of Energy Management Systems (EMS)	2015	2054	sq ft	point	$640.00	$0.00	$0.00	$640.00	NEW	1	1	$10.00	$640.00

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Commercial Gas Measure Costs

Measure #	Measure Description	First Year	End Year	Savings Units	Cost Units	Unit Equipment Cost	Unit Labor Costs	NPV of Lifetime O&M Cost	Implementation Cost Factor	Implementation Type (RET/ROB)	Initial Cost	Replacement Cost	Measure File Service Life (Yrs)	Full Per Unit Cost
2209	Installation of Air Side Heat Recovery Systems	2015	2054	sq ft	O-A CFM	$0.80	$0.00	$0.00	$0.80	NEW	1	1	$20.00	$0.80
2210	High Efficiency Non-Condensing Boiler 89% efficiency	2015	2054	sq ft	kBtuhr	$3.23	$0.00	$0.00	$3.23	NEW	1	1	$25.00	$3.23
2211	High Efficiency Condensing Boiler 95% efficiency	2015	2054	sq ft	kBtuhr	$7.09	$0.00	$0.00	$7.09	NEW	1	1	$25.00	$7.09
2212	Stack Heat Exchanger	2015	2054	sq ft	MMBtu saved	$8.08	$0.00	$0.00	$8.08	NEW	1	1	$20.00	$8.08
2213	Boiler Controls	2015	2054	sq ft	unit	$17,900.00	$0.00	$0.00	$17,900.00	NEW	1	1	$10.00	$17,900.00
2214	Hot water temperature reset	2015	2054	sq ft	MMBtu saved	$27.95	$0.00	$0.00	$27.95	NEW	1	1	$15.00	$27.95
2215	Demand controlled ventilation (DCV)	2015	2054	sq ft	zone	$500.00	$1,000.00	$0.00	$1,500.00	NEW	1	1	$10.00	$1,500.00
2216	Refrigeration heat recovery - space conditioning	2015	2054	sq ft	bldg	$0.00	$26,666.67	$0.00	$26,666.67	NEW	1	1	$15.00	$26,666.67
2220	Base Furnace	2015	2054	sq ft	kBtuhr				$0.00	NEW	1	1	$20.00	$0.00
2221	High Efficiency Windows (Multiple Glazed, Low Emissivity)	2015	2054	sq ft	sf-window	$54.70	$0.00	$0.00	$54.70	NEW	1	1	$20.00	$54.70
2227	Programmable communicating thermostat	2015	2054	sq ft	unit	$112.50	$100.00	$0.00	$212.50	NEW	1	1	$15.00	$212.50
2228	Installation of Energy Management Systems (EMS)	2015	2054	sq ft	point	$640.00	$0.00	$0.00	$640.00	NEW	1	1	$10.00	$640.00
2229	Installation of Air Side Heat Recovery Systems	2015	2054	sq ft	O-A CFM	$0.80	$0.00	$0.00	$0.80	NEW	1	1	$20.00	$0.80
2230	High Efficiency (Power Burner/ Premium) Furnace 95% efficiency	2015	2054	sq ft	kBtuhr	$9.00	$0.00	$0.00	$9.00	NEW	1	1	$18.00	$9.00
2231	Stack Heat Exchanger	2015	2054	sq ft	MMBtu saved	$8.08	$0.00	$0.00	$8.08	NEW	1	1	$20.00	$8.08
2232	Demand controlled ventilation (DCV)	2015	2054	sq ft	zone	$500.00	$1,000.00	$0.00	$1,500.00	NEW	1	1	$10.00	$1,500.00
2233	Refrigeration heat recovery - space conditioning	2015	2054	sq ft	bldg	$0.00	$32,000.00	$0.00	$32,000.00	NEW	1	1	$15.00	$32,000.00
2240	Base Other Heat	2015	2054	sq ft	kBtuhr				$0.00	NEW	1	1	$20.00	$0.00
2241	Condensing unit heaters	2015	2054	sq ft	unit	$1,000.00	$0.00	$0.00	$1,000.00	NEW	1	1	$18.00	$1,000.00
2242	Radiant heater	2015	2054	sq ft	unit	1938	0	0	1938	NEW	1	1	20	$1,938.00
2250	Base Water Heating - high standby loss (as % of load)	2015	2054	sq ft	kBtuhr				0	NEW	1	1	15	$0.00
2252	Demand controlled circulating systems - high standby loss (as % of load)	2015	2054	sq ft	unit	59	109.0815	0	168.0815	NEW	1	1	15	$168.08
2253	Tankless Water Heater - high standby loss applications	2015	2054	sq ft	unit	2526		1986.6533	2526	NEW	1	1	20	$4,512.65
2260	Base Water Heating - low standby loss (as % of load)	2015	2054	sq ft	kBtuhr				0	NEW	1	1	15	$0.00
2262	Demand controlled circulating systems - low standby loss (as % of load)	2015	2054	sq ft	unit	59	109.0815	0	168.0815	NEW	1	1	15	$168.08
2263	Condensing Water Heater (gas, 95% thermal efficiency)	2015	2054	sq ft	unit	1000	0	68.47583	1000	NEW	1	1	15	$1,068.48
2264	Pre-Rinse Spray Valve, 1.28 gpm or less (base 1.6 gpm)	2015	2054	unit	unit	65	0	0	65	NEW	1	1	5	$65.00
2270	Base Cooking - Fryer	2015	2054	unit	unit				0	NEW	1	1	12	$0.00
2271	Energy Star Fryer	2015	2054	unit	40 lb unit	1816.8	0	0	1816.8	NEW	1	1	12	$1,816.80
2280	Base Cooking - Steamer	2015	2054	unit	unit				0	NEW	1	1	12	$0.00
2281	Energy Star Steamer	2015	2054	unit	unit	998	0	0	998	NEW	1	1	12	$998.00
2290	Base Cooking - Oven	2015	2054	unit	unit				0	NEW	1	1	12	$0.00
2291	High-Efficiency Convection Oven	2015	2054	unit	unit	209.5	0	0	209.5	NEW	1	1	12	$209.50
2292	Conveyor Oven	2015	2054	unit	unit	1800	0	0	1800	NEW	1	1	12	$1,800.00
2293	Combination Oven	2015	2054	unit	unit	4300	0	0	4300	NEW	1	1	12	$4,300.00
2300	Base Cooking - Griddle	2015	2054	unit	unit	0	0	0	0	NEW	1	1	12	$0.00
2301	High-Efficiency Griddle	2015	2054	unit	unit	60	0	0	60	NEW	1	1	12	$60.00
2310	Base Cooking - Range	2015	2054	unit	unit	0	0	0	0	NEW	1	1	12	$0.00
2311	High-Efficiency Range	2015	2054	unit	unit	2493	0	0	2493	NEW	1	1	12	$2,493.00
2320	Base Miscellaneous	2015	2054	unit	unit	0			0	NEW	1	1	10	

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Commercial Gas Measure Inputs		APPLICABILITY FACTOR (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1000	Base Boiler	93.6%	96.5%	0.0%	2.9%	78.7%	100.0%	50.2%	24.0%	17.0%	92.1%	37.5%	0%
1001	High Efficiency Windows (Multiple Glazed, Low Emissivity)	93.6%	96.5%	0.0%	2.9%	78.7%	100.0%	50.2%	24.0%	17.0%	92.1%	37.5%	0%
1002	Insulation (ceiling)	0.0%	0.0%	0.0%	1.7%	0.0%	0.0%	0.0%	3.6%	3.2%	17.5%	5.6%	0%
1003	Insulation (wall)	31.8%	21.2%	0.0%	1.2%	0.0%	0.0%	0.0%	5.0%	9.9%	53.4%	24.0%	0%
1004	Insulation of Pipes	93.6%	96.5%	0.0%	2.9%	78.7%	100.0%	50.2%	24.0%	17.0%	92.1%	37.5%	0%
1005	Boiler Tune-Up	93.6%	96.5%	0.0%	2.9%	78.7%	100.0%	50.2%	24.0%	17.0%	92.1%	37.5%	0%
1006	Clock / Programmable Thermostat	23.4%	24.1%	0.0%	0.7%	19.7%	25.0%	12.6%	6.0%	4.3%	23.0%	9.4%	0%
1007	Programmable communicating thermostat	23.4%	24.1%	0.0%	0.7%	19.7%	25.0%	12.6%	6.0%	4.3%	23.0%	9.4%	0%
1008	Installation of Energy Management Systems (EMS)	93.6%	96.5%	0.0%	2.9%	78.7%	100.0%	50.2%	24.0%	17.0%	92.1%	37.5%	0%
1009	Installation of Air Side Heat Recovery Systems	93.6%	96.5%	0.0%	2.9%	78.7%	100.0%	50.2%	24.0%	17.0%	92.1%	37.5%	0%
1010	High Efficiency Non-Condensing Boiler 89% efficiency	93.6%	96.5%	0.0%	2.9%	78.7%	100.0%	50.2%	24.0%	17.0%	92.1%	37.5%	0%
1011	High Efficiency Condensing Boiler 95% efficiency	93.6%	96.5%	0.0%	2.9%	78.7%	100.0%	50.2%	24.0%	17.0%	92.1%	37.5%	0%
1012	Stack Heat Exchanger	93.6%	96.5%	0.0%	2.9%	78.7%	100.0%	50.2%	24.0%	17.0%	92.1%	37.5%	0%
1013	Boiler Controls	93.6%	96.5%	0.0%	2.9%	78.7%	100.0%	50.2%	24.0%	17.0%	92.1%	37.5%	0%
1014	Hot water temperature reset	93.6%	96.5%	0.0%	2.9%	78.7%	100.0%	50.2%	24.0%	17.0%	92.1%	37.5%	0%
1015	Demand controlled ventilation (DCV)	93.6%	96.5%	0.0%	2.9%	78.7%	100.0%	50.2%	24.0%	17.0%	92.1%	37.5%	0%
1018	Refrigeration heat recovery - space conditioning	0.0%	0.0%	99.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
1019	Custom Boiler	93.6%	96.5%	0.0%	2.9%	78.7%	100.0%	50.2%	24.0%	17.0%	92.1%	37.5%	0%
1020	Steam traps	29.5%	30.4%	0.0%	0.9%	24.8%	31.5%	15.8%	7.5%	5.4%	29.0%	11.8%	0%
1200	Base Furnace	0.0%	6.1%	52.4%	69.4%	5.0%	0.0%	5.8%	19.4%	8.4%	52.6%	26.9%	80%
1201	High Efficiency Windows (Multiple Glazed, Low Emissivity)	0.0%	6.1%	52.4%	69.4%	5.0%	0.0%	5.8%	19.4%	8.4%	52.6%	26.9%	80%
1202	Insulation (ceiling)	0.0%	0.0%	0.0%	2.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.5%	0.2%	1%
1203	Insulation (wall)	0.0%	1.3%	24.1%	28.5%	0.0%	0.0%	0.0%	4.1%	4.9%	30.5%	17.2%	46%
1204	Duct Repair and Sealing	0.0%	6.1%	52.4%	69.4%	5.0%	0.0%	5.8%	19.4%	8.4%	52.6%	26.9%	80%
1205	Duct Insulation	0.0%	6.1%	52.4%	69.4%	5.0%	0.0%	5.8%	19.4%	8.4%	52.6%	26.9%	80%
1206	Clock / Programmable Thermostat	0.0%	1.5%	13.1%	17.4%	1.3%	0.0%	1.4%	4.9%	2.1%	13.2%	6.7%	20%
1207	Programmable communicating thermostat	0.0%	1.5%	13.1%	17.4%	1.3%	0.0%	1.4%	4.9%	2.1%	13.2%	6.7%	20%
1208	Installation of Energy Management Systems (EMS)	0.0%	6.1%	52.4%	69.4%	5.0%	0.0%	5.8%	19.4%	8.4%	52.6%	26.9%	80%
1209	Installation of Air Side Heat Recovery Systems	0.0%	6.1%	52.4%	69.4%	5.0%	0.0%	5.8%	19.4%	8.4%	52.6%	26.9%	80%
1210	High Efficiency (Power Burner/ Premium) Furnace 95% efficiency	0.0%	6.1%	52.4%	69.4%	5.0%	0.0%	5.8%	19.4%	8.4%	52.6%	26.9%	80%
1211	Stack Heat Exchanger	0.0%	6.1%	52.4%	69.4%	5.0%	0.0%	5.8%	19.4%	8.4%	52.6%	26.9%	80%
1212	Demand controlled ventilation (DCV)	0.0%	6.1%	52.4%	69.4%	5.0%	0.0%	5.8%	19.4%	8.4%	52.6%	26.9%	80%
1213	Refrigeration heat recovery - space conditioning	0.0%	0.0%	52.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
1214	Custom Furnace	0.0%	6.1%	52.4%	69.4%	5.0%	0.0%	5.8%	19.4%	8.4%	52.6%	26.9%	80%
1400	Base Other Heat	2.6%	41.7%	30.4%	4.0%	78.9%	71.3%	68.8%	15.8%	40.1%	93.0%	27.2%	98%
1401	Condensing unit heaters	1.3%	20.8%	15.2%	2.0%	39.4%	35.6%	34.4%	7.9%	20.1%	46.5%	13.6%	49%
1402	Radiant heater	1.3%	20.8%	15.2%	2.0%	39.4%	35.6%	34.4%	7.9%	20.1%	46.5%	13.6%	49%
1403	Custom Other Heat	2.6%	41.7%	30.4%	4.0%	78.9%	71.3%	68.8%	15.8%	40.1%	93.0%	27.2%	98%
1500	Base Water Heating - high standby loss (as % of load)	100.0%	100.0%	36.9%	0.0%	0.0%	0.0%	94.4%	62.2%	8.3%	95.9%	41.5%	0%
1501	DHW Pipe Insulation - high standby loss (as % of load)	100.0%	100.0%	36.9%	0.0%	0.0%	0.0%	94.4%	62.2%	8.3%	95.9%	41.5%	0%
1502	Demand controlled circulating systems - high standby loss (as % of load)	100.0%	100.0%	36.9%	0.0%	0.0%	0.0%	94.4%	62.2%	8.3%	95.9%	41.5%	0%
1503	Tankless Water Heater - high standby loss applications	100.0%	100.0%	36.9%	0.0%	0.0%	0.0%	94.4%	62.2%	8.3%	95.9%	41.5%	0%
1504	Custom Water Heating-high stanby loss	100.0%	100.0%	36.9%	0.0%	0.0%	0.0%	94.4%	62.2%	8.3%	95.9%	41.5%	0%
1600	Base Water Heating - low standby loss (as % of load)	0.0%	0.0%	36.9%	79.2%	90.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
1601	DHW Pipe Insulation - low standby loss (as % of load)	0.0%	0.0%	36.9%	79.2%	90.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
1602	Demand controlled circulating systems - low standby loss (as % of load)	0.0%	0.0%	36.9%	79.2%	90.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
1603	Condensing Water Heater (gas, 95% thermal efficiency)	0.0%	0.0%	36.9%	79.2%	90.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
1604	Pre-Rinse Spray Valve, 1.28 gpm or less (base 1.6 gpm)	0.0%	0.0%	7.4%	15.8%	18.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
1605	Custom Water Heating-low stanby loss	0.0%	0.0%	36.9%	79.2%	90.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
1700	Base Cooking - Fryer	0.0%	0.0%	19.5%	46.1%	0.6%	66.2%	25.4%	71.8%	21.0%	2.1%	0.3%	0%
1701	Energy Star Fryer	0.0%	0.0%	19.5%	46.1%	0.6%	66.2%	25.4%	71.8%	21.0%	2.1%	0.3%	0%
1800	Base Cooking - Steamer	0.0%	37.1%	0.0%	12.6%	66.8%	66.2%	9.2%	74.3%	15.4%	0.6%	0.0%	0%
1801	Energy Star Steamer	0.0%	37.1%	0.0%	12.6%	66.8%	66.2%	9.2%	74.3%	15.4%	0.6%	0.0%	0%
1900	Base Cooking - Oven	0.0%	55.9%	25.5%	48.7%	84.5%	66.2%	18.0%	76.6%	16.6%	3.0%	4.7%	0%
1901	High-Efficiency Convection Oven	0.0%	18.5%	8.4%	16.1%	27.9%	21.8%	5.9%	25.3%	5.5%	1.0%	1.6%	0%
1902	Conveyor Oven	0.0%	18.5%	8.4%	16.1%	27.9%	21.8%	5.9%	25.3%	5.5%	1.0%	1.6%	0%
1903	Combination Oven	0.0%	18.5%	8.4%	16.1%	27.9%	21.8%	5.9%	25.3%	5.5%	1.0%	1.6%	0%
2000	Base Cooking - Griddle	0.0%	0.0%	3.1%	38.5%	18.3%	71.3%	10.5%	26.7%	15.4%	2.0%	0.3%	0%
2001	High-Efficiency Griddle	0.0%	0.0%	3.1%	38.5%	18.3%	71.3%	10.5%	26.7%	15.4%	2.0%	0.3%	0%
2010	Base Cooking - Range	0.0%	39.9%	25.5%	48.9%	88.2%	5.1%	48.0%	81.3%	22.0%	90.6%	0.3%	0%
2011	High-Efficiency Range	0.0%	39.9%	25.5%	48.9%	88.2%	5.1%	48.0%	81.3%	22.0%	90.6%	0.3%	0%

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Commercial Gas Measure Inputs		APPLICABILITY FACTOR (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
2020	Base Miscellaneous	33.0%	2.1%	0.0%	12.8%	0.0%	0.0%	0.0%	10.0%	10.0%	0.0%	0.0%	0%
2030	Base Whole Building	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100%
2031	Retrocommissioning	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100%
2100	Base Building Design - Standard Code	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30%
2101	15% better than code - Campuses	30.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2102	15% better than code - Education	0.0%	30.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2103	15% better than code - Food Sales	0.0%	0.0%	30.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2104	15% better than code - Food Service	0.0%	0.0%	0.0%	30.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2105	15% better than code - Healthcare	0.0%	0.0%	0.0%	0.0%	30.0%	30.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2106	15% better than code - Lodging	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	0.0%	0.0%	0.0%	0.0%	0%
2107	15% better than code - Office	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	0.0%	0.0%	0.0%	0%
2108	15% better than code - Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	0.0%	0.0%	0%
2109	15% better than code - Public Assembly	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	0.0%	0%
2110	15% better than code - Retail	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	0%
2111	15% better than code - Warehouse	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30%
2112	Commissioning	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30%
2120	Base Building Design - Standard Code	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12%
2121	30% better than code - Campuses	12.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2122	30% better than code - Education	0.0%	12.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2123	30% better than code - Food Sales	0.0%	0.0%	12.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2124	30% better than code - Food Service	0.0%	0.0%	0.0%	12.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2125	30% better than code - Healthcare	0.0%	0.0%	0.0%	0.0%	12.0%	12.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2126	30% better than code - Lodging	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.0%	0.0%	0.0%	0.0%	0.0%	0%
2127	30% better than code - Office	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.0%	0.0%	0.0%	0.0%	0%
2128	30% better than code - Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.0%	0.0%	0.0%	0%
2129	30% better than code - Public Assembly	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.0%	0.0%	0%
2130	30% better than code - Retail	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.0%	0%
2131	30% better than code - Warehouse	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12%
2132	Commissioning	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12%
2140	Base Building Design - Standard Code	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6%
2141	50% better than code - Campuses	6.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2142	50% better than code - Education	0.0%	6.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2143	50% better than code - Food Sales	0.0%	0.0%	6.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2144	50% better than code - Food Service	0.0%	0.0%	0.0%	6.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2145	50% better than code - Healthcare	0.0%	0.0%	0.0%	0.0%	6.0%	6.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2146	50% better than code - Lodging	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0%	0.0%	0.0%	0.0%	0.0%	0%
2147	50% better than code - Office	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0%	0.0%	0.0%	0.0%	0%
2148	50% better than code - Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0%	0.0%	0.0%	0%
2149	50% better than code - Public Assembly	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0%	0.0%	0%
2150	50% better than code - Retail	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0%	0%
2151	50% better than code - Warehouse	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6%
2152	Commissioning	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6%
2160	Base Building Design - Standard Code	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2%
2161	70% better than code - Campuses	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2162	70% better than code - Education	0.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2163	70% better than code - Food Sales	0.0%	0.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2164	70% better than code - Food Service	0.0%	0.0%	0.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2165	70% better than code - Healthcare	0.0%	0.0%	0.0%	0.0%	2.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2166	70% better than code - Lodging	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0%
2167	70% better than code - Office	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	0.0%	0.0%	0.0%	0%
2168	70% better than code - Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	0.0%	0.0%	0%
2169	70% better than code - Public Assembly	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	0.0%	0%
2170	70% better than code - Retail	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	0%
2171	70% better than code - Warehouse	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2%
2172	Commissioning	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2%
2200	Base Boiler	46.8%	48.2%	0.0%	1.5%	39.3%	50.0%	25.1%	12.0%	8.5%	46.0%	18.7%	0%
2201	High Efficiency Windows (Multiple Glazed, Low Emissivity)	46.8%	48.2%	0.0%	1.5%	39.3%	50.0%	25.1%	12.0%	8.5%	46.0%	18.7%	0%
2207	Programmable communicating thermostat	11.7%	12.1%	0.0%	0.4%	9.8%	12.5%	6.3%	3.0%	2.1%	11.5%	4.7%	0%
2208	Installation of Energy Management Systems (EMS)	46.8%	48.2%	0.0%	1.5%	39.3%	50.0%	25.1%	12.0%	8.5%	46.0%	18.7%	0%
2209	Installation of Air Side Heat Recovery Systems	46.8%	48.2%	0.0%	1.5%	39.3%	50.0%	25.1%	12.0%	8.5%	46.0%	18.7%	0%
2210	High Efficiency Non-Condensing Boiler 89% efficiency	46.8%	48.2%	0.0%	1.5%	39.3%	50.0%	25.1%	12.0%	8.5%	46.0%	18.7%	0%
2211	High Efficiency Condensing Boiler 95% efficiency	46.8%	48.2%	0.0%	1.5%	39.3%	50.0%	25.1%	12.0%	8.5%	46.0%	18.7%	0%

Commercial Gas Measure Inputs		APPLICABILITY FACTOR (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
2212	Stack Heat Exchanger	46.8%	48.2%	0.0%	1.5%	39.3%	50.0%	25.1%	12.0%	8.5%	46.0%	18.7%	0%
2213	Boiler Controls	46.8%	48.2%	0.0%	1.5%	39.3%	50.0%	25.1%	12.0%	8.5%	46.0%	18.7%	0%
2214	Hot water temperature reset	46.8%	48.2%	0.0%	1.5%	39.3%	50.0%	25.1%	12.0%	8.5%	46.0%	18.7%	0%
2215	Demand controlled ventilation (DCV)	46.8%	48.2%	0.0%	1.5%	39.3%	50.0%	25.1%	12.0%	8.5%	46.0%	18.7%	0%
2216	Refrigeration heat recovery - space conditioning	0.0%	0.0%	49.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2220	Base Furnace	0.0%	3.0%	26.2%	34.7%	2.5%	0.0%	2.9%	9.7%	4.2%	26.3%	13.5%	40%
2221	High Efficiency Windows (Multiple Glazed, Low Emissivity)	0.0%	3.0%	26.2%	34.7%	2.5%	0.0%	2.9%	9.7%	4.2%	26.3%	13.5%	40%
2227	Programmable communicating thermostat	0.0%	0.8%	6.6%	8.7%	0.6%	0.0%	0.7%	2.4%	1.0%	6.6%	3.4%	10%
2228	Installation of Energy Management Systems (EMS)	0.0%	3.0%	26.2%	34.7%	2.5%	0.0%	2.9%	9.7%	4.2%	26.3%	13.5%	40%
2229	Installation of Air Side Heat Recovery Systems	0.0%	3.0%	26.2%	34.7%	2.5%	0.0%	2.9%	9.7%	4.2%	26.3%	13.5%	40%
2230	High Efficiency (Power Burner/ Premium) Furnace 95% efficiency	0.0%	3.0%	26.2%	34.7%	2.5%	0.0%	2.9%	9.7%	4.2%	26.3%	13.5%	40%
2231	Stack Heat Exchanger	0.0%	3.0%	26.2%	34.7%	2.5%	0.0%	2.9%	9.7%	4.2%	26.3%	13.5%	40%
2232	Demand controlled ventilation (DCV)	0.0%	3.0%	26.2%	34.7%	2.5%	0.0%	2.9%	9.7%	4.2%	26.3%	13.5%	40%
2233	Refrigeration heat recovery - space conditioning	0.0%	0.0%	26.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
2240	Base Other Heat	1.3%	20.8%	15.2%	2.0%	39.4%	35.6%	34.4%	7.9%	20.1%	46.5%	13.6%	49%
2241	Condensing unit heaters	0.7%	10.4%	7.6%	1.0%	19.7%	17.8%	17.2%	3.9%	10.0%	23.2%	6.8%	24%
2242	Radiant heater	0.65%	10.41%	7.60%	1.00%	19.72%	17.82%	17.20%	3.94%	10.03%	23.24%	6.81%	24%
2250	Base Water Heating - high standby loss (as % of load)	50.00%	50.00%	18.43%	0.00%	0.00%	0.00%	47.22%	31.10%	4.16%	47.93%	20.77%	0%
2252	Demand controlled circulating systems - high standby loss (as % of load)	50.00%	50.00%	18.43%	0.00%	0.00%	0.00%	47.22%	31.10%	4.16%	47.93%	20.77%	0%
2253	Tankless Water Heater - high standby loss applications	50.00%	50.00%	18.43%	0.00%	0.00%	0.00%	47.22%	31.10%	4.16%	47.93%	20.77%	0%
2260	Base Water Heating - low standby loss (as % of load)	0.00%	0.00%	18.43%	39.60%	45.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
2262	Demand controlled circulating systems - low standby loss (as % of load)	0.00%	0.00%	18.43%	39.60%	45.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
2263	Condensing Water Heater (gas, 95% thermal efficiency)	0.00%	0.00%	18.43%	39.60%	45.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
2264	Pre-Rinse Spray Valve, 1.28 gpm or less (base 1.6 gpm)	0.00%	0.00%	3.69%	7.92%	9.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0%
2270	Base Cooking - Fryer	0.00%	0.00%	9.75%	23.07%	0.28%	33.09%	12.70%	35.90%	10.48%	1.05%	0.15%	0%
2271	Energy Star Fryer	0.00%	0.00%	9.75%	23.07%	0.28%	33.09%	12.70%	35.90%	10.48%	1.05%	0.15%	0%
2280	Base Cooking - Steamer	0.00%	18.54%	0.00%	6.32%	33.39%	33.09%	4.61%	37.13%	7.69%	0.29%	0.00%	0%
2281	Energy Star Steamer	0.00%	18.54%	0.00%	6.32%	33.39%	33.09%	4.61%	37.13%	7.69%	0.29%	0.00%	0%
2290	Base Cooking - Oven	0.00%	27.97%	12.76%	24.34%	42.26%	33.09%	8.99%	38.31%	8.31%	1.52%	2.36%	0%
2291	High-Efficiency Convection Oven	0.00%	9.23%	4.21%	8.03%	13.94%	10.92%	2.97%	12.64%	2.74%	0.50%	0.78%	0%
2292	Conveyor Oven	0.00%	9.23%	4.21%	8.03%	13.94%	10.92%	2.97%	12.64%	2.74%	0.50%	0.78%	0%
2293	Combination Oven	0.00%	9.23%	4.21%	8.03%	13.94%	10.92%	2.97%	12.64%	2.74%	0.50%	0.78%	0%
2300	Base Cooking - Griddle	0.00%	0.00%	1.55%	19.27%	9.14%	35.64%	5.26%	13.37%	7.69%	1.01%	0.15%	0%
2301	High-Efficiency Griddle	0.00%	0.00%	1.55%	19.27%	9.14%	35.64%	5.26%	13.37%	7.69%	1.01%	0.15%	0%
2310	Base Cooking - Range	0.00%	19.93%	12.76%	24.43%	44.12%	2.54%	23.98%	40.65%	10.99%	45.31%	0.15%	0%
2311	High-Efficiency Range	0.00%	19.93%	12.76%	24.43%	44.12%	2.54%	23.98%	40.65%	10.99%	45.31%	0.15%	0%
2320	Base Miscellaneous	16.50%	1.05%	0.00%	6.42%	0.00%	0.00%	0.00%	5.00%	5.00%	0.00%	0.00%	0%

DNV·GL

Commercial Gas Measure Inputs		ENERGY SAVINGS (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1000	Base Boiler	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1001	High Efficiency Windows (Multiple Glazed, Low Emissivity)	0%	1%	3%	1%	1%	1%	3%	18%	3%		5%	0%
1002	Insulation (ceiling)	16%	16%	20%	40%	6%	6%	25%	33%	23%	23%	23%	23%
1003	Insulation (wall)	18%	18%	38%	33%	35%	35%	7%	21%	29%	29%	29%	29%
1004	Insulation of Pipes	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1005	Boiler Tune-Up	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1006	Clock / Programmable Thermostat	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%
1007	Programmable communicating thermostat	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1008	Installation of Energy Management Systems (EMS)	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1009	Installation of Air Side Heat Recovery Systems	9%	15%	15%	25%	25%	25%	5%	15%	10%	10%	5%	0%
1010	High Efficiency Non-Condensing Boiler 89% efficiency	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%
1011	High Efficiency Condensing Boiler 95% efficiency	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%
1012	Stack Heat Exchanger	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1013	Boiler Controls	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
1014	Hot water temperature reset	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1015	Demand controlled ventilation (DCV)	26%	32%	37%	18%	0%	0%	12%	2%	12%	12%	15%	21%
1018	Refrigeration heat recovery - space conditioning	0%	0%	75%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1019	Custom Boiler	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1020	Steam traps	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%
1200	Base Furnace	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1201	High Efficiency Windows (Multiple Glazed, Low Emissivity)	0%	1%	3%	1%	1%	1%	3%	18%	3%	3%	5%	0%
1202	Insulation (ceiling)	16%	16%	20%	40%	6%	6%	25%	33%	23%	23%	23%	23%
1203	Insulation (wall)	18%	18%	38%	33%	35%	35%	7%	41%	29%	29%	29%	29%
1204	Duct Repair and Sealing	2%	1%	1%	2%	2%	2%	0%	2%	0%	0%	2%	1%
1205	Duct Insulation	4%	0%	0%	0%	2%	2%	2%	2%	2%	2%	2%	0%
1206	Clock / Programmable Thermostat	6%	6%	6%	6%	0%	0%	6%	6%	6%	6%	6%	6%
1207	Programmable communicating thermostat	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1208	Installation of Energy Management Systems (EMS)	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1209	Installation of Air Side Heat Recovery Systems	9%	15%	15%	25%	25%	25%	5%	15%	10%	10%	5%	0%
1210	High Efficiency (Power Burner/ Premium) Furnace 95% efficiency	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1211	Stack Heat Exchanger	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1212	Demand controlled ventilation (DCV)	26%	32%	37%	18%	0%	0%	12%	2%	12%	12%	15%	21%
1213	Refrigeration heat recovery - space conditioning	0%	0%	75%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1214	Custom Furnace	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1400	Base Other Heat	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1401	Condensing unit heaters	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%
1402	Radiant heater	0%	0%	13%	0%	0%	0%	0%	0%	13%	13%	13%	13%
1403	Custom Other Heat	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1500	Base Water Heating - high standby loss (as % of load)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1501	DHW Pipe Insulation - high standby loss (as % of load)	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1502	Demand controlled circulating systems - high standby loss (as % of load)	7%	5%	1%	2%	6%	6%	3%	6%	4%	4%	1%	4%
1503	Tankless Water Heater - high standby loss applications	0%	28%	43%	0%	26%	26%	19%	51%	40%	40%	41%	50%
1504	Custom Water Heating-high stanby loss	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1600	Base Water Heating - low standby loss (as % of load)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1601	DHW Pipe Insulation - low standby loss (as % of load)	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1602	Demand controlled circulating systems - low standby loss (as % of load)	7%	5%	1%	2%	6%	6%	3%	6%	4%	4%	1%	4%
1603	Condensing Water Heater (gas, 95% thermal efficiency)	25%	26%	25%	27%	25%	25%	25%	26%	27%	27%	26%	27%
1604	Pre-Rinse Spray Valve, 1.28 gpm or less (base 1.6 gpm)	4%	1%	3%	4%	1%	1%	0%	0%	1%	1%	0%	2%
1605	Custom Water Heating-low stanby loss	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1700	Base Cooking - Fryer	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1701	Energy Star Fryer	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
1800	Base Cooking - Steamer	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1801	Energy Star Steamer	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
1900	Base Cooking - Oven	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1901	High-Efficiency Convection Oven	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%
1902	Conveyor Oven	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%
1903	Combination Oven	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
2000	Base Cooking - Griddle	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2001	High-Efficiency Griddle	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%
2010	Base Cooking - Range	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2011	High-Efficiency Range	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%

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Commercial Gas Measure Inputs		ENERGY SAVINGS (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
2020	Base Miscellaneous	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2030	Base Whole Building	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2031	Retrocommissioning	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
2100	Base Building Design - Standard Code	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2101	15% better than code - Campuses	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2102	15% better than code - Education	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2103	15% better than code - Food Sales	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2104	15% better than code - Food Service	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2105	15% better than code - Healthcare	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2106	15% better than code - Lodging	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2107	15% better than code - Office	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2108	15% better than code - Other	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2109	15% better than code - Public Assembly	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2110	15% better than code - Retail	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2111	15% better than code - Warehouse	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
2112	Commissioning	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
2120	Base Building Design - Standard Code	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2121	30% better than code - Campuses	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
2122	30% better than code - Education	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
2123	30% better than code - Food Sales	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
2124	30% better than code - Food Service	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
2125	30% better than code - Healthcare	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
2126	30% better than code - Lodging	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
2127	30% better than code - Office	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
2128	30% better than code - Other	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
2129	30% better than code - Public Assembly	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
2130	30% better than code - Retail	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
2131	30% better than code - Warehouse	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
2132	Commissioning	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
2140	Base Building Design - Standard Code	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2141	50% better than code - Campuses	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
2142	50% better than code - Education	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
2143	50% better than code - Food Sales	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
2144	50% better than code - Food Service	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
2145	50% better than code - Healthcare	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
2146	50% better than code - Lodging	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
2147	50% better than code - Office	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
2148	50% better than code - Other	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
2149	50% better than code - Public Assembly	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
2150	50% better than code - Retail	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
2151	50% better than code - Warehouse	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
2152	Commissioning	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
2160	Base Building Design - Standard Code	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2161	70% better than code - Campuses	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
2162	70% better than code - Education	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
2163	70% better than code - Food Sales	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
2164	70% better than code - Food Service	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
2165	70% better than code - Healthcare	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
2166	70% better than code - Lodging	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
2167	70% better than code - Office	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
2168	70% better than code - Other	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
2169	70% better than code - Public Assembly	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
2170	70% better than code - Retail	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
2171	70% better than code - Warehouse	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
2172	Commissioning	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
2200	Base Boiler	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2201	High Efficiency Windows (Multiple Glazed, Low Emissivity)	0%	1%	3%	1%	1%	1%	3%	18%	3%	0%	5%	0%
2207	Programmable communicating thermostat	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
2208	Installation of Energy Management Systems (EMS)	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
2209	Installation of Air Side Heat Recovery Systems	9%	15%	15%	25%	25%	25%	5%	15%	10%	10%	5%	0%
2210	High Efficiency Non-Condensing Boiler 89% efficiency	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%
2211	High Efficiency Condensing Boiler 95% efficiency	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%

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Commercial Gas Measure Inputs		ENERGY SAVINGS (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
2212	Stack Heat Exchanger	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2213	Boiler Controls	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
2214	Hot water temperature reset	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
2215	Demand controlled ventilation (DCV)	26%	32%	37%	18%	0%	0%	12%	2%	12%	12%	15%	21%
2216	Refrigeration heat recovery - space conditioning	0%	0%	75%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2220	Base Furnace	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2221	High Efficiency Windows (Multiple Glazed, Low Emissivity)	0%	1%	3%	1%	1%	1%	3%	18%	3%	3%	5%	0%
2227	Programmable communicating thermostat	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
2228	Installation of Energy Management Systems (EMS)	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
2229	Installation of Air Side Heat Recovery Systems	9%	15%	15%	25%	25%	25%	5%	15%	10%	10%	5%	0%
2230	High Efficiency (Power Burner/ Premium) Furnace 95% efficiency	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2231	Stack Heat Exchanger	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2232	Demand controlled ventilation (DCV)	26%	32%	37%	18%	0%	0%	12%	2%	12%	12%	15%	21%
2233	Refrigeration heat recovery - space conditioning	0%	0%	75%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2240	Base Other Heat	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2241	Condensing unit heaters	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%
2242	Radiant heater	0%	0%	13%	0%	0%	0%	0%	0%	13%	13%	13%	13%
2250	Base Water Heating - high standby loss (as % of load)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2252	Demand controlled circulating systems - high standby loss (as % of load)	7%	5%	1%	2%	6%	6%	3%	6%	4%	4%	1%	4%
2253	Tankless Water Heater - high standby loss applications	0%	28%	43%	0%	26%	26%	19%	51%	40%	40%	41%	50%
2260	Base Water Heating - low standby loss (as % of load)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2262	Demand controlled circulating systems - low standby loss (as % of load)	7%	5%	1%	2%	6%	6%	3%	6%	4%	4%	1%	4%
2263	Condensing Water Heater (gas, 95% thermal efficiency)	25%	26%	25%	27%	25%	25%	25%	26%	27%	27%	26%	27%
2264	Pre-Rinse Spray Valve, 1.28 gpm or less (base 1.6 gpm)	4%	1%	3%	4%	1%	1%	0%	0%	1%	1%	0%	2%
2270	Base Cooking - Fryer	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2271	Energy Star Fryer	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
2280	Base Cooking - Steamer	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2281	Energy Star Steamer	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
2290	Base Cooking - Oven	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2291	High-Efficiency Convection Oven	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%
2292	Conveyor Oven	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%
2293	Combination Oven	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
2300	Base Cooking - Griddle	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2301	High-Efficiency Griddle	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%
2310	Base Cooking - Range	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2311	High-Efficiency Range	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
2320	Base Miscellaneous	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

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Commercial Gas Measure Inputs		Standards Adjustment Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1000	Base Boiler	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1001	High Efficiency Windows (Multiple Glazed, Low Emissivity)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1002	Insulation (ceiling)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1003	Insulation (wall)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1004	Insulation of Pipes	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1005	Boiler Tune-Up	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1006	Clock / Programmable Thermostat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1007	Programmable communicating thermostat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1008	Installation of Energy Management Systems (EMS)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1009	Installation of Air Side Heat Recovery Systems	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1010	High Efficiency Non-Condensing Boiler 89% efficiency	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1011	High Efficiency Condensing Boiler 95% efficiency	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1012	Stack Heat Exchanger	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1013	Boiler Controls	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1014	Hot water temperature reset	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1015	Demand controlled ventilation (DCV)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1018	Refrigeration heat recovery - space conditioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1019	Custom Boiler	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1020	Steam traps	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1200	Base Furnace	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1201	High Efficiency Windows (Multiple Glazed, Low Emissivity)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1202	Insulation (ceiling)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1203	Insulation (wall)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1204	Duct Repair and Sealing	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1205	Duct Insulation	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1206	Clock / Programmable Thermostat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1207	Programmable communicating thermostat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1208	Installation of Energy Management Systems (EMS)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1209	Installation of Air Side Heat Recovery Systems	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1210	High Efficiency (Power Burner/ Premium) Furnace 95% efficiency	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1211	Stack Heat Exchanger	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1212	Demand controlled ventilation (DCV)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1213	Refrigeration heat recovery - space conditioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1214	Custom Furnace	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1400	Base Other Heat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1401	Condensing unit heaters	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1402	Radiant heater	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1403	Custom Other Heat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1500	Base Water Heating - high standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1501	DHW Pipe Insulation - high standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1502	Demand controlled circulating systems - high standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1503	Tankless Water Heater - high standby loss applications	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1504	Custom Water Heating-high stanby loss	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1600	Base Water Heating - low standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1601	DHW Pipe Insulation - low standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1602	Demand controlled circulating systems - low standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1603	Condensing Water Heater (gas, 95% thermal efficiency)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1604	Pre-Rinse Spray Valve, 1.28 gpm or less (base 1.6 gpm)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1605	Custom Water Heating-low stanby loss	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1700	Base Cooking - Fryer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1701	Energy Star Fryer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1800	Base Cooking - Steamer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1801	Energy Star Steamer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1900	Base Cooking - Oven	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1901	High-Efficiency Convection Oven	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1902	Conveyor Oven	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1903	Combination Oven	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2000	Base Cooking - Griddle	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

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Commercial Gas Measure Inputs		Standards Adjustment Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
2001	High-Efficiency Griddle	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2010	Base Cooking - Range	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2011	High-Efficiency Range	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2020	Base Miscellaneous	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2030	Base Whole Building	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2031	Retrocommissioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2100	Base Building Design - Standard Code	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2101	15% better than code - Campuses	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2102	15% better than code - Education	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2103	15% better than code - Food Sales	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2104	15% better than code - Food Service	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2105	15% better than code - Healthcare	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2106	15% better than code - Lodging	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2107	15% better than code - Office	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2108	15% better than code - Other	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2109	15% better than code - Public Assembly	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2110	15% better than code - Retail	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2111	15% better than code - Warehouse	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2112	Commissioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2120	Base Building Design - Standard Code	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2121	30% better than code - Campuses	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2122	30% better than code - Education	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2123	30% better than code - Food Sales	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2124	30% better than code - Food Service	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2125	30% better than code - Healthcare	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2126	30% better than code - Lodging	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2127	30% better than code - Office	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2128	30% better than code - Other	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2129	30% better than code - Public Assembly	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2130	30% better than code - Retail	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2131	30% better than code - Warehouse	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2132	Commissioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2140	Base Building Design - Standard Code	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2141	50% better than code - Campuses	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2142	50% better than code - Education	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2143	50% better than code - Food Sales	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2144	50% better than code - Food Service	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2145	50% better than code - Healthcare	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2146	50% better than code - Lodging	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2147	50% better than code - Office	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2148	50% better than code - Other	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2149	50% better than code - Public Assembly	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2150	50% better than code - Retail	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2151	50% better than code - Warehouse	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2152	Commissioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2160	Base Building Design - Standard Code	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2161	70% better than code - Campuses	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2162	70% better than code - Education	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2163	70% better than code - Food Sales	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2164	70% better than code - Food Service	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2165	70% better than code - Healthcare	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2166	70% better than code - Lodging	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2167	70% better than code - Office	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2168	70% better than code - Other	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2169	70% better than code - Public Assembly	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2170	70% better than code - Retail	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2171	70% better than code - Warehouse	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2172	Commissioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

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Commercial Gas Measure Inputs		Standards Adjustment Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
2200	Base Boiler	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2201	High Efficiency Windows (Multiple Glazed, Low Emissivity)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2207	Programmable communicating thermostat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2208	Installation of Energy Management Systems (EMS)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2209	Installation of Air Side Heat Recovery Systems	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2210	High Efficiency Non-Condensing Boiler 89% efficiency	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2211	High Efficiency Condensing Boiler 95% efficiency	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2212	Stack Heat Exchanger	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2213	Boiler Controls	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2214	Hot water temperature reset	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2215	Demand controlled ventilation (DCV)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2216	Refrigeration heat recovery - space conditioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2220	Base Furnace	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2221	High Efficiency Windows (Multiple Glazed, Low Emissivity)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2227	Programmable communicating thermostat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2228	Installation of Energy Management Systems (EMS)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2229	Installation of Air Side Heat Recovery Systems	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2230	High Efficiency (Power Burner/ Premium) Furnace 95% efficiency	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2231	Stack Heat Exchanger	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2232	Demand controlled ventilation (DCV)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2233	Refrigeration heat recovery - space conditioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2240	Base Other Heat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2241	Condensing unit heaters	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2242	Radiant heater	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2250	Base Water Heating - high standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2252	Demand controlled circulating systems - high standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2253	Tankless Water Heater - high standby loss applications	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2260	Base Water Heating - low standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2262	Demand controlled circulating systems - low standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2263	Condensing Water Heater (gas, 95% thermal efficiency)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2264	Pre-Rinse Spray Valve, 1.28 gpm or less (base 1.6 gpm)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2270	Base Cooking - Fryer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2271	Energy Star Fryer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2280	Base Cooking - Steamer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2281	Energy Star Steamer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2290	Base Cooking - Oven	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2291	High-Efficiency Convection Oven	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2292	Conveyor Oven	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2293	Combination Oven	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2300	Base Cooking - Griddle	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2301	High-Efficiency Griddle	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2310	Base Cooking - Range	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2311	High-Efficiency Range	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2320	Base Miscellaneous	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

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Commercial Gas Measure Inputs		**Incomplete Factor (percent)**											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1000	Base Boiler	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1001	High Efficiency Windows (Multiple Glazed, Low Emissivity)	74%	28%	34%	61%	1%	1%	17%	22%	25%	25%	47%	75%
1002	Insulation (ceiling)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1003	Insulation (wall)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1004	Insulation of Pipes	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1005	Boiler Tune-Up	10%	25%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1006	Clock / Programmable Thermostat	70%	80%	72%	43%	64%	64%	60%	71%	69%	69%	49%	29%
1007	Programmable communicating thermostat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1008	Installation of Energy Management Systems (EMS)	35%	27%	65%	98%	68%	68%	79%	44%	66%	66%	81%	97%
1009	Installation of Air Side Heat Recovery Systems	90%	58%	76%	78%	90%	90%	50%	90%	50%	50%	90%	69%
1010	High Efficiency Non-Condensing Boiler 89% efficiency	87%	77%	87%	87%	94%	89%	87%	87%	87%	87%	87%	87%
1011	High Efficiency Condensing Boiler 95% efficiency	71%	99%	71%	71%	96%	71%	71%	83%	71%	5%	71%	71%
1012	Stack Heat Exchanger	81%	84%	87%	86%	79%	79%	85%	84%	84%	84%	85%	84%
1013	Boiler Controls	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
1014	Hot water temperature reset	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1015	Demand controlled ventilation (DCV)	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
1018	Refrigeration heat recovery - space conditioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1019	Custom Boiler	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1020	Steam traps	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1200	Base Furnace	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1201	High Efficiency Windows (Multiple Glazed, Low Emissivity)	74%	28%	34%	61%	1%	1%	17%	22%	25%	25%	47%	75%
1202	Insulation (ceiling)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1203	Insulation (wall)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1204	Duct Repair and Sealing	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1205	Duct Insulation	74%	72%	72%	57%	70%	70%	79%	59%	83%	83%	85%	62%
1206	Clock / Programmable Thermostat	35%	94%	12%	28%	80%	35%	1%	62%	1%	10%	28%	35%
1207	Programmable communicating thermostat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1208	Installation of Energy Management Systems (EMS)	35%	27%	65%	98%	68%	68%	79%	44%	66%	66%	81%	97%
1209	Installation of Air Side Heat Recovery Systems	90%	58%	76%	78%	90%	90%	50%	90%	50%	50%	90%	69%
1210	High Efficiency (Power Burner/ Premium) Furnace 95% efficiency	95%	95%	95%	95%	91%	95%	95%	95%	95%	98%	95%	95%
1211	Stack Heat Exchanger	81%	84%	87%	86%	79%	79%	85%	84%	84%	84%	85%	84%
1212	Demand controlled ventilation (DCV)	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
1213	Refrigeration heat recovery - space conditioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1214	Custom Furnace	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1400	Base Other Heat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1401	Condensing unit heaters	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%
1402	Radiant heater	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
1403	Custom Other Heat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1500	Base Water Heating - high standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1501	DHW Pipe Insulation - high standby loss (as % of load)	80%	96%	96%	92%	80%	80%	80%	97%	97%	4%	80%	80%
1502	Demand controlled circulating systems - high standby loss (as % of load)	47%	93%	100%	100%	93%	93%	10%	86%	97%	97%	98%	100%
1503	Tankless Water Heater - high standby loss applications	94%	91%	91%	89%	91%	91%	68%	94%	99%	98%	97%	91%
1504	Custom Water Heating-high stanby loss	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1600	Base Water Heating - low standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1601	DHW Pipe Insulation - low standby loss (as % of load)	80%	96%	96%	92%	80%	80%	80%	97%	97%	4%	80%	80%
1602	Demand controlled circulating systems - low standby loss (as % of load)	47%	93%	100%	100%	93%	93%	10%	86%	97%	97%	98%	100%
1603	Condensing Water Heater (gas, 95% thermal efficiency)	64%	64%	64%	100%	64%	64%	86%	64%	64%	5%	64%	64%
1604	Pre-Rinse Spray Valve, 1.28 gpm or less (base 1.6 gpm)	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
1605	Custom Water Heating-low stanby loss	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1700	Base Cooking - Fryer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1701	Energy Star Fryer	93%	93%	93%	93%	93%	93%	93%	93%	93%	93%	93%	93%
1800	Base Cooking - Steamer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1801	Energy Star Steamer	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%
1900	Base Cooking - Oven	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1901	High-Efficiency Convection Oven	63%	98%	63%	79%	21%	63%	63%	98%	63%	19%	63%	63%
1902	Conveyor Oven	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
1903	Combination Oven	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
2000	Base Cooking - Griddle	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

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Commercial Gas Measure Inputs		Incomplete Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
2001	High-Efficiency Griddle	93%	93%	93%	93%	93%	93%	93%	93%	93%	93%	93%	93%
2010	Base Cooking - Range	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2011	High-Efficiency Range	49%	49%	49%	49%	49%	0%	49%	98%	49%	49%	49%	49%
2020	Base Miscellaneous	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2030	Base Whole Building	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2031	Retrocommissioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2100	Base Building Design - Standard Code	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2101	15% better than code - Campuses	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2102	15% better than code - Education	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2103	15% better than code - Food Sales	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2104	15% better than code - Food Service	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
2105	15% better than code - Healthcare	0%	0%	0%	0%	100%	100%	0%	0%	0%	0%	0%	0%
2106	15% better than code - Lodging	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%
2107	15% better than code - Office	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%
2108	15% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%
2109	15% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%
2110	15% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%
2111	15% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
2112	Commissioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2120	Base Building Design - Standard Code	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2121	30% better than code - Campuses	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2122	30% better than code - Education	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2123	30% better than code - Food Sales	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2124	30% better than code - Food Service	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
2125	30% better than code - Healthcare	0%	0%	0%	0%	100%	100%	0%	0%	0%	0%	0%	0%
2126	30% better than code - Lodging	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%
2127	30% better than code - Office	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%
2128	30% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%
2129	30% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%
2130	30% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%
2131	30% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
2132	Commissioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2140	Base Building Design - Standard Code	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2141	50% better than code - Campuses	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2142	50% better than code - Education	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2143	50% better than code - Food Sales	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2144	50% better than code - Food Service	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
2145	50% better than code - Healthcare	0%	0%	0%	0%	100%	100%	0%	0%	0%	0%	0%	0%
2146	50% better than code - Lodging	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%
2147	50% better than code - Office	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%
2148	50% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%
2149	50% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%
2150	50% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%
2151	50% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
2152	Commissioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2160	Base Building Design - Standard Code	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2161	70% better than code - Campuses	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2162	70% better than code - Education	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2163	70% better than code - Food Sales	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2164	70% better than code - Food Service	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
2165	70% better than code - Healthcare	0%	0%	0%	0%	100%	100%	0%	0%	0%	0%	0%	0%
2166	70% better than code - Lodging	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%
2167	70% better than code - Office	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%
2168	70% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%
2169	70% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%
2170	70% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%
2171	70% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
2172	Commissioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

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Commercial Gas Measure Inputs		Incomplete Factor (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
2200	Base Boiler	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2201	High Efficiency Windows (Multiple Glazed, Low Emissivity)	74%	28%	34%	61%	1%	1%	17%	22%	25%	25%	47%	75%
2207	Programmable communicating thermostat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2208	Installation of Energy Management Systems (EMS)	35%	27%	65%	98%	68%	68%	79%	44%	66%	66%	81%	97%
2209	Installation of Air Side Heat Recovery Systems	90%	58%	76%	78%	90%	90%	50%	90%	50%	50%	90%	69%
2210	High Efficiency Non-Condensing Boiler 89% efficiency	87%	77%	87%	87%	94%	89%	87%	87%	87%	87%	87%	87%
2211	High Efficiency Condensing Boiler 95% efficiency	71%	99%	71%	71%	96%	71%	71%	83%	71%	5%	71%	71%
2212	Stack Heat Exchanger	81%	84%	87%	86%	79%	79%	85%	84%	84%	84%	85%	84%
2213	Boiler Controls	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
2214	Hot water temperature reset	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
2215	Demand controlled ventilation (DCV)	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
2216	Refrigeration heat recovery - space conditioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2220	Base Furnace	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2221	High Efficiency Windows (Multiple Glazed, Low Emissivity)	74%	28%	34%	61%	1%	1%	17%	22%	25%	25%	47%	75%
2227	Programmable communicating thermostat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2228	Installation of Energy Management Systems (EMS)	35%	27%	65%	98%	68%	68%	79%	44%	66%	66%	81%	97%
2229	Installation of Air Side Heat Recovery Systems	90%	58%	76%	78%	90%	90%	50%	90%	50%	50%	90%	69%
2230	High Efficiency (Power Burner/ Premium) Furnace 95% efficiency	95%	95%	95%	95%	91%	95%	95%	95%	95%	98%	95%	95%
2231	Stack Heat Exchanger	81%	84%	87%	86%	79%	79%	85%	84%	84%	84%	85%	84%
2232	Demand controlled ventilation (DCV)	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
2233	Refrigeration heat recovery - space conditioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2240	Base Other Heat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2241	Condensing unit heaters	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%
2242	Radiant heater	95.00%	95.00%	95.00%	95.00%	95.00%	95.00%	95.00%	95.00%	95.00%	95.00%	95.00%	95%
2250	Base Water Heating - high standby loss (as % of load)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2252	Demand controlled circulating systems - high standby loss (as % of load)	46.90%	92.50%	100.00%	100.00%	92.80%	92.80%	10.00%	86.10%	97.10%	97.10%	97.70%	100%
2253	Tankless Water Heater - high standby loss applications	93.63%	91.11%	91.11%	88.91%	91.11%	91.11%	67.53%	93.72%	99.38%	97.88%	96.71%	91%
2260	Base Water Heating - low standby loss (as % of load)	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2262	Demand controlled circulating systems - low standby loss (as % of load)	46.90%	92.50%	100.00%	100.00%	92.80%	92.80%	10.00%	86.10%	97.10%	97.10%	97.70%	100%
2263	Condensing Water Heater (gas, 95% thermal efficiency)	63.58%	63.58%	63.58%	99.54%	63.58%	63.58%	86.47%	63.58%	63.58%	4.74%	63.58%	64%
2264	Pre-Rinse Spray Valve, 1.28 gpm or less (base 1.6 gpm)	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80%
2270	Base Cooking - Fryer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2271	Energy Star Fryer	93.00%	93.00%	93.00%	93.00%	93.00%	93.00%	93.00%	93.00%	93.00%	93.00%	93.00%	93%
2280	Base Cooking - Steamer	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2281	Energy Star Steamer	65.19%	65.19%	65.19%	65.19%	65.19%	65.19%	65.19%	65.19%	65.19%	65.19%	65.19%	65%
2290	Base Cooking - Oven	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2291	High-Efficiency Convection Oven	62.91%	97.58%	62.91%	79.16%	20.98%	62.91%	62.91%	97.57%	62.91%	19.24%	62.91%	63%
2292	Conveyor Oven	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80%
2293	Combination Oven	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80%
2300	Base Cooking - Griddle	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2301	High-Efficiency Griddle	92.95%	92.95%	92.95%	92.95%	92.95%	92.86%	92.95%	93.03%	92.95%	92.95%	92.95%	93%
2310	Base Cooking - Range	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%
2311	High-Efficiency Range	48.85%	48.85%	48.85%	48.85%	48.85%	0.00%	48.85%	97.71%	48.85%	48.85%	48.85%	49%
2320	Base Miscellaneous	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100%

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Commercial Gas Measure Inputs		FEASIBILITY FACTOR (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	ublic Assemb	Retail	Warehouse
1004	Insulation of Pipes	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1005	Boiler Tune-Up	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1006	Clock / Programmable Thermostat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1007	Programmable communicating thermostat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1008	Installation of Energy Management Systems (EMS)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1009	Installation of Air Side Heat Recovery Systems	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1010	High Efficiency Non-Condensing Boiler 89% efficiency	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1011	High Efficiency Condensing Boiler 95% efficiency	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1012	Stack Heat Exchanger	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1013	Boiler Controls	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1014	Hot water temperature reset	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1015	Demand controlled ventilation (DCV)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1018	Refrigeration heat recovery - space conditioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1019	Custom Boiler	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1020	Steam traps	23%	64%	57%	57%	57%	89%	57%	100%	10%	57%	57%	57%
1200	Base Furnace	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1201	High Efficiency Windows (Multiple Glazed, Low Emissivity)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1202	Insulation (ceiling)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1203	Insulation (wall)	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1204	Duct Repair and Sealing	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1205	Duct Insulation	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1206	Clock / Programmable Thermostat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1207	Programmable communicating thermostat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1208	Installation of Energy Management Systems (EMS)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1209	Installation of Air Side Heat Recovery Systems	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1210	High Efficiency (Power Burner/ Premium) Furnace 95% efficiency	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1211	Stack Heat Exchanger	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1212	Demand controlled ventilation (DCV)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1213	Refrigeration heat recovery - space conditioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1214	Custom Furnace	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1400	Base Other Heat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1401	Condensing unit heaters	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1402	Radiant heater	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1403	Custom Other Heat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1500	Base Water Heating - high standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1501	DHW Pipe Insulation - high standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1502	Demand controlled circulating systems - high standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1503	Tankless Water Heater - high standby loss applications	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
1504	Custom Water Heating-high stanby loss	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1600	Base Water Heating - low standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1601	DHW Pipe Insulation - low standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1602	Demand controlled circulating systems - low standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1603	Condensing Water Heater (gas, 95% thermal efficiency)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1604	Pre-Rinse Spray Valve, 1.28 gpm or less (base 1.6 gpm)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1605	Custom Water Heating-low stanby loss	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1700	Base Cooking - Fryer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1701	Energy Star Fryer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1800	Base Cooking - Steamer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1801	Energy Star Steamer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1900	Base Cooking - Oven	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1901	High-Efficiency Convection Oven	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1902	Conveyor Oven	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1903	Combination Oven	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2000	Base Cooking - Griddle	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2001	High-Efficiency Griddle	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Commercial Gas Measure Inputs		FEASIBILITY FACTOR (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	ublic Assemb	Retail	Warehouse
2010	Base Cooking - Range	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2011	High-Efficiency Range	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2020	Base Miscellaneous	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2030	Base Whole Building	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2031	Retrocommissioning	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%
2100	Base Building Design - Standard Code	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2101	15% better than code - Campuses	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2102	15% better than code - Education	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2103	15% better than code - Food Sales	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2104	15% better than code - Food Service	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2105	15% better than code - Healthcare	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2106	15% better than code - Lodging	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2107	15% better than code - Office	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2108	15% better than code - Other	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2109	15% better than code - Public Assembly	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2110	15% better than code - Retail	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2111	15% better than code - Warehouse	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2112	Commissioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2120	Base Building Design - Standard Code	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2121	30% better than code - Campuses	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2122	30% better than code - Education	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2123	30% better than code - Food Sales	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2124	30% better than code - Food Service	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2125	30% better than code - Healthcare	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2126	30% better than code - Lodging	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2127	30% better than code - Office	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2128	30% better than code - Other	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2129	30% better than code - Public Assembly	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2130	30% better than code - Retail	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2131	30% better than code - Warehouse	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2132	Commissioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2140	Base Building Design - Standard Code	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2141	50% better than code - Campuses	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2142	50% better than code - Education	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2143	50% better than code - Food Sales	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2144	50% better than code - Food Service	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2145	50% better than code - Healthcare	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2146	50% better than code - Lodging	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2147	50% better than code - Office	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2148	50% better than code - Other	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2149	50% better than code - Public Assembly	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2150	50% better than code - Retail	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2151	50% better than code - Warehouse	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2152	Commissioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2160	Base Building Design - Standard Code	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2161	70% better than code - Campuses	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2162	70% better than code - Education	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2163	70% better than code - Food Sales	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2164	70% better than code - Food Service	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2165	70% better than code - Healthcare	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2166	70% better than code - Lodging	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2167	70% better than code - Office	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2168	70% better than code - Other	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2169	70% better than code - Public Assembly	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2170	70% better than code - Retail	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

DNV·GL

Commercial Gas Measure Inputs		FEASIBILITY FACTOR (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	ublic Assemb	Retail	Warehouse
2171	70% better than code - Warehouse	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2172	Commissioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2200	Base Boiler	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2201	High Efficiency Windows (Multiple Glazed, Low Emissivity)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2207	Programmable communicating thermostat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2208	Installation of Energy Management Systems (EMS)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2209	Installation of Air Side Heat Recovery Systems	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2210	High Efficiency Non-Condensing Boiler 89% efficiency	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2211	High Efficiency Condensing Boiler 95% efficiency	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2212	Stack Heat Exchanger	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2213	Boiler Controls	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2214	Hot water temperature reset	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2215	Demand controlled ventilation (DCV)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2216	Refrigeration heat recovery - space conditioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2220	Base Furnace	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2221	High Efficiency Windows (Multiple Glazed, Low Emissivity)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2227	Programmable communicating thermostat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2228	Installation of Energy Management Systems (EMS)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2229	Installation of Air Side Heat Recovery Systems	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2230	High Efficiency (Power Burner/ Premium) Furnace 95% efficiency	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2231	Stack Heat Exchanger	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2232	Demand controlled ventilation (DCV)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2233	Refrigeration heat recovery - space conditioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2240	Base Other Heat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2241	Condensing unit heaters	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2242	Radiant heater	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2250	Base Water Heating - high standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2252	Demand controlled circulating systems - high standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2253	Tankless Water Heater - high standby loss applications	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
2260	Base Water Heating - low standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2262	Demand controlled circulating systems - low standby loss (as % of load)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2263	Condensing Water Heater (gas, 95% thermal efficiency)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2264	Pre-Rinse Spray Valve, 1.28 gpm or less (base 1.6 gpm)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2270	Base Cooking - Fryer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2271	Energy Star Fryer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2280	Base Cooking - Steamer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2281	Energy Star Steamer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2290	Base Cooking - Oven	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2291	High-Efficiency Convection Oven	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2292	Conveyor Oven	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2293	Combination Oven	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2300	Base Cooking - Griddle	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2301	High-Efficiency Griddle	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2310	Base Cooking - Range	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2311	High-Efficiency Range	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2320	Base Miscellaneous	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Commercial Gas Measure Inputs		**TECHNOLOGY SATURATION (units/square foot)**											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1000	Base Boiler	0.0062	0.0321	0.0000	0.0003	0.0047	0.0145	0.0470	0.0136	0.0529	0.0371	0.0162	0.0000
1001	High Efficiency Windows (Multiple Glazed, Low Emissivity)	0.0625	0.0242	0.0409	0.0460	0.0201	0.0201	0.0945	0.0877	0.0284	0.0284	0.0284	0.0171
1002	Insulation (ceiling)	0.2087	0.4369	0.8807	0.5418	0.2413	0.2413	0.1856	0.3364	0.5269	0.5269	0.6184	0.7806
1003	Insulation (wall)	0.1674	0.1433	0.3561	0.5773	0.1097	0.1097	0.1155	0.1872	0.1934	0.1934	0.3734	0.1874
1004	Insulation of Pipes	0.0008	0.0006	0.0016	0.0004	0.0004	0.0007	0.0004	0.0015	0.0018	0.0001	0.0009	0.0003
1005	Boiler Tune-Up	0.0062	0.0321	0.0000	0.0003	0.0047	0.0145	0.0470	0.0136	0.0529	0.0371	0.0162	0.0000
1006	Clock / Programmable Thermostat	0.0033	0.0029	0.0000	0.0017	0.0017	0.0031	0.0017	0.0065	0.0079	0.0006	0.0039	0.0000
1007	Programmable communicating thermostat	0.0033	0.0029	0.0000	0.0017	0.0017	0.0031	0.0017	0.0065	0.0079	0.0006	0.0039	0.0000
1008	Installation of Energy Management Systems (EMS)	0.0002	0.0001	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0008	0.0001	0.0004	0.0002
1009	Installation of Air Side Heat Recovery Systems	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1010	High Efficiency Non-Condensing Boiler 89% efficiency	0.0800	0.0696	0.0000	0.0400	0.0405	0.0745	0.0400	0.1562	0.1898	0.0140	0.0911	0.0000
1011	High Efficiency Condensing Boiler 95% efficiency	0.0721	0.0584	0.0000	0.0360	0.0348	0.0673	0.0360	0.1370	0.1711	0.0148	0.0821	0.0000
1012	Stack Heat Exchanger	0.0017	0.0015	0.0037	0.0009	0.0009	0.0016	0.0008	0.0034	0.0043	0.0003	0.0020	0.0007
1013	Boiler Controls	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1014	Hot water temperature reset	0.0007	0.0006	0.0016	0.0004	0.0004	0.0007	0.0004	0.0014	0.0017	0.0001	0.0008	0.0003
1015	Demand controlled ventilation (DCV)	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
1018	Refrigeration heat recovery - space conditioning	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1019	Custom Boiler	0.0036	0.0031	0.0077	0.0018	0.0018	0.0034	0.0018	0.0070	0.0085	0.0006	0.0041	0.0015
1020	Steam traps	0.0025	0.0021	0.0053	0.0012	0.0013	0.0023	0.0012	0.0049	0.0059	0.0004	0.0028	0.0010
1200	Base Furnace	0.0000	0.0021	0.0012	0.0035	0.0010	0.0000	0.0973	0.0006	0.0005	0.0025	0.0001	0.0002
1201	High Efficiency Windows (Multiple Glazed, Low Emissivity)	0.0625	0.0242	0.0409	0.0460	0.0201	0.0201	0.0945	0.0877	0.0284	0.0284	0.0284	0.0171
1202	Insulation (ceiling)	0.2087	0.4369	0.8807	0.5418	0.2413	0.2413	0.1856	0.3364	0.5269	0.5269	0.6184	0.7806
1203	Insulation (wall)	0.1674	0.1433	0.3561	0.5773	0.1097	0.1097	0.1155	0.1440	0.1934	0.1934	0.3734	0.1874
1204	Duct Repair and Sealing	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1205	Duct Insulation	0.0145	0.0170	0.0332	0.0793	0.0142	0.0142	0.0315	0.0453	0.0313	0.0313	0.0311	0.0153
1206	Clock / Programmable Thermostat	0.0033	0.0029	0.0000	0.0017	0.0017	0.0031	0.0017	0.0065	0.0079	0.0006	0.0039	0.0000
1207	Programmable communicating thermostat	0.0033	0.0029	0.0000	0.0017	0.0017	0.0031	0.0017	0.0065	0.0079	0.0006	0.0039	0.0000
1208	Installation of Energy Management Systems (EMS)	0.0002	0.0001	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0008	0.0001	0.0004	0.0002
1209	Installation of Air Side Heat Recovery Systems	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1210	High Efficiency (Power Burner/ Premium) Furnace 95% efficiency	0.0000	0.0322	0.0187	0.0532	0.0146	0.0000	1.4595	0.0091	0.0069	0.0379	0.0014	0.0023
1211	Stack Heat Exchanger	0.0017	0.0096	0.0144	0.0192	0.0237	0.0284	0.0326	0.0384	0.0454	0.0504	0.0527	0.0576
1212	Demand controlled ventilation (DCV)	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
1213	Refrigeration heat recovery - space conditioning	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1214	Custom Furnace	0.0036	0.0031	0.0077	0.0018	0.0018	0.0034	0.0018	0.0070	0.0085	0.0006	0.0041	0.0015
1400	Base Other Heat	0.0000	0.0037	0.0008	0.0012	0.0173	0.0000	0.0004	0.0004	0.0053	0.0001	0.0003	0.0757
1401	Condensing unit heaters	0.0000	0.0004	0.0001	0.0001	0.0017	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0076
1402	Radiant heater	0.0000	0.0004	0.0001	0.0001	0.0017	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0076
1403	Custom Other Heat	0.0036	0.0031	0.0077	0.0018	0.0018	0.0034	0.0018	0.0070	0.0085	0.0006	0.0041	0.0015
1500	Base Water Heating - high standby loss (as % of load)	0.0027	0.0032	0.0024	0.0301	0.0025	0.0069	0.0272	0.0047	0.0048	0.0048	0.0397	0.0000
1501	DHW Pipe Insulation - high standby loss (as % of load)	0.0003	0.0000	0.0000	0.0008	0.0001	0.0007	0.0005	0.0004	0.0005	0.0003	0.0001	0.0000
1502	Demand controlled circulating systems - high standby loss (as % of load)	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0002	0.0000
1503	Tankless Water Heater - high standby loss applications	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0002	0.0000
1504	Custom Water Heating-high stanby loss	0.0013	0.0002	0.0001	0.0041	0.0005	0.0036	0.0024	0.0018	0.0025	0.0016	0.0005	0.0000
1600	Base Water Heating - low standby loss (as % of load)	0.0027	0.0032	0.0024	0.0301	0.0025	0.0069	0.0272	0.0047	0.0048	0.0048	0.0397	0.0000
1601	DHW Pipe Insulation - low standby loss (as % of load)	0.0003	0.0000	0.0000	0.0008	0.0001	0.0007	0.0005	0.0004	0.0005	0.0003	0.0001	0.0000
1602	Demand controlled circulating systems - low standby loss (as % of load)	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0002	0.0000
1603	Condensing Water Heater (gas, 95% thermal efficiency)	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0002	0.0000
1604	Pre-Rinse Spray Valve, 1.28 gpm or less (base 1.6 gpm)	0.0000	0.0001	0.0001	0.0004	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0000
1605	Custom Water Heating-low stanby loss	0.0013	0.0002	0.0001	0.0041	0.0005	0.0036	0.0024	0.0018	0.0025	0.0016	0.0005	0.0000
1700	Base Cooking - Fryer	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000
1701	Energy Star Fryer	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000
1800	Base Cooking - Steamer	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1801	Energy Star Steamer	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
1900	Base Cooking - Oven	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0005	0.0000
1901	High-Efficiency Convection Oven	0.0000	0.0002	0.0000	0.0032	0.0000	0.0000	0.0000	0.0001	0.0001	0.0009	0.0005	0.0000
1902	Conveyor Oven	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0005	0.0000
1903	Combination Oven	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0005	0.0000
2000	Base Cooking - Griddle	0.0000	0.0000	0.0001	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000

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Commercial Gas Measure Inputs		TECHNOLOGY SATURATION (units/square foot)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
2001	High-Efficiency Griddle	0.0000	0.0000	0.0001	0.0008	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
2010	Base Cooking - Range	0.0000	0.0000	0.0001	0.0007	0.0000	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000
2011	High-Efficiency Range	0.0000	0.0000	0.0001	0.0007	0.0000	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000
2020	Base Miscellaneous	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2030	Base Whole Building	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2031	Retrocommissioning	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2100	Base Building Design - Standard Code	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2101	15% better than code - Campuses	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2102	15% better than code - Education	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2103	15% better than code - Food Sales	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2104	15% better than code - Food Service	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2105	15% better than code - Healthcare	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2106	15% better than code - Lodging	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2107	15% better than code - Office	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2108	15% better than code - Other	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2109	15% better than code - Public Assembly	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2110	15% better than code - Retail	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2111	15% better than code - Warehouse	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2112	Commissioning	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2120	Base Building Design - Standard Code	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2121	30% better than code - Campuses	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2122	30% better than code - Education	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2123	30% better than code - Food Sales	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2124	30% better than code - Food Service	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2125	30% better than code - Healthcare	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2126	30% better than code - Lodging	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2127	30% better than code - Office	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2128	30% better than code - Other	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2129	30% better than code - Public Assembly	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2130	30% better than code - Retail	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2131	30% better than code - Warehouse	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2132	Commissioning	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2140	Base Building Design - Standard Code	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2141	50% better than code - Campuses	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2142	50% better than code - Education	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2143	50% better than code - Food Sales	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2144	50% better than code - Food Service	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2145	50% better than code - Healthcare	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2146	50% better than code - Lodging	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2147	50% better than code - Office	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2148	50% better than code - Other	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2149	50% better than code - Public Assembly	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2150	50% better than code - Retail	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2151	50% better than code - Warehouse	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2152	Commissioning	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2160	Base Building Design - Standard Code	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2161	70% better than code - Campuses	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2162	70% better than code - Education	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2163	70% better than code - Food Sales	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2164	70% better than code - Food Service	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2165	70% better than code - Healthcare	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2166	70% better than code - Lodging	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2167	70% better than code - Office	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2168	70% better than code - Other	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2169	70% better than code - Public Assembly	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2170	70% better than code - Retail	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2171	70% better than code - Warehouse	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2172	Commissioning	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

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Commercial Gas Measure Inputs		TECHNOLOGY SATURATION (units/square foot)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
2200	Base Boiler	0.0062	0.0321	0.0000	0.0003	0.0047	0.0145	0.0470	0.0136	0.0529	0.0371	0.0162	0.0000
2201	High Efficiency Windows (Multiple Glazed, Low Emissivity)	0.0625	0.0242	0.0409	0.0460	0.0201	0.0201	0.0945	0.0877	0.0284	0.0284	0.0284	0.0171
2207	Programmable communicating thermostat	0.0033	0.0029	0.0000	0.0017	0.0017	0.0031	0.0017	0.0065	0.0079	0.0006	0.0039	0.0000
2208	Installation of Energy Management Systems (EMS)	0.0002	0.0001	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0008	0.0001	0.0004	0.0002
2209	Installation of Air Side Heat Recovery Systems	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2210	High Efficiency Non-Condensing Boiler 89% efficiency	0.0800	0.0696	0.0000	0.0400	0.0405	0.0745	0.0400	0.1562	0.1898	0.0140	0.0911	0.0000
2211	High Efficiency Condensing Boiler 95% efficiency	0.0721	0.0584	0.0000	0.0360	0.0348	0.0673	0.0360	0.1370	0.1711	0.0148	0.0821	0.0000
2212	Stack Heat Exchanger	0.0017	0.0015	0.0037	0.0009	0.0009	0.0016	0.0008	0.0034	0.0043	0.0003	0.0020	0.0007
2213	Boiler Controls	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2214	Hot water temperature reset	0.0007	0.0006	0.0016	0.0004	0.0004	0.0007	0.0004	0.0014	0.0017	0.0001	0.0008	0.0003
2215	Demand controlled ventilation (DCV)	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
2216	Refrigeration heat recovery - space conditioning	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2220	Base Furnace	0.0000	0.0021	0.0012	0.0035	0.0010	0.0000	0.0973	0.0006	0.0005	0.0025	0.0001	0.0002
2221	High Efficiency Windows (Multiple Glazed, Low Emissivity)	0.0625	0.0242	0.0409	0.0460	0.0201	0.0201	0.0945	0.0877	0.0284	0.0284	0.0284	0.0171
2227	Programmable communicating thermostat	0.0033	0.0029	0.0000	0.0017	0.0017	0.0031	0.0017	0.0065	0.0079	0.0006	0.0039	0.0000
2228	Installation of Energy Management Systems (EMS)	0.0002	0.0001	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0008	0.0001	0.0004	0.0002
2229	Installation of Air Side Heat Recovery Systems	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2230	High Efficiency (Power Burner/ Premium) Furnace 95% efficiency	0.0000	0.0322	0.0187	0.0532	0.0146	0.0000	1.4595	0.0091	0.0069	0.0379	0.0014	0.0023
2231	Stack Heat Exchanger	0.0017	0.0096	0.0144	0.0192	0.0237	0.0284	0.0326	0.0384	0.0454	0.0504	0.0527	0.0576
2232	Demand controlled ventilation (DCV)	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
2233	Refrigeration heat recovery - space conditioning	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2240	Base Other Heat	0.0000	0.0037	0.0008	0.0012	0.0173	0.0000	0.0004	0.0004	0.0053	0.0001	0.0003	0.0757
2241	Condensing unit heaters	0.0000	0.0004	0.0001	0.0001	0.0017	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0076
2242	Radiant heater	0.0000	0.0004	0.0001	0.0001	0.0017	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0076
2250	Base Water Heating - high standby loss (as % of load)	0.0027	0.0032	0.0024	0.0301	0.0025	0.0069	0.0272	0.0047	0.0048	0.0048	0.0397	0.0000
2252	Demand controlled circulating systems - high standby loss (as % of load)	0.0008	0.0000	0.0000	0.0002	0.0000	0.0000	0.0029	0.0002	0.0002	0.0002	0.0000	0.0000
2253	Tankless Water Heater - high standby loss applications	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0002	0.0000
2260	Base Water Heating - low standby loss (as % of load)	0.0027	0.0032	0.0024	0.0301	0.0025	0.0069	0.0272	0.0047	0.0048	0.0048	0.0397	0.0000
2262	Demand controlled circulating systems - low standby loss (as % of load)	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0002	0.0000
2263	Condensing Water Heater (gas, 95% thermal efficiency)	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0002	0.0000
2264	Pre-Rinse Spray Valve, 1.28 gpm or less (base 1.6 gpm)	0.0000	0.0001	0.0001	0.0004	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0000
2270	Base Cooking - Fryer	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000
2271	Energy Star Fryer	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000
2280	Base Cooking - Steamer	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
2281	Energy Star Steamer	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
2290	Base Cooking - Oven	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0005	0.0000
2291	High-Efficiency Convection Oven	0.0000	0.0002	0.0000	0.0032	0.0000	0.0000	0.0000	0.0001	0.0001	0.0009	0.0005	0.0000
2292	Conveyor Oven	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0005	0.0000
2293	Combination Oven	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0005	0.0000
2300	Base Cooking - Griddle	0.0000	0.0000	0.0001	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
2301	High-Efficiency Griddle	0.0000	0.0000	0.0001	0.0008	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
2310	Base Cooking - Range	0.0000	0.0000	0.0001	0.0007	0.0000	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000
2311	High-Efficiency Range	0.0000	0.0000	0.0001	0.0007	0.0000	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000
2320	Base Miscellaneous	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Commercial Gas Measure Inputs — **APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)**

Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
1000	Base Boiler	94%	96%	0%	3%	79%	100%	50%	24%	17%	92%	37%	0%
1001	High Efficiency Windows (Multiple Glazed, Low Emissivity)	69%	27%	0%	2%	1%	1%	9%	5%	4%	23%	18%	0%
1002	Insulation (ceiling)	0%	0%	0%	2%	0%	0%	0%	4%	3%	17%	6%	0%
1003	Insulation (wall)	32%	21%	0%	1%	0%	0%	0%	5%	10%	53%	24%	0%
1004	Insulation of Pipes	23%	24%	0%	1%	20%	25%	13%	6%	4%	23%	9%	0%
1005	Boiler Tune-Up	9%	24%	0%	0%	8%	10%	5%	2%	2%	9%	4%	0%
1006	Clock / Programmable Thermostat	16%	19%	0%	0%	13%	16%	8%	4%	3%	16%	5%	0%
1007	Programmable communicating thermostat	23%	24%	0%	1%	20%	25%	13%	6%	4%	23%	9%	0%
1008	Installation of Energy Management Systems (EMS)	33%	26%	0%	3%	54%	68%	40%	11%	11%	61%	30%	0%
1009	Installation of Air Side Heat Recovery Systems	84%	56%	0%	2%	71%	90%	25%	22%	9%	46%	34%	0%
1010	High Efficiency Non-Condensing Boiler 89% efficiency	81%	75%	0%	3%	74%	89%	44%	21%	15%	80%	33%	0%
1011	High Efficiency Condensing Boiler 95% efficiency	67%	96%	0%	2%	76%	71%	36%	20%	12%	5%	27%	0%
1012	Stack Heat Exchanger	76%	81%	0%	3%	62%	79%	43%	20%	14%	77%	32%	0%
1013	Boiler Controls	75%	77%	0%	2%	63%	80%	40%	19%	14%	74%	30%	0%
1014	Hot water temperature reset	4%	12%	0%	0%	9%	18%	6%	5%	0%	10%	4%	0%
1015	Demand controlled ventilation (DCV)	84%	87%	0%	3%	71%	90%	45%	22%	15%	83%	34%	0%
1018	Refrigeration heat recovery - space conditioning	0%	0%	99%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1019	Custom Boiler	94%	96%	0%	3%	79%	100%	50%	24%	17%	92%	37%	0%
1020	Steam traps	7%	8%	0%	0%	6%	8%	4%	2%	1%	7%	3%	0%
1200	Base Furnace	0%	6%	52%	69%	5%	0%	6%	19%	8%	53%	27%	80%
1201	High Efficiency Windows (Multiple Glazed, Low Emissivity)	0%	2%	18%	42%	0%	0%	1%	4%	2%	13%	13%	60%
1202	Insulation (ceiling)	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	1%
1203	Insulation (wall)	0%	1%	24%	28%	0%	0%	0%	4%	5%	31%	17%	46%
1204	Duct Repair and Sealing	0%	2%	13%	17%	1%	0%	1%	5%	2%	13%	7%	20%
1205	Duct Insulation	0%	4%	38%	39%	4%	0%	5%	11%	7%	44%	23%	50%
1206	Clock / Programmable Thermostat	0%	1%	2%	5%	1%	0%	0%	3%	0%	1%	2%	7%
1207	Programmable communicating thermostat	0%	2%	13%	17%	1%	0%	1%	5%	2%	13%	7%	20%
1208	Installation of Energy Management Systems (EMS)	0%	2%	34%	68%	3%	0%	5%	9%	6%	35%	22%	78%
1209	Installation of Air Side Heat Recovery Systems	0%	4%	40%	54%	5%	0%	3%	17%	4%	26%	24%	55%
1210	High Efficiency (Power Burner/ Premium) Furnace 95% efficiency	0%	6%	50%	66%	5%	0%	5%	18%	8%	52%	25%	76%
1211	Stack Heat Exchanger	0%	5%	46%	60%	4%	0%	5%	16%	7%	44%	23%	67%
1212	Demand controlled ventilation (DCV)	0%	5%	47%	62%	5%	0%	5%	17%	8%	47%	24%	72%
1213	Refrigeration heat recovery - space conditioning	0%	0%	52%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1214	Custom Furnace	0%	6%	52%	69%	5%	0%	6%	19%	8%	53%	27%	80%
1400	Base Other Heat	3%	42%	30%	4%	79%	71%	69%	16%	40%	93%	27%	98%
1401	Condensing unit heaters	1%	20%	15%	2%	39%	35%	34%	8%	20%	46%	13%	48%
1402	Radiant heater	1%	20%	14%	2%	37%	34%	33%	7%	19%	44%	13%	47%
1403	Custom Other Heat	1%	21%	15%	2%	39%	36%	34%	8%	20%	46%	14%	49%
1500	Base Water Heating - high standby loss (as % of load)	100%	100%	37%	0%	0%	0%	94%	62%	8%	96%	42%	0%
1501	DHW Pipe Insulation - high standby loss (as % of load)	80%	96%	35%	0%	0%	0%	76%	60%	8%	4%	33%	0%
1502	Demand controlled circulating systems - high standby loss (as % of load)	47%	93%	37%	0%	0%	0%	9%	54%	8%	93%	41%	0%
1503	Tankless Water Heater - high standby loss applications	94%	91%	34%	0%	0%	0%	64%	58%	8%	94%	40%	0%
1504	Custom Water Heating-high stanby loss	100%	100%	37%	0%	0%	0%	94%	62%	8%	96%	42%	0%
1600	Base Water Heating - low standby loss (as % of load)	0%	0%	37%	79%	90%	0%	0%	0%	0%	0%	0%	0%
1601	DHW Pipe Insulation - low standby loss (as % of load)	0%	0%	35%	73%	72%	0%	0%	0%	0%	0%	0%	0%
1602	Demand controlled circulating systems - low standby loss (as % of load)	0%	0%	37%	79%	84%	0%	0%	0%	0%	0%	0%	0%
1603	Condensing Water Heater (gas, 95% thermal efficiency)	0%	0%	23%	79%	57%	0%	0%	0%	0%	0%	0%	0%
1604	Pre-Rinse Spray Valve, 1.28 gpm or less (base 1.6 gpm)	0%	0%	6%	13%	14%	0%	0%	0%	0%	0%	0%	0%
1605	Custom Water Heating-low stanby loss	0%	0%	37%	79%	90%	0%	0%	0%	0%	0%	0%	0%
1700	Base Cooking - Fryer	0%	0%	19%	46%	1%	66%	25%	72%	21%	2%	0%	0%
1701	Energy Star Fryer	0%	0%	18%	43%	1%	62%	24%	67%	19%	2%	0%	0%
1800	Base Cooking - Steamer	0%	37%	0%	13%	67%	66%	9%	74%	15%	1%	0%	0%
1801	Energy Star Steamer	0%	24%	0%	8%	44%	43%	6%	48%	10%	0%	0%	0%
1900	Base Cooking - Oven	0%	56%	26%	49%	85%	66%	18%	77%	17%	3%	5%	0%
1901	High-Efficiency Convection Oven	0%	18%	5%	13%	6%	14%	4%	25%	3%	0%	1%	0%
1902	Conveyor Oven	0%	15%	7%	13%	22%	17%	5%	20%	4%	1%	1%	0%
1903	Combination Oven	0%	15%	7%	13%	22%	17%	5%	20%	4%	1%	1%	0%
2000	Base Cooking - Griddle	0%	0%	3%	39%	18%	71%	11%	27%	15%	2%	0%	0%

DNV·GL

Commercial Gas Measure Inputs		APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
2001	High-Efficiency Griddle	0%	0%	3%	36%	17%	66%	10%	25%	14%	2%	0%	0%
2010	Base Cooking - Range	0%	13%	9%	16%	29%	2%	16%	27%	7%	30%	0%	0%
2011	High-Efficiency Range	0%	19%	12%	24%	43%	0%	23%	79%	11%	44%	0%	0%
2020	Base Miscellaneous	33%	2%	0%	13%	0%	0%	0%	10%	10%	0%	0%	0%
2030	Base Whole Building	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2031	Retrocommissioning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2100	Base Building Design - Standard Code	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
2101	15% better than code - Campuses	30%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2102	15% better than code - Education	0%	30%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2103	15% better than code - Food Sales	0%	0%	30%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2104	15% better than code - Food Service	0%	0%	0%	30%	0%	0%	0%	0%	0%	0%	0%	0%
2105	15% better than code - Healthcare	0%	0%	0%	0%	30%	30%	0%	0%	0%	0%	0%	0%
2106	15% better than code - Lodging	0%	0%	0%	0%	0%	0%	30%	0%	0%	0%	0%	0%
2107	15% better than code - Office	0%	0%	0%	0%	0%	0%	0%	30%	0%	0%	0%	0%
2108	15% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	30%	0%	0%	0%
2109	15% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	30%	0%	0%
2110	15% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	30%	0%
2111	15% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	30%
2112	Commissioning	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
2120	Base Building Design - Standard Code	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
2121	30% better than code - Campuses	12%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2122	30% better than code - Education	0%	12%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2123	30% better than code - Food Sales	0%	0%	12%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2124	30% better than code - Food Service	0%	0%	0%	12%	0%	0%	0%	0%	0%	0%	0%	0%
2125	30% better than code - Healthcare	0%	0%	0%	0%	12%	12%	0%	0%	0%	0%	0%	0%
2126	30% better than code - Lodging	0%	0%	0%	0%	0%	0%	12%	0%	0%	0%	0%	0%
2127	30% better than code - Office	0%	0%	0%	0%	0%	0%	0%	12%	0%	0%	0%	0%
2128	30% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	12%	0%	0%	0%
2129	30% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	12%	0%	0%
2130	30% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	12%	0%
2131	30% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	12%
2132	Commissioning	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
2140	Base Building Design - Standard Code	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
2141	50% better than code - Campuses	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2142	50% better than code - Education	0%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2143	50% better than code - Food Sales	0%	0%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2144	50% better than code - Food Service	0%	0%	0%	6%	0%	0%	0%	0%	0%	0%	0%	0%
2145	50% better than code - Healthcare	0%	0%	0%	0%	6%	6%	0%	0%	0%	0%	0%	0%
2146	50% better than code - Lodging	0%	0%	0%	0%	0%	0%	6%	0%	0%	0%	0%	0%
2147	50% better than code - Office	0%	0%	0%	0%	0%	0%	0%	6%	0%	0%	0%	0%
2148	50% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	6%	0%	0%	0%
2149	50% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	0%	0%
2150	50% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	0%
2151	50% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%
2152	Commissioning	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
2160	Base Building Design - Standard Code	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
2161	70% better than code - Campuses	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2162	70% better than code - Education	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2163	70% better than code - Food Sales	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2164	70% better than code - Food Service	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%
2165	70% better than code - Healthcare	0%	0%	0%	0%	2%	2%	0%	0%	0%	0%	0%	0%
2166	70% better than code - Lodging	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%
2167	70% better than code - Office	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%
2168	70% better than code - Other	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%
2169	70% better than code - Public Assembly	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%
2170	70% better than code - Retail	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%
2171	70% better than code - Warehouse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%
2172	Commissioning	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%

Commercial Gas Measure Inputs		APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)											
Measure #	Measure Description	College/University	Education	Food Sales	Food Service	Healthcare	Hospital	Lodging	Office	Other	Public Assembly	Retail	Warehouse
2200	Base Boiler	47%	48%	0%	1%	39%	50%	25%	12%	9%	46%	19%	0%
2201	High Efficiency Windows (Multiple Glazed, Low Emissivity)	35%	14%	0%	1%	0%	1%	4%	3%	2%	12%	9%	0%
2207	Programmable communicating thermostat	12%	12%	0%	0%	10%	13%	6%	3%	2%	12%	5%	0%
2208	Installation of Energy Management Systems (EMS)	16%	13%	0%	1%	27%	34%	20%	5%	6%	30%	15%	0%
2209	Installation of Air Side Heat Recovery Systems	42%	28%	0%	1%	35%	45%	12%	11%	4%	23%	17%	0%
2210	High Efficiency Non-Condensing Boiler 89% efficiency	41%	37%	0%	1%	37%	45%	22%	10%	7%	40%	16%	0%
2211	High Efficiency Condensing Boiler 95% efficiency	33%	48%	0%	1%	38%	36%	18%	10%	6%	2%	13%	0%
2212	Stack Heat Exchanger	38%	41%	0%	1%	31%	40%	21%	10%	7%	39%	16%	0%
2213	Boiler Controls	37%	39%	0%	1%	31%	40%	20%	10%	7%	37%	15%	0%
2214	Hot water temperature reset	9%	10%	0%	0%	8%	10%	5%	2%	2%	9%	4%	0%
2215	Demand controlled ventilation (DCV)	42%	43%	0%	1%	35%	45%	23%	11%	8%	41%	17%	0%
2216	Refrigeration heat recovery - space conditioning	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2220	Base Furnace	0%	3%	26%	35%	3%	0%	3%	10%	4%	26%	13%	40%
2221	High Efficiency Windows (Multiple Glazed, Low Emissivity)	0%	1%	9%	21%	0%	0%	0%	2%	1%	7%	6%	30%
2227	Programmable communicating thermostat	0%	1%	7%	9%	1%	0%	1%	2%	1%	7%	3%	10%
2228	Installation of Energy Management Systems (EMS)	0%	1%	17%	34%	2%	0%	2%	4%	3%	17%	11%	39%
2229	Installation of Air Side Heat Recovery Systems	0%	2%	20%	27%	2%	0%	1%	9%	2%	13%	12%	28%
2230	High Efficiency (Power Burner/ Premium) Furnace 95% efficiency	0%	3%	25%	33%	2%	0%	3%	9%	4%	26%	13%	38%
2231	Stack Heat Exchanger	0%	3%	23%	30%	2%	0%	2%	8%	4%	22%	11%	34%
2232	Demand controlled ventilation (DCV)	0%	3%	24%	31%	2%	0%	3%	9%	4%	24%	12%	36%
2233	Refrigeration heat recovery - space conditioning	0%	0%	26%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2240	Base Other Heat	1%	21%	15%	2%	39%	36%	34%	8%	20%	46%	14%	49%
2241	Condensing unit heaters	0%	5%	4%	0%	10%	9%	8%	2%	5%	11%	3%	12%
2242	Radiant heater	1%	10%	7%	1%	19%	17%	16%	4%	10%	22%	6%	23%
2250	Base Water Heating - high standby loss (as % of load)	50%	50%	18%	0%	0%	0%	47%	31%	4%	48%	21%	0%
2252	Demand controlled circulating systems - high standby loss (as % of load)	23%	46%	18%	0%	0%	0%	5%	27%	4%	47%	20%	0%
2253	Tankless Water Heater - high standby loss applications	47%	46%	17%	0%	0%	0%	32%	29%	4%	47%	20%	0%
2260	Base Water Heating - low standby loss (as % of load)	0%	0%	18%	40%	45%	0%	0%	0%	0%	0%	0%	0%
2262	Demand controlled circulating systems - low standby loss (as % of load)	0%	0%	18%	40%	42%	0%	0%	0%	0%	0%	0%	0%
2263	Condensing Water Heater (gas, 95% thermal efficiency)	0%	0%	12%	39%	29%	0%	0%	0%	0%	0%	0%	0%
2264	Pre-Rinse Spray Valve, 1.28 gpm or less (base 1.6 gpm)	0%	0%	3%	6%	7%	0%	0%	0%	0%	0%	0%	0%
2270	Base Cooking - Fryer	0%	0%	10%	23%	0%	33%	13%	36%	10%	1%	0%	0%
2271	Energy Star Fryer	0%	0%	9%	21%	0%	31%	12%	33%	10%	1%	0%	0%
2280	Base Cooking - Steamer	0%	19%	0%	6%	33%	33%	5%	37%	8%	0%	0%	0%
2281	Energy Star Steamer	0%	12%	0%	4%	22%	22%	3%	24%	5%	0%	0%	0%
2290	Base Cooking - Oven	0%	28%	13%	24%	42%	33%	9%	38%	8%	2%	2%	0%
2291	High-Efficiency Convection Oven	0%	9%	3%	6%	3%	7%	2%	12%	2%	0%	0%	0%
2292	Conveyor Oven	0%	7%	3%	6%	11%	9%	2%	10%	2%	0%	1%	0%
2293	Combination Oven	0%	7%	3%	6%	11%	9%	2%	10%	2%	0%	1%	0%
2300	Base Cooking - Griddle	0%	0%	2%	19%	9%	36%	5%	13%	8%	1%	0%	0%
2301	High-Efficiency Griddle	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2310	Base Cooking - Range	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2311	High-Efficiency Range	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2320	Base Miscellaneous	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

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Industrial Electric Measure Inputs		BASE TECHNOLOGY EUIs (kWh/square foot)
Measure #	Measure Description	All Industrial Building Type 1
1000	Base Compressed Air	1.4
1050	Base Non-Cycling refrigerated air dryer	0.0
1100	Base <5 HP drive/fan/motor	1.2
1120	Base 6-20 HP drive/fan/motor	2.8
1140	Base 21-50 HP drive/fan/motor	1.2
1160	Base 51-100 HP drive/fan/motor	5.0
1180	Base 100+ HP drive/fan/motor	18.8
1190	Base Pumps	16.9
1200	Base Process Heating	24.7
1230	Base Process Cooling	4.6
1260	Base Other Process	44.2
1300	Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	1.1
1350	Base DX Packaged System, EER=10.3, 10 tons	1.1
1400	Base Ventilation	0.7
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	1.7
1520	Base Other Fluorescent Fixture	0.3
1540	Base Metal Halide, 400W	1.4
1560	Base Outdoor High Pressure Sodium 250W Lamp	0.4
1600	Base Other	1.1
1700	Base Whole Building	18.7
1000	Base Compressed Air	1.4
1050	Base Non-Cycling refrigerated air dryer	0.0
1100	Base <5 HP drive/fan/motor	1.2
1120	Base 6-20 HP drive/fan/motor	2.8
1140	Base 21-50 HP drive/fan/motor	1.2
1160	Base 51-100 HP drive/fan/motor	5.0
1180	Base 100+ HP drive/fan/motor	18.8
1190	Base Pumps	16.9
1200	Base Process Heating	24.75
1230	Base Process Cooling	4.56
1260	Base Other Process	44.18
1300	Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	1.12
1350	Base DX Packaged System, EER=10.3, 10 tons	1.12
1400	Base Ventilation	0.74

Industrial Electric Measure Inputs		**BASE TECHNOLOGY EUIs (kWh/square foot)**
		All Industrial
Measure #	Measure Description	Building Type 1
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	1.67
1520	Base Other Fluorescent Fixture	0.27
1540	Base Metal Halide, 400W	1.35
1560	Base Outdoor High Pressure Sodium 250W Lamp	0.40
1600	Base Other	1.09

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Industrial Electric Measure Inputs		BASE TECHNOLOGY EUIs / DEMAND (kW/square foot)
		All Industrial
Measure #	Measure Description	Building Type 1
1000	Base Compressed Air	0.000168
1050	Base Non-Cycling refrigerated air dryer	0.000006
1100	Base <5 HP drive/fan/motor	0.000145
1120	Base 6-20 HP drive/fan/motor	0.000354
1140	Base 21-50 HP drive/fan/motor	0.000151
1160	Base 51-100 HP drive/fan/motor	0.000622
1180	Base 100+ HP drive/fan/motor	0.002341
1190	Base Pumps	0.002110
1200	Base Process Heating	0.003084
1230	Base Process Cooling	0.000568
1260	Base Other Process	0.005505
1300	Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	0.000139
1350	Base DX Packaged System, EER=10.3, 10 tons	0.000139
1400	Base Ventilation	0.000093
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	0.000209
1520	Base Other Fluorescent Fixture	0.000033
1540	Base Metal Halide, 400W	0.000169
1560	Base Outdoor High Pressure Sodium 250W Lamp	0.000050
1600	Base Other	0.000136
1700	Base Whole Building	0.002326
1000	Base Compressed Air	0.000168
1050	Base Non-Cycling refrigerated air dryer	0.000006
1100	Base <5 HP drive/fan/motor	0.000145
1120	Base 6-20 HP drive/fan/motor	0.000354
1140	Base 21-50 HP drive/fan/motor	0.000151
1160	Base 51-100 HP drive/fan/motor	0.000622
1180	Base 100+ HP drive/fan/motor	0.002341
1190	Base Pumps	0.002110
1200	Base Process Heating	0.003084
1230	Base Process Cooling	0.000568
1260	Base Other Process	0.005505
1300	Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	0.000139
1350	Base DX Packaged System, EER=10.3, 10 tons	0.000139
1400	Base Ventilation	0.000093

Industrial Electric Measure Inputs		**BASE TECHNOLOGY EUIs / DEMAND (kW/square foot)**
		All Industrial
Measure #	Measure Description	Building Type 1
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	0.000209
1520	Base Other Fluorescent Fixture	0.000033
1540	Base Metal Halide, 400W	0.000169
1560	Base Outdoor High Pressure Sodium 250W Lamp	0.000050
1600	Base Other	0.000136

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Industrial Electric Measure Costs

Measure #	Measure Description	First Year	End Year	Savings Units	Cost Units	Unit Equipment Cost	Unit Labor Costs	NPV of Lifetime O&M Cost	Implementation Cost Factor	Implementation Type (RET/ROB)	Initial Cost	Replacement Cost	Measure File Service Life (Yrs)	Full Per Unit Cost
1000	Base Compressed Air	2015	2054	sqft					$0.00	RET	1	1	13.00	$0.00
1001	Compressed Air-Leak Reduction/ Maintenance	2015	2054	sqft	facility	$31,683.00			$31,683.00	RET	1	1	1.00	$31,683.00
1002	Compressed Air- Cold Air Intake	2015	2054	sqft	facility	$1,600.00			$1,600.00	RET	1	1	13.00	$1,600.00
1003	Compressed Air - Controls	2015	2054	sqft	facility	$17,000.00			$17,000.00	RET	1	1	10.00	$17,000.00
1004	Compressed Air - System Optimization	2015	2054	sqft	facility	$2,300.00			$2,300.00	RET	1	1	13.00	$2,300.00
1006	Air compressor zero-loss drains	2015	2054	sqft	unit	$488.00			$488.00	RET	1	1	13.00	$488.00
1007	Compressed Air Low Pressure Drop Filters	2015	2054	sqft	HP	$4.60			$4.60	RET	1	1	3.00	$4.60
1008	High Efficiency Air Compressors	2015	2054	sqft	HP	$200.00			$200.00	ROB	1	1	13.00	$200.00
1009	Custom Compressed Air	2015	2054	sqft	kWh saved	$0.35			$0.35	ROB	1	1	25.00	$0.35
1050	Base Non-Cycling refrigerated air dryer	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
1051	Cycling refrigerated dryer	2015	2054	sqft	CFM	$6.54			$6.54	RET	1	1	15.00	$6.54
1100	Base <5 HP drive/fan/motor	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
1101	Replace 1-5 HP motor	2015	2054	sqft	HP	$208.00			$208.00	ROB	1	1	15.00	$208.00
1102	Variable Speed Drive Control, <5 HP	2015	2054	sqft	HP	$450.00			$450.00	RET	1	1	10.00	$450.00
1103	Motors - Maintenance (Cost is for predictive maintenance) (<5 HP)	2015	2054	sqft	HP	$9.00			$9.00	RET	1	1	1.00	$9.00
1104	Motors- System Optimization and sizing (<5 HP)	2015	2054	sqft	HP	$160.00			$160.00	RET	1	1	15.00	$160.00
1120	Base 6-20 HP drive/fan/motor	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
1121	Replace 6-20 HP motor	2015	2054	sqft	HP	$104.00			$104.00	ROB	1	1	15.00	$104.00
1122	Variable Speed Drive Control, (6-20 hp)	2015	2054	sqft	HP	$221.00			$221.00	RET	1	1	10.00	$221.00
1123	Motors - Maintenance (Cost is for predictive maintenance), (6-20 hp)	2015	2054	sqft	HP	$9.00			$9.00	RET	1	1	1.00	$9.00
1124	Motors- System Optimization and sizing, (6-20 hp)	2015	2054	sqft	HP	$160.00			$160.00	RET	1	1	15.00	$160.00
1125	Custom Measures--Drives, (6-20 hp)	2015	2054	sqft	kWh saved	$0.37	$0.00	$0.00	$0.37	ROB	1	1	15.00	$0.37
1140	Base 21-50 HP drive/fan/motor	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
1141	Replace 21-50 HP motor	2015	2054	sqft	HP	$99.00			$99.00	ROB	1	1	15.00	$99.00
1142	Variable speed drive control (21-50 hp)	2015	2054	sqft	HP	$153.00			$153.00	RET	1	1	10.00	$153.00
1143	Motors - Maintenance (Cost is for predictive maintenance) (21-50 hp)	2015	2054	sqft	HP	$9.00			$9.00	RET	1	1	1.00	$9.00
1144	Motors- System Optimization and sizing (21-50 hp)	2015	2054	sqft	HP	$160.00			$160.00	RET	1	1	15.00	$160.00
1145	Custom Measures--Drives (21-50 hp)	2015	2054	sqft	kWh saved	$0.37	$0.00	$0.00	$0.37	ROB	1	1	15.00	$0.37
1160	Base 51-100 HP drive/fan/motor	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
1161	Replace 51-100 HP motor	2015	2054	sqft	HP	$104.00			$104.00	ROB	1	1	15.00	$104.00
1162	Variable speed drive control (51-100 hp)	2015	2054	sqft	HP	$114.00			$114.00	RET	1	1	10.00	$114.00
1163	Motors - Maintenance (Cost is for predictive maintenance) (51-100 hp)	2015	2054	sqft	HP	$9.00			$9.00	RET	1	1	1.00	$9.00
1164	Motors- System Optimization and sizing (51-100 hp)	2015	2054	sqft	HP	$160.00			$160.00	RET	1	1	15.00	$160.00
1165	Custom Measures--Drives (51-100 hp)	2015	2054	sqft	kWh saved	$0.37	$0.00	$0.00	$0.37	ROB	1	1	15.00	$0.37
1180	Base 100+ HP drive/fan/motor	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
1181	Replace 100+ HP motor	2015	2054	sqft	HP	$111.00			$111.00	ROB	1	1	15.00	$111.00
1182	Variable speed drive control (100+ hp)	2015	2054	sqft	HP	$88.00			$88.00	RET	1	1	10.00	$88.00
1183	Motors - Maintenance (Cost is for predictive maintenance) (100+ hp)	2015	2054	sqft	HP	$9.00			$9.00	RET	1	1	1.00	$9.00
1184	Motors- System Optimization and sizing (100+ hp)	2015	2054	sqft	HP	$160.00			$160.00	RET	1	1	15.00	$160.00
1185	Custom Measures--Drives (100+ hp)	2015	2054	sqft	kWh saved	$0.37	$0.00	$0.00	$0.37	ROB	1	1	15.00	$0.37
1190	Base Pumps	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
1191	Replace motor (pumps)	2015	2054	unit	HP	$104.00			$104.00	ROB	1	1	15.00	$104.00
1192	Variable speed drive (pumps)	2015	2054	unit	HP	$117.00			$117.00	RET	1	1	10.00	$117.00
1193	Pump system maintenence (coating, mechanical refurbishment, flow paths, pressure switches)	2015	2054	sqft	HP	$120.00			$120.00	RET	1	1	10.00	$120.00
1194	Correct sizing of pumps	2015	2054	sqft	HP	$300.00			$300.00	RET	1	1	20.00	$300.00
1195	Trim or change impeller	2015	2054	sqft	HP	$85.00			$85.00	RET	1	1	8.00	$85.00
1196	Water/Wastewater Custom Projects	2015	2054	facility	kWh saved	$0.99	$0.00	$0.00	$0.99	ROB	1	1	20.00	$0.99
1200	Base Process Heating	2015	2054	sqft	base kWh				$0.00	RET	1	1	15.00	$0.00
1201	Custom Measures--Process Heating	2015	2054	sqft	kWh saved	$0.76	$0.00	$0.00	$0.76	ROB	1	1	15.00	$0.76
1230	Base Process Cooling	2015	2054	sqft	base kWh				$0.00	RET	1	1	15.00	$0.00
1231	Custom Measures--Process Cooling	2015	2054	sqft	kWh saved	$1.00	$0.00	$0.00	$1.00	ROB	1	1	16.00	$1.00
1260	Base Other Process	2015	2054	sqft					$0.00	RET	1	1	10.00	$0.00
1266	Electric Drive Injection Molder (Plastics)	2015	2054	unit	ton	$883.00			$883.00	RET	1	1	10.00	$883.00
1267	Efficient Hybrid/Servo Drive Injection Molder (Plastics)	2015	2054	unit	ton	$565.00			$565.00	RET	1	1	10.00	$565.00
1268	Barrel Insulation on Injection Molder (Plastics)	2015	2054	unit	kWh saved	$0.79			$0.79	RET	1	1	10.00	$0.79
1269	Custom Measures--Other Process	2015	2054	sqft	kWh saved	$0.66	$0.00	$0.00	$0.66	ROB	1	1	15.00	$0.66
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	2015	2054	sqft	ton	$240.00			$240.00	ROB	1	1	23.00	$240.00
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	2015	2054	sqft	ton	$122.00			$122.00	ROB	1	1	23.00	$122.00
1302	Cool Roof - Chiller	2015	2054	sqft	sf-roof	$8.45			$8.45	ROB	1	1	15.00	$8.45
1304	VSD for Chiller Pumps and Towers	2015	2054	sqft	HP	$175.44			$175.44	RET	1	1	15.00	$175.44
1350	Base DX Packaged System, EER=10.0, 30 tons	2015	2054	sqft	ton	$672.40			$672.40	ROB	1	1	15.00	$672.40
1351	ROB DX Packaged System, EER=10.8, 30 tons	2015	2054	sqft	ton	$37.83			$37.83	ROB	1	1	15.00	$37.83

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Industrial Electric Measure Costs

Measure #	Measure Description	First Year	End Year	Savings Units	Cost Units	Unit Equipment Cost	Unit Labor Costs	NPV of Lifetime O&M Cost	Implementation Cost Factor	Implementation Type (RET/ROB)	Initial Cost	Replacement Cost	Measure File Service Life (Yrs)	Full Per Unit Cost
1352	ROB DX Packaged System, EER=11.7, 30 tons	2015	2054	sqft	ton	$93.42			$93.42	ROB	1	1	15.00	$93.42
1354	Automated Fault Detection	2015	2054	sqft	unit	$300.00			$300.00	RET	1	1	15.00	$300.00
1355	Advanced Controllers for RTUs	2015	2054	sqft	unit	$2,600.00	$750.00		$3,350.00	RET	1	1	10.00	$3,350.00
1356	Cool Roof - DX	2015	2054	sqft	sf-roof	$8.45			$8.45	RET	1	1	15.00	$8.45
1357	RTU VSD	2015	2054	sqft	unit	$2,125.00			$2,125.00	RET	1	1	10.00	$2,125.00
1358	Dual Enthalpy Economizer Controls	2015	2054	sqft	unit	$800.00			$800.00	RET	1	1	10.00	$800.00
1360	Aerosol Duct Sealing	2015	2054	sqft	ton	$338.00			$338.00	RET	1	1	18.00	$338.00
1400	Base Ventilation	2015	2054	sqft	unit	$0.00			$0.00		1	1	10.00	$0.00
1401	Demand Controlled Ventilation	2015	2054	sqft	unit	$2,100.00			$2,100.00	RET	1	1	10.00	$2,100.00
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	2015	2054	sqft					$0.00	RET	1	1	13.00	$0.00
1501	RET 4L4' Low Watt High Performance T8 (83 W)	2015	2054	sqft	fixture	$60.00			$60.00	RET	1	1	13.00	$60.00
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	2015	2054	sqft	fixture	$25.00			$25.00	ROB	1	1	24,000.00	$25.00
1503	RET 4L4' LED Tube	2015	2054	sqft	fixture	$67.14			$67.14	RET	1	1	13.00	$67.14
1504	Upstream 4L4' LED Tube	2015	2054	sqft	fixture	$32.14			$32.14	ROB	1	1	10.00	$32.14
1505	RET LED Troffer (base 4L4'T8)	2015	2054	sqft	fixture	$87.50			$87.50	RET	1	1	13.00	$87.50
1506	Occupancy Sensor, 4L4' Fluorescent Fixtures	2015	2054	sqft	fixture	$45.00			$45.00	RET	1	1	9.00	$45.00
1507	Advanced Lighting Controls	2015	2054	sqft	sq ft	$0.75			$0.75	RET	1	1	9.00	$0.75
1508	Daylight Dimming Controls	2015	2054	sqft	last controlled	$100.00			$100.00	RET	1	1	9.00	$100.00
1520	Base Other Fluorescent Fixture	2015	2054	sqft					$0.00	RET	1	1	13.00	$0.00
1521	RET Low Watt High Performance T8 (Base Other Fluorescent)	2015	2054	sqft	fixture	$60.00			$60.00	RET	1	1	13.00	$60.00
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	2015	2054	sqft	fixture	$25.00			$25.00	ROB	1	1	24,000.00	$25.00
1523	RET LED Tube (Base Other Fluorescent)	2015	2054	sqft	fixture	$67.14			$67.14	RET	1	1	13.00	$67.14
1524	Upstream LED Tube (Base Other Fluorescent)	2015	2054	sqft	fixture	$42.64			$32.14	ROB	1	1	10.00	$42.64
1525	RET LED Troffer (Base Other Fluorescent)	2015	2054	sqft	fixture	$87.50			$87.50	RET	1	1	13.00	$87.50
1526	Occupancy Sensor (Base Other Fluorescent)	2015	2054	sqft	fixture	$45.00			$45.00	RET	1	1	9.00	$45.00
1527	Advanced Lighting Controls (Base Other Fluorescent)	2015	2054	sqft	sq ft	$0.75			$0.75	RET	1	1	9.00	$0.75
1528	Daylight Dimming Controls (Base Other Fluorescent)	2015	2054	sqft	last controlled	$100.00			$100.00	RET	1	1	9.00	$100.00
1540	Base Metal Halide, 400W	2015	2054	sqft					$0.00	RET	1	1	18.00	$0.00
1541	High Bay T5 HO (240W)	2015	2054	sqft	fixture	$100.00	$0.00		$100.00	RET	1	1	13.00	$100.00
1542	High Bay Induction Lighting	2015	2054	sqft	fixture	$480.00	$60.00		$540.00	RET	1	1	20.00	$540.00
1543	PSMH with electronic ballast	2015	2054	sqft	fixture	$144.00	$60.00		$204.00	RET	1	1	16.00	$204.00
1544	High Bay LED Lighting	2015	2054	sqft	fixture	$200.00			$200.00	RET	1	1	35,000.00	$200.00
1560	Base Outdoor High Pressure Sodium 250W Lamp	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
1561	LED Outdoor Area Lighting (other than pole-mounted)	2015	2054	sqft	fixture	$120.00			$120.00	RET	1	1	18.00	$120.00
1600	Base Other	2015	2054	sqft					$0.00	RET	1	1	10.00	$0.00
1700	Base Whole Building	2015	2054	sqft					$0.00	RET	1	1	20.00	$0.00
1701	Energy management Program- Resource Conservation Manager (outside consultant)	2015	2054	sqft	facility	$40,000.00	$40,000.00		$80,000.00	RET	1	1	1.00	$80,000.00
1702	Superior energy performance certification	2015	2054	sqft	facility	$105,000.00	$214,000.00		$319,000.00	RET	1	1	3.00	$319,000.00
1000	Base Compressed Air	2015	2054	sqft					$0.00	New	1	1	13.00	$0.00
1008	High Efficiency Air Compressors	2015	2054	sqft	HP	$164.00			$164.00	New	1	1	13.00	$164.00
1009	Custom Compressed Air	2015	2054	sqft	kWh saved	$0.35			$0.35	New	1	1	25.00	$0.35
1050	Base Non-Cycling refrigerated air dryer	2015	2054	sqft					$0.00	New	1	1	15.00	$0.00
1100	Base <5 HP drive/fan/motor	2015	2054	sqft					$0.00	New	1	1	15.00	$0.00
1120	Base 6-20 HP drive/fan/motor	2015	2054	sqft					$0.00	New	1	1	15.00	$0.00
1125	Custom Measures--Drives, (6-20 hp)	2015	2054	sqft	kWh saved	$0.37	$0.00	$0.00	$0.37	New	1	1	15.00	$0.37
1140	Base 21-50 HP drive/fan/motor	2015	2054	sqft					$0.00	New	1	1	15.00	$0.00
1145	Custom Measures--Drives (21-50 hp)	2015	2054	sqft	kWh saved	$0.37	$0.00	$0.00	$0.37	New	1	1	15.00	$0.37
1160	Base 51-100 HP drive/fan/motor	2015	2054	sqft					$0.00	New	1	1	15.00	$0.00
1165	Custom Measures--Drives (51-100 hp)	2015	2054	sqft	kWh saved	$0.37	$0.00	$0.00	$0.37	New	1	1	15.00	$0.37
1180	Base 100+ HP drive/fan/motor	2015	2054	sqft					$0.00	New	1	1	15.00	$0.00
1185	Custom Measures--Drives (100+ hp)	2015	2054	sqft	kWh saved	$0.37	$0.00	$0.00	$0.37	New	1	1	15.00	$0.37
1190	Base Pumps	2015	2054	sqft					$0.00	New	1	1	15.00	$0.00
1196	Water/Wastewater Custom Projects	2015	2054	facility	kWh saved	$0.99	$0.00	$0.00	$0.99	New	1	1	20.00	$0.99
1200	Base Process Heating	2015	2054	sqft	base kWh				$0.00	New	1	1	15.00	$0.00
1201	Custom Measures--Process Heating	2015	2054	sqft	kWh saved	$0.76	$0.00	$0.00	$0.76	New	1	1	15.00	$0.76
1230	Base Process Cooling	2015	2054	sqft	base kWh				$0.00	New	1	1	15.00	$0.00
1231	Custom Measures--Process Cooling	2015	2054	sqft	kWh saved	$1.00	$0.00	$0.00	$1.00	New	1	1	16.00	$1.00
1260	Base Other Process	2015	2054	sqft					$0.00	New	1	1	10.00	$0.00
1269	Custom Measures--Other Process	2015	2054	sqft	kWh saved	$0.66	$0.00	$0.00	$0.66	New	1	1	15.00	$0.66
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	2015	2054	sqft	ton	$220.00			$220.00	New	1	1	23.00	$220.00
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	2015	2054	sqft	ton	$48.00			$48.00	New	1	1	23.00	$48.00
1302	Cool Roof - Chiller	2015	2054	sqft	sf-roof	$8.45			$8.45	New	1	1	15.00	$8.45

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Industrial Electric Measure Costs

Measure #	Measure Description	First Year	End Year	Savings Units	Cost Units	Unit Equipment Cost	Unit Labor Costs	NPV of Lifetime O&M Cost	Implementation Cost Factor	Implementation Type (RET/ROB)	Initial Cost	Replacement Cost	Measure File Service Life (Yrs)	Full Per Unit Cost
1350	Base DX Packaged System, EER=10.0, 30 tons	2015	2054	sqft	ton	$672.40			$672.40	New	1	1	15.00	$672.40
1351	ROB DX Packaged System, EER=10.8, 30 tons	2015	2054	sqft	ton	$37.83			$37.83	New	1	1	15.00	$37.83
1352	ROB DX Packaged System, EER=11.7, 30 tons	2015	2054	sqft	ton	$93.42			$93.42	New	1	1	15.00	$93.42
1353	Automated Fault Detection	2015	2054	sqft	unit	$300.00			$300.00	New	1	1	15.00	$300.00
1354	VRF Conditioning Systems	2015	2054	sqft	sqft	$24.20			$24.20	New	1	1	15.00	$24.20
1400	Base Ventilation	2015	2054	sqft						New		1	10.00	
1401	Demand Controlled Ventilation	2015	2054	sqft	unit	$2,100.00			$2,100.00	RET	1	1	10.00	$2,100.00
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	2015	2054	sqft					$0.00	New	1	1	13.00	$0.00
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	2015	2054	sqft	fixture	$25.00			$25.00	New	1	1	10.00	$25.00
1504	Upstream 4L4' LED Tube	2015	2054	sqft	fixture	$32.14			$32.14	New	1	1	10.00	$32.14
1520	Base Other Fluorescent Fixture	2015	2054	sqft					$0.00	New	1	1	13.00	$0.00
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	2015	2054	sqft	fixture	$25.00			$25.00	New	1	1	10.00	$25.00
1524	Upstream LED Tube (Base Other Fluorescent)	2015	2054	sqft	fixture	$42.64			$42.64	New	1	1	10.00	$42.64
1540	Base Metal Halide, 400W	2015	2054	sqft					$0.00	New	1	1	18.00	$0.00
1560	Base Outdoor High Pressure Sodium 250W Lamp	2015	2054	sqft					$0.00	New	1	1	15.00	$0.00
1600	Base Other	2015	2054	sqft					0	New	1	1	10.00	$0.00

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Industrial Electric Measure Inputs		APPLICABILITY FACTOR (percent)
Measure #	Measure Description	All Industrial Building Type 1
1000	Base Compressed Air	63.6%
1001	Compressed Air-Leak Reduction/ Maintenance	63.6%
1002	Compressed Air- Cold Air Intake	63.6%
1003	Compressed Air - Controls	63.6%
1004	Compressed Air - System Optimization	63.6%
1006	Air compressor zero-loss drains	63.6%
1007	Compressed Air Low Pressure Drop Filters	63.6%
1008	High Efficiency Air Compressors	63.6%
1009	Custom Compressed Air	63.6%
1050	Base Non-Cycling refrigerated air dryer	24.6%
1051	Cycling refrigerated dryer	24.6%
1100	Base <5 HP drive/fan/motor	35.0%
1101	Replace 1-5 HP motor	35.0%
1102	Variable Speed Drive Control, <5 HP	35.0%
1103	Motors - Maintenance (Cost is for predictive maintenance) (<5 HP)	35.0%
1104	Motors- System Optimization and sizing (<5 HP)	35.0%
1120	Base 6-20 HP drive/fan/motor	32.1%
1121	Replace 6-20 HP motor	32.1%
1122	Variable Speed Drive Control, (6-20 hp)	32.1%
1123	Motors - Maintenance (Cost is for predictive maintenance), (6-20 hp)	32.1%
1124	Motors- System Optimization and sizing, (6-20 hp)	32.1%
1125	Custom Measures--Drives, (6-20 hp)	32.1%
1140	Base 21-50 HP drive/fan/motor	8.1%
1141	Replace 21-50 HP motor	8.1%
1142	Variable speed drive control (21-50 hp)	8.1%
1143	Motors - Maintenance (Cost is for predictive maintenance) (21-50 hp)	8.1%
1144	Motors- System Optimization and sizing (21-50 hp)	8.1%
1145	Custom Measures--Drives (21-50 hp)	8.1%
1160	Base 51-100 HP drive/fan/motor	14.9%
1161	Replace 51-100 HP motor	14.9%
1162	Variable speed drive control (51-100 hp)	14.9%
1163	Motors - Maintenance (Cost is for predictive maintenance) (51-100 hp)	14.9%
1164	Motors- System Optimization and sizing (51-100 hp)	14.9%
1165	Custom Measures--Drives (51-100 hp)	14.9%

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Industrial Electric Measure Inputs		APPLICABILITY FACTOR (percent)
Measure #	Measure Description	All Industrial Building Type 1
1180	Base 100+ HP drive/fan/motor	20.4%
1181	Replace 100+ HP motor	20.4%
1182	Variable speed drive control (100+ hp)	20.4%
1183	Motors - Maintenance (Cost is for predictive maintenance) (100+ hp)	20.4%
1184	Motors- System Optimization and sizing (100+ hp)	20.4%
1185	Custom Measures--Drives (100+ hp)	20.4%
1190	Base Pumps	15.0%
1191	Replace motor (pumps)	15.0%
1192	Variable speed drive (pumps)	15.0%
1193	Pump system maintenence (coating, mechanical refurbishment, flow paths, pressure switches)	15.0%
1194	Correct sizing of pumps	15.0%
1195	Trim or change impeller	15.0%
1196	Water/Wastewater Custom Projects	7.5%
1200	Base Process Heating	8.3%
1201	Custom Measures--Process Heating	8.3%
1230	Base Process Cooling	29.5%
1231	Custom Measures--Process Cooling	29.5%
1260	Base Other Process	4.7%
1266	Electric Drive Injection Molder (Plastics)	1.9%
1267	Efficient Hybrid/Servo Drive Injection Molder (Plastics)	1.9%
1268	Barrel Insulation on Injection Molder (Plastics)	1.9%
1269	Custom Measures--Other Process	4.7%
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	50.8%
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	50.8%
1302	Cool Roof - Chiller	50.8%
1304	VSD for Chiller Pumps and Towers	50.8%
1350	Base DX Packaged System, EER=10.0, 30 tons	19.1%
1351	ROB DX Packaged System, EER=10.8, 30 tons	19.1%
1352	ROB DX Packaged System, EER=11.7, 30 tons	19.1%
1354	Automated Fault Detection	19.1%
1355	Advanced Controllers for RTUs	19.1%
1356	Cool Roof - DX	19.1%
1357	RTU VSD	19.1%
1358	Dual Enthalpy Economizer Controls	19.1%

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Industrial Electric Measure Inputs		APPLICABILITY FACTOR (percent)
Measure #	Measure Description	All Industrial Building Type 1
1360	Aerosol Duct Sealing	19.1%
1400	Base Ventilation	100.0%
1401	Demand Controlled Ventilation	100.0%
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	41.1%
1501	RET 4L4' Low Watt High Performance T8 (83 W)	12.3%
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	28.8%
1503	RET 4L4' LED Tube	12.3%
1504	Upstream 4L4' LED Tube	28.8%
1505	RET LED Troffer (base 4L4'T8)	12.3%
1506	Occupancy Sensor, 4L4' Fluorescent Fixtures	41.1%
1507	Advanced Lighting Controls	41.1%
1508	Daylight Dimming Controls	41.1%
1520	Base Other Fluorescent Fixture	17.1%
1521	RET Low Watt High Performance T8 (Base Other Fluorescent)	5.1%
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	11.9%
1523	RET LED Tube (Base Other Fluorescent)	5.1%
1524	Upstream LED Tube (Base Other Fluorescent)	11.9%
1525	RET LED Troffer (Base Other Fluorescent)	5.1%
1526	Occupancy Sensor (Base Other Fluorescent)	17.1%
1527	Advanced Lighting Controls (Base Other Fluorescent)	17.1%
1528	Daylight Dimming Controls (Base Other Fluorescent)	17.1%
1540	Base Metal Halide, 400W	16.4%
1541	High Bay T5 HO (240W)	16.4%
1542	High Bay Induction Lighting	16.4%
1543	PSMH with electronic ballast	16.4%
1544	High Bay LED Lighting	16.4%
1560	Base Outdoor High Pressure Sodium 250W Lamp	47.2%
1561	LED Outdoor Area Lighting (other than pole-mounted)	47.2%
1600	Base Other	100.0%
1700	Base Whole Building	100.0%
1701	Energy management Program- Resource Conservation Manager (outside consultant)	10.0%
1702	Superior energy performance certification	10.0%
1000	Base Compressed Air	63.6%
1008	High Efficiency Air Compressors	63.6%

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Industrial Electric Measure Inputs Measure #	Measure Description	APPLICABILITY FACTOR (percent) All Industrial Building Type 1
1009	Custom Compressed Air	63.6%
1050	Base Non-Cycling refrigerated air dryer	24.6%
1100	Base <5 HP drive/fan/motor	35.0%
1120	Base 6-20 HP drive/fan/motor	32.1%
1125	Custom Measures--Drives, (6-20 hp)	32.1%
1140	Base 21-50 HP drive/fan/motor	8.1%
1145	Custom Measures--Drives (21-50 hp)	8.1%
1160	Base 51-100 HP drive/fan/motor	14.9%
1165	Custom Measures--Drives (51-100 hp)	14.9%
1180	Base 100+ HP drive/fan/motor	20.4%
1185	Custom Measures--Drives (100+ hp)	20.4%
1190	Base Pumps	15.0%
1196	Water/Wastewater Custom Projects	7.5%
1200	Base Process Heating	8.3%
1201	Custom Measures--Process Heating	8.3%
1230	Base Process Cooling	29.5%
1231	Custom Measures--Process Cooling	29.5%
1260	Base Other Process	4.7%
1269	Custom Measures--Other Process	4.7%
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	19.1%
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	50.8%
1302	Cool Roof - Chiller	50.8%
1350	Base DX Packaged System, EER=10.0, 30 tons	19.1%
1351	ROB DX Packaged System, EER=10.8, 30 tons	19.1%
1352	ROB DX Packaged System, EER=11.7, 30 tons	19.1%
1353	Automated Fault Detection	19.1%
1354	VRF Conditioning Systems	19.1%
1400	Base Ventilation	100.0%
1401	Demand Controlled Ventilation	100.0%
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	41.1%
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	28.8%
1504	Upstream 4L4' LED Tube	28.8%
1520	Base Other Fluorescent Fixture	17.1%
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	11.9%

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Industrial Electric Measure Inputs		APPLICABILITY FACTOR (percent)
		All Industrial
Measure #	Measure Description	Building Type 1
1524	Upstream LED Tube (Base Other Fluorescent)	28.8%
1540	Base Metal Halide, 400W	16.4%
1560	Base Outdoor High Pressure Sodium 250W Lamp	47.2%
1600	Base Other	100.00%

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Industrial Electric Measure Inputs Measure #	Measure Description	ENERGY SAVINGS (percent) All Industiral Building Type 1
1000	Base Compressed Air	0%
1001	Compressed Air-Leak Reduction/ Maintenance	15%
1002	Compressed Air- Cold Air Intake	2%
1003	Compressed Air - Controls	4%
1004	Compressed Air - System Optimization	10%
1006	Air compressor zero-loss drains	3%
1007	Compressed Air Low Pressure Drop Filters	1%
1008	High Efficiency Air Compressors	28%
1009	Custom Compressed Air	15%
1050	Base Non-Cycling refrigerated air dryer	0%
1051	Cycling refrigerated dryer	2%
1100	Base <5 HP drive/fan/motor	0%
1101	Replace 1-5 HP motor	2%
1102	Variable Speed Drive Control, <5 HP	15%
1103	Motors - Maintenance (Cost is for predictive maintenance) (<5 HP)	9%
1104	Motors- System Optimization and sizing (<5 HP)	10%
1120	Base 6-20 HP drive/fan/motor	0%
1121	Replace 6-20 HP motor	1%
1122	Variable Speed Drive Control, (6-20 hp)	15%
1123	Motors - Maintenance (Cost is for predictive maintenance), (6-20 hp)	9%
1124	Motors- System Optimization and sizing, (6-20 hp)	10%
1125	Custom Measures--Drives, (6-20 hp)	15%
1140	Base 21-50 HP drive/fan/motor	0%
1141	Replace 21-50 HP motor	1%
1142	Variable speed drive control (21-50 hp)	15%
1143	Motors - Maintenance (Cost is for predictive maintenance) (21-50 hp)	9%
1144	Motors- System Optimization and sizing (21-50 hp)	10%
1145	Custom Measures--Drives (21-50 hp)	15%
1160	Base 51-100 HP drive/fan/motor	0%
1161	Replace 51-100 HP motor	1%
1162	Variable speed drive control (51-100 hp)	15%
1163	Motors - Maintenance (Cost is for predictive maintenance) (51-100 hp)	9%
1164	Motors- System Optimization and sizing (51-100 hp)	10%
1165	Custom Measures--Drives (51-100 hp)	15%

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Industrial Electric Measure Inputs		ENERGY SAVINGS (percent)
Measure #	Measure Description	All Industiral Building Type 1
1180	Base 100+ HP drive/fan/motor	0%
1181	Replace 100+ HP motor	0%
1182	Variable speed drive control (100+ hp)	15%
1183	Motors - Maintenance (Cost is for predictive maintenance) (100+ hp)	9%
1184	Motors- System Optimization and sizing (100+ hp)	10%
1185	Custom Measures--Drives (100+ hp)	15%
1190	Base Pumps	0%
1191	Replace motor (pumps)	1%
1192	Variable speed drive (pumps)	15%
1193	Pump system maintenence (coating, mechanical refurbishment, flow paths, pressure switches)	15%
1194	Correct sizing of pumps	15%
1195	Trim or change impeller	0%
1196	Water/Wastewater Custom Projects	20%
1200	Base Process Heating	0%
1201	Custom Measures--Process Heating	15%
1230	Base Process Cooling	0%
1231	Custom Measures--Process Cooling	15%
1260	Base Other Process	0%
1266	Electric Drive Injection Molder (Plastics)	74%
1267	Efficient Hybrid/Servo Drive Injection Molder (Plastics)	50%
1268	Barrel Insulation on Injection Molder (Plastics)	27%
1269	Custom Measures--Other Process	15%
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	0%
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	7%
1302	Cool Roof - Chiller	18%
1304	VSD for Chiller Pumps and Towers	2%
1350	Base DX Packaged System, EER=10.0, 30 tons	0%
1351	ROB DX Packaged System, EER=10.8, 30 tons	7%
1352	ROB DX Packaged System, EER=11.7, 30 tons	15%
1354	Automated Fault Detection	19%
1355	Advanced Controllers for RTUs	24%
1356	Cool Roof - DX	6%
1357	RTU VSD	30%
1358	Dual Enthalpy Economizer Controls	4%

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Industrial Electric Measure Inputs		ENERGY SAVINGS (percent)
Measure #	Measure Description	All Industiral Building Type 1
1360	Aerosol Duct Sealing	19%
1400	Base Ventilation	0%
1401	Demand Controlled Ventilation	13%
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	0%
1501	RET 4L4' Low Watt High Performance T8 (83 W)	35%
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	24%
1503	RET 4L4' LED Tube	30%
1504	Upstream 4L4' LED Tube	24%
1505	RET LED Troffer (base 4L4'T8)	38%
1506	Occupancy Sensor, 4L4' Fluorescent Fixtures	30%
1507	Advanced Lighting Controls	38%
1508	Daylight Dimming Controls	8%
1520	Base Other Fluorescent Fixture	0%
1521	RET Low Watt High Performance T8 (Base Other Fluorescent)	35%
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	24%
1523	RET LED Tube (Base Other Fluorescent)	30%
1524	Upstream LED Tube (Base Other Fluorescent)	24%
1525	RET LED Troffer (Base Other Fluorescent)	38%
1526	Occupancy Sensor (Base Other Fluorescent)	30%
1527	Advanced Lighting Controls (Base Other Fluorescent)	38%
1528	Daylight Dimming Controls (Base Other Fluorescent)	8%
1540	Base Metal Halide, 400W	0%
1541	High Bay T5 HO (240W)	60%
1542	High Bay Induction Lighting	45%
1543	PSMH with electronic ballast	20%
1544	High Bay LED Lighting	70%
1560	Base Outdoor High Pressure Sodium 250W Lamp	0%
1561	LED Outdoor Area Lighting (other than pole-mounted)	76%
1600	Base Other	0%
1700	Base Whole Building	0%
1701	Energy management Program- Resource Conservation Manager (outside consultant)	0%
1702	Superior energy performance certification	3%
1000	Base Compressed Air	0%
1008	High Efficiency Air Compressors	28%

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Industrial Electric Measure Inputs Measure #	 Measure Description	ENERGY SAVINGS (percent) All Industiral Building Type 1
1009	Custom Compressed Air	15%
1050	Base Non-Cycling refrigerated air dryer	0%
1100	Base <5 HP drive/fan/motor	0%
1120	Base 6-20 HP drive/fan/motor	0%
1125	Custom Measures--Drives, (6-20 hp)	15%
1140	Base 21-50 HP drive/fan/motor	0%
1145	Custom Measures--Drives (21-50 hp)	15%
1160	Base 51-100 HP drive/fan/motor	0%
1165	Custom Measures--Drives (51-100 hp)	15%
1180	Base 100+ HP drive/fan/motor	0%
1185	Custom Measures--Drives (100+ hp)	15%
1190	Base Pumps	0%
1196	Water/Wastewater Custom Projects	20%
1200	Base Process Heating	0%
1201	Custom Measures--Process Heating	15%
1230	Base Process Cooling	0%
1231	Custom Measures--Process Cooling	15%
1260	Base Other Process	0%
1269	Custom Measures--Other Process	15%
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	15%
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	7%
1302	Cool Roof - Chiller	18%
1350	Base DX Packaged System, EER=10.0, 30 tons	0%
1351	ROB DX Packaged System, EER=10.8, 30 tons	7%
1352	ROB DX Packaged System, EER=11.7, 30 tons	15%
1353	Automated Fault Detection	19%
1354	VRF Conditioning Systems	15%
1400	Base Ventilation	0%
1401	Demand Controlled Ventilation	3%
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	0%
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	24%
1504	Upstream 4L4' LED Tube	24%
1520	Base Other Fluorescent Fixture	0%
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	24%

Industrial Electric Measure Inputs Measure #	 Measure Description	ENERGY SAVINGS (percent) All Industiral Building Type 1
1524	Upstream LED Tube (Base Other Fluorescent)	24%
1540	Base Metal Halide, 400W	0%
1560	Base Outdoor High Pressure Sodium 250W Lamp	0%
1600	Base Other	0%

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Industrial Electric Measure Inputs		DEMAND SAVINGS (percent)
Measure #	Measure Description	All Industiral Building Type 1
1000	Base Compressed Air	0%
1001	Compressed Air-Leak Reduction/ Maintenance	15%
1002	Compressed Air- Cold Air Intake	0%
1003	Compressed Air - Controls	0%
1004	Compressed Air - System Optimization	10%
1006	Air compressor zero-loss drains	3%
1007	Compressed Air Low Pressure Drop Filters	1%
1008	High Efficiency Air Compressors	22%
1009	Custom Compressed Air	15%
1050	Base Non-Cycling refrigerated air dryer	0%
1051	Cycling refrigerated dryer	1%
1100	Base <5 HP drive/fan/motor	0%
1101	Replace 1-5 HP motor	3%
1102	Variable Speed Drive Control, <5 HP	15%
1103	Motors - Maintenance (Cost is for predictive maintenance) (<5 HP)	0%
1104	Motors- System Optimization and sizing (<5 HP)	10%
1120	Base 6-20 HP drive/fan/motor	0%
1121	Replace 6-20 HP motor	1%
1122	Variable Speed Drive Control, (6-20 hp)	15%
1123	Motors - Maintenance (Cost is for predictive maintenance), (6-20 hp)	0%
1124	Motors- System Optimization and sizing, (6-20 hp)	10%
1125	Custom Measures--Drives, (6-20 hp)	15%
1140	Base 21-50 HP drive/fan/motor	0%
1141	Replace 21-50 HP motor	1%
1142	Variable speed drive control (21-50 hp)	15%
1143	Motors - Maintenance (Cost is for predictive maintenance) (21-50 hp)	0%
1144	Motors- System Optimization and sizing (21-50 hp)	10%
1145	Custom Measures--Drives (21-50 hp)	15%
1160	Base 51-100 HP drive/fan/motor	0%
1161	Replace 51-100 HP motor	1%
1162	Variable speed drive control (51-100 hp)	15%
1163	Motors - Maintenance (Cost is for predictive maintenance) (51-100 hp)	0%
1164	Motors- System Optimization and sizing (51-100 hp)	10%
1165	Custom Measures--Drives (51-100 hp)	15%

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Industrial Electric Measure Inputs		DEMAND SAVINGS (percent)
Measure #	Measure Description	All Industiral Building Type 1
1180	Base 100+ HP drive/fan/motor	0%
1181	Replace 100+ HP motor	0%
1182	Variable speed drive control (100+ hp)	15%
1183	Motors - Maintenance (Cost is for predictive maintenance) (100+ hp)	0%
1184	Motors- System Optimization and sizing (100+ hp)	10%
1185	Custom Measures--Drives (100+ hp)	15%
1190	Base Pumps	0%
1191	Replace motor (pumps)	1%
1192	Variable speed drive (pumps)	15%
1193	Pump system maintenence (coating, mechanical refurbishment, flow paths, pressure switches)	2%
1194	Correct sizing of pumps	15%
1195	Trim or change impeller	15%
1196	Water/Wastewater Custom Projects	20%
1200	Base Process Heating	0%
1201	Custom Measures--Process Heating	15%
1230	Base Process Cooling	0%
1231	Custom Measures--Process Cooling	15%
1260	Base Other Process	0%
1266	Electric Drive Injection Molder (Plastics)	66%
1267	Efficient Hybrid/Servo Drive Injection Molder (Plastics)	46%
1268	Barrel Insulation on Injection Molder (Plastics)	22%
1269	Custom Measures--Other Process	15%
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	0%
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	5%
1302	Cool Roof - Chiller	14%
1304	VSD for Chiller Pumps and Towers	0%
1350	Base DX Packaged System, EER=10.0, 30 tons	0%
1351	ROB DX Packaged System, EER=10.8, 30 tons	7%
1352	ROB DX Packaged System, EER=11.7, 30 tons	15%
1354	Automated Fault Detection	19%
1355	Advanced Controllers for RTUs	0%
1356	Cool Roof - DX	5%
1357	RTU VSD	17%
1358	Dual Enthalpy Economizer Controls	25%

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Industrial Electric Measure Inputs Measure #	 Measure Description	DEMAND SAVINGS (percent) All Industiral Building Type 1
1360	Aerosol Duct Sealing	19%
1400	Base Ventilation	0%
1401	Demand Controlled Ventilation	3%
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	0%
1501	RET 4L4' Low Watt High Performance T8 (83 W)	33%
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	26%
1503	RET 4L4' LED Tube	28%
1504	Upstream 4L4' LED Tube	23%
1505	RET LED Troffer (base 4L4'T8)	35%
1506	Occupancy Sensor, 4L4' Fluorescent Fixtures	30%
1507	Advanced Lighting Controls	38%
1508	Daylight Dimming Controls	4%
1520	Base Other Fluorescent Fixture	0%
1521	RET Low Watt High Performance T8 (Base Other Fluorescent)	33%
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	26%
1523	RET LED Tube (Base Other Fluorescent)	28%
1524	Upstream LED Tube (Base Other Fluorescent)	23%
1525	RET LED Troffer (Base Other Fluorescent)	35%
1526	Occupancy Sensor (Base Other Fluorescent)	30%
1527	Advanced Lighting Controls (Base Other Fluorescent)	38%
1528	Daylight Dimming Controls (Base Other Fluorescent)	4%
1540	Base Metal Halide, 400W	0%
1541	High Bay T5 HO (240W)	56%
1542	High Bay Induction Lighting	41%
1543	PSMH with electronic ballast	19%
1544	High Bay LED Lighting	65%
1560	Base Outdoor High Pressure Sodium 250W Lamp	0%
1561	LED Outdoor Area Lighting (other than pole-mounted)	0%
1600	Base Other	0%
1700	Base Whole Building	0%
1701	Energy management Program- Resource Conservation Manager (outside consultant)	0%
1702	Superior energy performance certification	0%
1000	Base Compressed Air	0%
1008	High Efficiency Air Compressors	22%

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Industrial Electric Measure Inputs		DEMAND SAVINGS (percent)
Measure #	Measure Description	All Industiral Building Type 1
1009	Custom Compressed Air	15%
1050	Base Non-Cycling refrigerated air dryer	0%
1100	Base <5 HP drive/fan/motor	0%
1120	Base 6-20 HP drive/fan/motor	0%
1125	Custom Measures--Drives, (6-20 hp)	15%
1140	Base 21-50 HP drive/fan/motor	0%
1145	Custom Measures--Drives (21-50 hp)	15%
1160	Base 51-100 HP drive/fan/motor	0%
1165	Custom Measures--Drives (51-100 hp)	15%
1180	Base 100+ HP drive/fan/motor	0%
1185	Custom Measures--Drives (100+ hp)	15%
1190	Base Pumps	0%
1196	Water/Wastewater Custom Projects	20%
1200	Base Process Heating	0%
1201	Custom Measures--Process Heating	15%
1230	Base Process Cooling	0%
1231	Custom Measures--Process Cooling	15%
1260	Base Other Process	0%
1269	Custom Measures--Other Process	15%
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	15%
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	5%
1302	Cool Roof - Chiller	14%
1350	Base DX Packaged System, EER=10.0, 30 tons	0%
1351	ROB DX Packaged System, EER=10.8, 30 tons	7%
1352	ROB DX Packaged System, EER=11.7, 30 tons	15%
1353	Automated Fault Detection	19%
1354	VRF Conditioning Systems	15%
1400	Base Ventilation	0%
1401	Demand Controlled Ventilation	13%
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	0%
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	26%
1504	Upstream 4L4' LED Tube	23%
1520	Base Other Fluorescent Fixture	0%
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	26%

Industrial Electric Measure Inputs Measure #	 Measure Description	DEMAND SAVINGS (percent) All Industiral Building Type 1
1524	Upstream LED Tube (Base Other Fluorescent)	23%
1540	Base Metal Halide, 400W	0%
1560	Base Outdoor High Pressure Sodium 250W Lamp	0%
1600	Base Other	0%

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Industrial Electric Measure Inputs		Standards Adjustment Factor (percent)
		All Industrial
Measure #	Measure Description	Building Type 1
1000	Base Compressed Air	100%
1001	Compressed Air-Leak Reduction/ Maintenance	100%
1002	Compressed Air- Cold Air Intake	100%
1003	Compressed Air - Controls	100%
1004	Compressed Air - System Optimization	100%
1006	Air compressor zero-loss drains	100%
1007	Compressed Air Low Pressure Drop Filters	100%
1008	High Efficiency Air Compressors	100%
1009	Custom Compressed Air	100%
1050	Base Non-Cycling refrigerated air dryer	100%
1051	Cycling refrigerated dryer	100%
1100	Base <5 HP drive/fan/motor	99%
1101	Replace 1-5 HP motor	99%
1102	Variable Speed Drive Control, <5 HP	99%
1103	Motors - Maintenance (Cost is for predictive maintenance) (<5 HP)	99%
1104	Motors- System Optimization and sizing (<5 HP)	99%
1120	Base 6-20 HP drive/fan/motor	99%
1121	Replace 6-20 HP motor	99%
1122	Variable Speed Drive Control, (6-20 hp)	99%
1123	Motors - Maintenance (Cost is for predictive maintenance), (6-20 hp)	99%
1124	Motors- System Optimization and sizing, (6-20 hp)	99%
1125	Custom Measures--Drives, (6-20 hp)	99%
1140	Base 21-50 HP drive/fan/motor	99%
1141	Replace 21-50 HP motor	99%
1142	Variable speed drive control (21-50 hp)	99%
1143	Motors - Maintenance (Cost is for predictive maintenance) (21-50 hp)	99%
1144	Motors- System Optimization and sizing (21-50 hp)	99%
1145	Custom Measures--Drives (21-50 hp)	99%
1160	Base 51-100 HP drive/fan/motor	99%
1161	Replace 51-100 HP motor	99%
1162	Variable speed drive control (51-100 hp)	99%
1163	Motors - Maintenance (Cost is for predictive maintenance) (51-100 hp)	99%
1164	Motors- System Optimization and sizing (51-100 hp)	99%
1165	Custom Measures--Drives (51-100 hp)	99%

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Industrial Electric Measure Inputs		Standards Adjustment Factor (percent)
		All Industrial
Measure #	Measure Description	Building Type 1
1180	Base 100+ HP drive/fan/motor	99%
1181	Replace 100+ HP motor	99%
1182	Variable speed drive control (100+ hp)	99%
1183	Motors - Maintenance (Cost is for predictive maintenance) (100+ hp)	99%
1184	Motors- System Optimization and sizing (100+ hp)	99%
1185	Custom Measures--Drives (100+ hp)	99%
1190	Base Pumps	99%
1191	Replace motor (pumps)	99%
1192	Variable speed drive (pumps)	99%
1193	Pump system maintenence (coating, mechanical refurbishment, flow paths, pressure switches)	99%
1194	Correct sizing of pumps	99%
1195	Trim or change impeller	99%
1196	Water/Wastewater Custom Projects	99%
1200	Base Process Heating	100%
1201	Custom Measures--Process Heating	100%
1230	Base Process Cooling	100%
1231	Custom Measures--Process Cooling	100%
1260	Base Other Process	100%
1266	Electric Drive Injection Molder (Plastics)	100%
1267	Efficient Hybrid/Servo Drive Injection Molder (Plastics)	100%
1268	Barrel Insulation on Injection Molder (Plastics)	100%
1269	Custom Measures--Other Process	100%
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	100%
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	97%
1302	Cool Roof - Chiller	100%
1304	VSD for Chiller Pumps and Towers	100%
1350	Base DX Packaged System, EER=10.0, 30 tons	100%
1351	ROB DX Packaged System, EER=10.8, 30 tons	98%
1352	ROB DX Packaged System, EER=11.7, 30 tons	98%
1354	Automated Fault Detection	100%
1355	Advanced Controllers for RTUs	100%
1356	Cool Roof - DX	100%
1357	RTU VSD	100%
1358	Dual Enthalpy Economizer Controls	100%

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Industrial Electric Measure Inputs		Standards Adjustment Factor (percent)
		All Industrial
Measure #	Measure Description	Building Type 1
1360	Aerosol Duct Sealing	100%
1400	Base Ventilation	100%
1401	Demand Controlled Ventilation	100%
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	100%
1501	RET 4L4' Low Watt High Performance T8 (83 W)	100%
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	94%
1503	RET 4L4' LED Tube	100%
1504	Upstream 4L4' LED Tube	94%
1505	RET LED Troffer (base 4L4'T8)	100%
1506	Occupancy Sensor, 4L4' Fluorescent Fixtures	100%
1507	Advanced Lighting Controls	100%
1508	Daylight Dimming Controls	100%
1520	Base Other Fluorescent Fixture	100%
1521	RET Low Watt High Performance T8 (Base Other Fluorescent)	100%
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	94%
1523	RET LED Tube (Base Other Fluorescent)	100%
1524	Upstream LED Tube (Base Other Fluorescent)	94%
1525	RET LED Troffer (Base Other Fluorescent)	100%
1526	Occupancy Sensor (Base Other Fluorescent)	100%
1527	Advanced Lighting Controls (Base Other Fluorescent)	100%
1528	Daylight Dimming Controls (Base Other Fluorescent)	100%
1540	Base Metal Halide, 400W	100%
1541	High Bay T5 HO (240W)	100%
1542	High Bay Induction Lighting	100%
1543	PSMH with electronic ballast	100%
1544	High Bay LED Lighting	100%
1560	Base Outdoor High Pressure Sodium 250W Lamp	100%
1561	LED Outdoor Area Lighting (other than pole-mounted)	100%
1600	Base Other	100%
1700	Base Whole Building	100%
1701	Energy management Program- Resource Conservation Manager (outside consultant)	100%
1702	Superior energy performance certification	100%
1000	Base Compressed Air	100%
1008	High Efficiency Air Compressors	100%

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Industrial Electric Measure Inputs		Standards Adjustment Factor (percent)
		All Industrial
Measure #	Measure Description	Building Type 1
1009	Custom Compressed Air	100%
1050	Base Non-Cycling refrigerated air dryer	100%
1100	Base <5 HP drive/fan/motor	99%
1120	Base 6-20 HP drive/fan/motor	99%
1125	Custom Measures--Drives, (6-20 hp)	99%
1140	Base 21-50 HP drive/fan/motor	99%
1145	Custom Measures--Drives (21-50 hp)	99%
1160	Base 51-100 HP drive/fan/motor	99%
1165	Custom Measures--Drives (51-100 hp)	99%
1180	Base 100+ HP drive/fan/motor	99%
1185	Custom Measures--Drives (100+ hp)	99%
1190	Base Pumps	99%
1196	Water/Wastewater Custom Projects	99%
1200	Base Process Heating	100%
1201	Custom Measures--Process Heating	100%
1230	Base Process Cooling	100%
1231	Custom Measures--Process Cooling	100%
1260	Base Other Process	100%
1269	Custom Measures--Other Process	100%
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	97%
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	97%
1302	Cool Roof - Chiller	97%
1350	Base DX Packaged System, EER=10.0, 30 tons	98%
1351	ROB DX Packaged System, EER=10.8, 30 tons	98%
1352	ROB DX Packaged System, EER=11.7, 30 tons	98%
1353	Automated Fault Detection	98%
1354	VRF Conditioning Systems	98%
1400	Base Ventilation	100%
1401	Demand Controlled Ventilation	100%
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	94%
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	94%
1504	Upstream 4L4' LED Tube	94%
1520	Base Other Fluorescent Fixture	94%
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	94%

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Industrial Electric Measure Inputs		Standards Adjustment Factor (percent)
		All Industrial
Measure #	Measure Description	Building Type 1
1524	Upstream LED Tube (Base Other Fluorescent)	94%
1540	Base Metal Halide, 400W	100%
1560	Base Outdoor High Pressure Sodium 250W Lamp	100%
1600	Base Other	100%

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Industrial Electric Measure Inputs		INCOMPLETE FACTOR (percent)
Measure #	Measure Description	All Industrial Building Type 1
1000	Base Compressed Air	100%
1001	Compressed Air-Leak Reduction/ Maintenance	31%
1002	Compressed Air- Cold Air Intake	70%
1003	Compressed Air - Controls	25%
1004	Compressed Air - System Optimization	50%
1006	Air compressor zero-loss drains	70%
1007	Compressed Air Low Pressure Drop Filters	70%
1008	High Efficiency Air Compressors	70%
1009	Custom Compressed Air	100%
1050	Base Non-Cycling refrigerated air dryer	100%
1051	Cycling refrigerated dryer	70%
1100	Base <5 HP drive/fan/motor	100%
1101	Replace 1-5 HP motor	87%
1102	Variable Speed Drive Control, <5 HP	90%
1103	Motors - Maintenance (Cost is for predictive maintenance) (<5 HP)	50%
1104	Motors- System Optimization and sizing (<5 HP)	20%
1120	Base 6-20 HP drive/fan/motor	100%
1121	Replace 6-20 HP motor	64%
1122	Variable Speed Drive Control, (6-20 hp)	90%
1123	Motors - Maintenance (Cost is for predictive maintenance), (6-20 hp)	50%
1124	Motors- System Optimization and sizing, (6-20 hp)	20%
1125	Custom Measures--Drives, (6-20 hp)	100%
1140	Base 21-50 HP drive/fan/motor	100%
1141	Replace 21-50 HP motor	64%
1142	Variable speed drive control (21-50 hp)	90%
1143	Motors - Maintenance (Cost is for predictive maintenance) (21-50 hp)	50%
1144	Motors- System Optimization and sizing (21-50 hp)	20%
1145	Custom Measures--Drives (21-50 hp)	100%
1160	Base 51-100 HP drive/fan/motor	100%
1161	Replace 51-100 HP motor	64%
1162	Variable speed drive control (51-100 hp)	90%
1163	Motors - Maintenance (Cost is for predictive maintenance) (51-100 hp)	50%

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Industrial Electric Measure Inputs		INCOMPLETE FACTOR (percent)
Measure #	Measure Description	All Industrial Building Type 1
1164	Motors- System Optimization and sizing (51-100 hp)	20%
1165	Custom Measures--Drives (51-100 hp)	100%
1180	Base 100+ HP drive/fan/motor	100%
1181	Replace 100+ HP motor	26%
1182	Variable speed drive control (100+ hp)	80%
1183	Motors - Maintenance (Cost is for predictive maintenance) (100+ hp)	50%
1184	Motors- System Optimization and sizing (100+ hp)	20%
1185	Custom Measures--Drives (100+ hp)	100%
1190	Base Pumps	100%
1191	Replace motor (pumps)	64%
1192	Variable speed drive (pumps)	75%
1193	Pump system maintenence (coating, mechanical refurbishment, flow paths, pressure switches)	18%
1194	Correct sizing of pumps	20%
1195	Trim or change impeller	70%
1196	Water/Wastewater Custom Projects	100%
1200	Base Process Heating	100%
1201	Custom Measures--Process Heating	100%
1230	Base Process Cooling	100%
1231	Custom Measures--Process Cooling	100%
1260	Base Other Process	100%
1266	Electric Drive Injection Molder (Plastics)	70%
1267	Efficient Hybrid/Servo Drive Injection Molder (Plastics)	70%
1268	Barrel Insulation on Injection Molder (Plastics)	70%
1269	Custom Measures--Other Process	100%
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	100%
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	68%
1302	Cool Roof - Chiller	50%
1304	VSD for Chiller Pumps and Towers	34%
1350	Base DX Packaged System, EER=10.0, 30 tons	100%
1351	ROB DX Packaged System, EER=10.8, 30 tons	100%
1352	ROB DX Packaged System, EER=11.7, 30 tons	100%
1354	Automated Fault Detection	100%

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Industrial Electric Measure Inputs		INCOMPLETE FACTOR (percent)
Measure #	Measure Description	All Industrial Building Type 1
1355	Advanced Controllers for RTUs	70%
1356	Cool Roof - DX	66%
1357	RTU VSD	70%
1358	Dual Enthalpy Economizer Controls	53%
1360	Aerosol Duct Sealing	97%
1400	Base Ventilation	100%
1401	Demand Controlled Ventilation	13%
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	100%
1501	RET 4L4' Low Watt High Performance T8 (83 W)	88%
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	88%
1503	RET 4L4' LED Tube	99%
1504	Upstream 4L4' LED Tube	100%
1505	RET LED Troffer (base 4L4'T8)	100%
1506	Occupancy Sensor, 4L4' Fluorescent Fixtures	98%
1507	Advanced Lighting Controls	92%
1508	Daylight Dimming Controls	90%
1520	Base Other Fluorescent Fixture	100%
1521	RET Low Watt High Performance T8 (Base Other Fluorescent)	88%
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	88%
1523	RET LED Tube (Base Other Fluorescent)	99%
1524	Upstream LED Tube (Base Other Fluorescent)	100%
1525	RET LED Troffer (Base Other Fluorescent)	100%
1526	Occupancy Sensor (Base Other Fluorescent)	97%
1527	Advanced Lighting Controls (Base Other Fluorescent)	81%
1528	Daylight Dimming Controls (Base Other Fluorescent)	81%
1540	Base Metal Halide, 400W	100%
1541	High Bay T5 HO (240W)	79%
1542	High Bay Induction Lighting	100%
1543	PSMH with electronic ballast	50%
1544	High Bay LED Lighting	100%
1560	Base Outdoor High Pressure Sodium 250W Lamp	100%
1561	LED Outdoor Area Lighting (other than pole-mounted)	99%

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Industrial Electric Measure Inputs Measure #	Measure Description	INCOMPLETE FACTOR (percent) All Industrial Building Type 1
1600	Base Other	100%
1700	Base Whole Building	100%
1701	Energy management Program- Resource Conservation Manager (outside consultant)	90%
1702	Superior energy performance certification	90%
1000	Base Compressed Air	100%
1008	High Efficiency Air Compressors	70%
1009	Custom Compressed Air	100%
1050	Base Non-Cycling refrigerated air dryer	100%
1100	Base <5 HP drive/fan/motor	100%
1120	Base 6-20 HP drive/fan/motor	100%
1125	Custom Measures--Drives, (6-20 hp)	100%
1140	Base 21-50 HP drive/fan/motor	100%
1145	Custom Measures--Drives (21-50 hp)	100%
1160	Base 51-100 HP drive/fan/motor	100%
1165	Custom Measures--Drives (51-100 hp)	100%
1180	Base 100+ HP drive/fan/motor	100%
1185	Custom Measures--Drives (100+ hp)	100%
1190	Base Pumps	100%
1196	Water/Wastewater Custom Projects	100%
1200	Base Process Heating	100%
1201	Custom Measures--Process Heating	100%
1230	Base Process Cooling	100%
1231	Custom Measures--Process Cooling	100%
1260	Base Other Process	100%
1269	Custom Measures--Other Process	100%
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	100%
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	68%
1302	Cool Roof - Chiller	50%
1350	Base DX Packaged System, EER=10.0, 30 tons	100%
1351	ROB DX Packaged System, EER=10.8, 30 tons	100%
1352	ROB DX Packaged System, EER=11.7, 30 tons	100%
1353	Automated Fault Detection	100%

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Industrial Electric Measure Inputs Measure #	Measure Description	INCOMPLETE FACTOR (percent) All Industrial Building Type 1
1354	VRF Conditioning Systems	100%
1400	Base Ventilation	100%
1401	Demand Controlled Ventilation	13%
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	100%
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	88%
1504	Upstream 4L4' LED Tube	100%
1520	Base Other Fluorescent Fixture	100%
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	88%
1524	Upstream LED Tube (Base Other Fluorescent)	100%
1540	Base Metal Halide, 400W	100%
1560	Base Outdoor High Pressure Sodium 250W Lamp	100%
1600	Base Other	100%

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Industrial Electric Measure Inputs Measure #	Measure Description	FEASIBILITY FACTOR (percent) All Industrial Building Type 1
1000	Base Compressed Air	85%
1001	Compressed Air-Leak Reduction/ Maintenance	85%
1002	Compressed Air- Cold Air Intake	85%
1003	Compressed Air - Controls	85%
1004	Compressed Air - System Optimization	85%
1006	Air compressor zero-loss drains	85%
1007	Compressed Air Low Pressure Drop Filters	85%
1008	High Efficiency Air Compressors	85%
1009	Custom Compressed Air	85%
1050	Base Non-Cycling refrigerated air dryer	85%
1051	Cycling refrigerated dryer	85%
1100	Base <5 HP drive/fan/motor	100%
1101	Replace 1-5 HP motor	100%
1102	Variable Speed Drive Control, <5 HP	100%
1103	Motors - Maintenance (Cost is for predictive maintenance) (<5 HP)	100%
1104	Motors- System Optimization and sizing (<5 HP)	100%
1120	Base 6-20 HP drive/fan/motor	100%
1121	Replace 6-20 HP motor	100%
1122	Variable Speed Drive Control, (6-20 hp)	100%
1123	Motors - Maintenance (Cost is for predictive maintenance), (6-20 hp)	100%
1124	Motors- System Optimization and sizing, (6-20 hp)	100%
1125	Custom Measures--Drives, (6-20 hp)	100%
1140	Base 21-50 HP drive/fan/motor	100%
1141	Replace 21-50 HP motor	100%
1142	Variable speed drive control (21-50 hp)	100%
1143	Motors - Maintenance (Cost is for predictive maintenance) (21-50 hp)	100%
1144	Motors- System Optimization and sizing (21-50 hp)	100%
1145	Custom Measures--Drives (21-50 hp)	100%
1160	Base 51-100 HP drive/fan/motor	100%
1161	Replace 51-100 HP motor	100%
1162	Variable speed drive control (51-100 hp)	100%
1163	Motors - Maintenance (Cost is for predictive maintenance) (51-100 hp)	100%

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Industrial Electric Measure Inputs Measure #	Measure Description	FEASIBILITY FACTOR (percent) All Industrial Building Type 1
1164	Motors- System Optimization and sizing (51-100 hp)	100%
1165	Custom Measures--Drives (51-100 hp)	100%
1180	Base 100+ HP drive/fan/motor	100%
1181	Replace 100+ HP motor	100%
1182	Variable speed drive control (100+ hp)	100%
1183	Motors - Maintenance (Cost is for predictive maintenance) (100+ hp)	100%
1184	Motors- System Optimization and sizing (100+ hp)	100%
1185	Custom Measures--Drives (100+ hp)	100%
1190	Base Pumps	100%
1191	Replace motor (pumps)	100%
1192	Variable speed drive (pumps)	100%
1193	Pump system maintenence (coating, mechanical refurbishment, flow paths, pressure switches)	100%
1194	Correct sizing of pumps	100%
1195	Trim or change impeller	100%
1196	Water/Wastewater Custom Projects	100%
1200	Base Process Heating	60%
1201	Custom Measures--Process Heating	60%
1230	Base Process Cooling	50%
1231	Custom Measures--Process Cooling	50%
1260	Base Other Process	85%
1266	Electric Drive Injection Molder (Plastics)	85%
1267	Efficient Hybrid/Servo Drive Injection Molder (Plastics)	85%
1268	Barrel Insulation on Injection Molder (Plastics)	85%
1269	Custom Measures--Other Process	85%
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	100%
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	100%
1302	Cool Roof - Chiller	20%
1304	VSD for Chiller Pumps and Towers	100%
1350	Base DX Packaged System, EER=10.0, 30 tons	100%
1351	ROB DX Packaged System, EER=10.8, 30 tons	100%
1352	ROB DX Packaged System, EER=11.7, 30 tons	100%
1354	Automated Fault Detection	5%

Industrial Electric Measure Inputs		FEASIBILITY FACTOR (percent)
Measure #	Measure Description	All Industrial Building Type 1
1355	Advanced Controllers for RTUs	100%
1356	Cool Roof - DX	20%
1357	RTU VSD	100%
1358	Dual Enthalpy Economizer Controls	100%
1360	Aerosol Duct Sealing	100%
1400	Base Ventilation	100%
1401	Demand Controlled Ventilation	70%
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	100%
1501	RET 4L4' Low Watt High Performance T8 (83 W)	100%
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	100%
1503	RET 4L4' LED Tube	100%
1504	Upstream 4L4' LED Tube	100%
1505	RET LED Troffer (base 4L4'T8)	100%
1506	Occupancy Sensor, 4L4' Fluorescent Fixtures	100%
1507	Advanced Lighting Controls	100%
1508	Daylight Dimming Controls	20%
1520	Base Other Fluorescent Fixture	100%
1521	RET Low Watt High Performance T8 (Base Other Fluorescent)	100%
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	100%
1523	RET LED Tube (Base Other Fluorescent)	100%
1524	Upstream LED Tube (Base Other Fluorescent)	100%
1525	RET LED Troffer (Base Other Fluorescent)	100%
1526	Occupancy Sensor (Base Other Fluorescent)	100%
1527	Advanced Lighting Controls (Base Other Fluorescent)	100%
1528	Daylight Dimming Controls (Base Other Fluorescent)	20%
1540	Base Metal Halide, 400W	100%
1541	High Bay T5 HO (240W)	100%
1542	High Bay Induction Lighting	100%
1543	PSMH with electronic ballast	100%
1544	High Bay LED Lighting	100%
1560	Base Outdoor High Pressure Sodium 250W Lamp	100%
1561	LED Outdoor Area Lighting (other than pole-mounted)	100%

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Industrial Electric Measure Inputs Measure #	Measure Description	**FEASIBILITY FACTOR (percent)** All Industrial Building Type 1
1600	Base Other	100%
1700	Base Whole Building	100%
1701	Energy management Program- Resource Conservation Manager (outside consultant)	100%
1702	Superior energy performance certification	100%
1000	Base Compressed Air	85%
1008	High Efficiency Air Compressors	85%
1009	Custom Compressed Air	85%
1050	Base Non-Cycling refrigerated air dryer	85%
1100	Base <5 HP drive/fan/motor	100%
1120	Base 6-20 HP drive/fan/motor	100%
1125	Custom Measures--Drives, (6-20 hp)	100%
1140	Base 21-50 HP drive/fan/motor	100%
1145	Custom Measures--Drives (21-50 hp)	100%
1160	Base 51-100 HP drive/fan/motor	100%
1165	Custom Measures--Drives (51-100 hp)	100%
1180	Base 100+ HP drive/fan/motor	100%
1185	Custom Measures--Drives (100+ hp)	100%
1190	Base Pumps	100%
1196	Water/Wastewater Custom Projects	100%
1200	Base Process Heating	60%
1201	Custom Measures--Process Heating	60%
1230	Base Process Cooling	50%
1231	Custom Measures--Process Cooling	50%
1260	Base Other Process	85%
1269	Custom Measures--Other Process	85%
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	100%
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	100%
1302	Cool Roof - Chiller	100%
1350	Base DX Packaged System, EER=10.0, 30 tons	100%
1351	ROB DX Packaged System, EER=10.8, 30 tons	100%
1352	ROB DX Packaged System, EER=11.7, 30 tons	100%
1353	Automated Fault Detection	5%

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Industrial Electric Measure Inputs		FEASIBILITY FACTOR (percent)
		All Industrial
Measure #	Measure Description	Building Type 1
1354	VRF Conditioning Systems	50%
1400	Base Ventilation	100%
1401	Demand Controlled Ventilation	70%
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	100%
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	100%
1504	Upstream 4L4' LED Tube	100%
1520	Base Other Fluorescent Fixture	100%
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	100%
1524	Upstream LED Tube (Base Other Fluorescent)	100%
1540	Base Metal Halide, 400W	100%
1560	Base Outdoor High Pressure Sodium 250W Lamp	100%
1600	Base Other	100.00%

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Industrial Electric Measure Inputs		TECHNOLOGY SATURATION (units/square foot)
Measure #	Measure Description	All Industrial Building Type 1
1000	Base Compressed Air	0.0003
1001	Compressed Air-Leak Reduction/ Maintenance	0.0000
1002	Compressed Air- Cold Air Intake	0.0000
1003	Compressed Air - Controls	0.0000
1004	Compressed Air - System Optimization	0.0000
1006	Air compressor zero-loss drains	0.0000
1007	Compressed Air Low Pressure Drop Filters	0.0014
1008	High Efficiency Air Compressors	0.0016
1009	Custom Compressed Air	0.2027
1050	Base Non-Cycling refrigerated air dryer	0.0024
1051	Cycling refrigerated dryer	0.0001
1100	Base <5 HP drive/fan/motor	0.0005
1101	Replace 1-5 HP motor	0.0005
1102	Variable Speed Drive Control, <5 HP	0.0005
1103	Motors - Maintenance (Cost is for predictive maintenance) (<5 HP)	0.0005
1104	Motors- System Optimization and sizing (<5 HP)	0.0005
1120	Base 6-20 HP drive/fan/motor	0.0013
1121	Replace 6-20 HP motor	0.0013
1122	Variable Speed Drive Control, (6-20 hp)	0.0013
1123	Motors - Maintenance (Cost is for predictive maintenance), (6-20 hp)	0.0013
1124	Motors- System Optimization and sizing, (6-20 hp)	0.0013
1125	Custom Measures--Drives, (6-20 hp)	0.4261
1140	Base 21-50 HP drive/fan/motor	0.0005
1141	Replace 21-50 HP motor	0.0005
1142	Variable speed drive control (21-50 hp)	0.0005
1143	Motors - Maintenance (Cost is for predictive maintenance) (21-50 hp)	0.0005
1144	Motors- System Optimization and sizing (21-50 hp)	0.0005
1145	Custom Measures--Drives (21-50 hp)	0.1816
1160	Base 51-100 HP drive/fan/motor	0.0022
1161	Replace 51-100 HP motor	0.0022
1162	Variable speed drive control (51-100 hp)	0.0022
1163	Motors - Maintenance (Cost is for predictive maintenance) (51-100 hp)	0.0022

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Industrial Electric Measure Inputs		TECHNOLOGY SATURATION (units/square foot)
Measure #	Measure Description	All Industrial Building Type 1
1164	Motors- System Optimization and sizing (51-100 hp)	0.0022
1165	Custom Measures--Drives (51-100 hp)	0.7483
1180	Base 100+ HP drive/fan/motor	0.0084
1181	Replace 100+ HP motor	0.0084
1182	Variable speed drive control (100+ hp)	0.0084
1183	Motors - Maintenance (Cost is for predictive maintenance) (100+ hp)	0.0084
1184	Motors- System Optimization and sizing (100+ hp)	0.0084
1185	Custom Measures--Drives (100+ hp)	2.8181
1190	Base Pumps	0.0002
1191	Replace motor (pumps)	0.0025
1192	Variable speed drive (pumps)	0.0025
1193	Pump system maintenence (coating, mechanical refurbishment, flow paths, pressure switches)	0.0025
1194	Correct sizing of pumps	0.0025
1195	Trim or change impeller	0.0025
1196	Water/Wastewater Custom Projects	3.3870
1200	Base Process Heating	24.7495
1201	Custom Measures--Process Heating	3.7124
1230	Base Process Cooling	4.5579
1231	Custom Measures--Process Cooling	0.6837
1260	Base Other Process	0.0100
1266	Electric Drive Injection Molder (Plastics)	0.0170
1267	Efficient Hybrid/Servo Drive Injection Molder (Plastics)	0.0170
1268	Barrel Insulation on Injection Molder (Plastics)	12.9798
1269	Custom Measures--Other Process	6.6269
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	0.0049
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	0.0049
1302	Cool Roof - Chiller	1.0000
1304	VSD for Chiller Pumps and Towers	0.0000
1350	Base DX Packaged System, EER=10.0, 30 tons	0.0016
1351	ROB DX Packaged System, EER=10.8, 30 tons	0.0016
1352	ROB DX Packaged System, EER=11.7, 30 tons	0.0016

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Industrial Electric Measure Inputs		TECHNOLOGY SATURATION (units/square foot)
Measure #	Measure Description	All Industrial Building Type 1
1354	Automated Fault Detection	0.0002
1355	Advanced Controllers for RTUs	0.0002
1356	Cool Roof - DX	1.0000
1357	RTU VSD	0.0002
1358	Dual Enthalpy Economizer Controls	0.0002
1360	Aerosol Duct Sealing	0.0016
1400	Base Ventilation	0.0000
1401	Demand Controlled Ventilation	0.0000
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	0.0025
1501	RET 4L4' Low Watt High Performance T8 (83 W)	0.0025
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	0.0025
1503	RET 4L4' LED Tube	0.0025
1504	Upstream 4L4' LED Tube	0.0025
1505	RET LED Troffer (base 4L4'T8)	0.0025
1506	Occupancy Sensor, 4L4' Fluorescent Fixtures	0.0025
1507	Advanced Lighting Controls	1.0000
1508	Daylight Dimming Controls	0.0008
1520	Base Other Fluorescent Fixture	0.0007
1521	RET Low Watt High Performance T8 (Base Other Fluorescent)	0.0007
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	0.0007
1523	RET LED Tube (Base Other Fluorescent)	0.0007
1524	Upstream LED Tube (Base Other Fluorescent)	0.0007
1525	RET LED Troffer (Base Other Fluorescent)	0.0007
1526	Occupancy Sensor (Base Other Fluorescent)	0.0007
1527	Advanced Lighting Controls (Base Other Fluorescent)	1.0000
1528	Daylight Dimming Controls (Base Other Fluorescent)	0.0002
1540	Base Metal Halide, 400W	0.0006
1541	High Bay T5 HO (240W)	0.0006
1542	High Bay Induction Lighting	0.0006
1543	PSMH with electronic ballast	0.0006
1544	High Bay LED Lighting	0.0006
1560	Base Outdoor High Pressure Sodium 250W Lamp	0.0015

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Industrial Electric Measure Inputs		TECHNOLOGY SATURATION (units/square foot)
Measure #	Measure Description	All Industrial Building Type 1
1561	LED Outdoor Area Lighting (other than pole-mounted)	0.0015
1600	Base Other	1.0000
1700	Base Whole Building	1.0000
1701	Energy management Program- Resource Conservation Manager (outside consultant)	0.0000
1702	Superior energy performance certification	0.0000
1000	Base Compressed Air	0.0003
1008	High Efficiency Air Compressors	0.0016
1009	Custom Compressed Air	0.2027
1050	Base Non-Cycling refrigerated air dryer	0.0024
1100	Base <5 HP drive/fan/motor	0.0005
1120	Base 6-20 HP drive/fan/motor	0.0013
1125	Custom Measures--Drives, (6-20 hp)	0.4261
1140	Base 21-50 HP drive/fan/motor	0.0005
1145	Custom Measures--Drives (21-50 hp)	0.1816
1160	Base 51-100 HP drive/fan/motor	0.0022
1165	Custom Measures--Drives (51-100 hp)	0.7483
1180	Base 100+ HP drive/fan/motor	0.0084
1185	Custom Measures--Drives (100+ hp)	2.8181
1190	Base Pumps	0.0002
1196	Water/Wastewater Custom Projects	3.3870
1200	Base Process Heating	24.7495
1201	Custom Measures--Process Heating	3.7124
1230	Base Process Cooling	4.5579
1231	Custom Measures--Process Cooling	0.6837
1260	Base Other Process	0.0100
1269	Custom Measures--Other Process	6.6269
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	0.0016
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	0.0049
1302	Cool Roof - Chiller	1.0000
1350	Base DX Packaged System, EER=10.0, 30 tons	0.0016
1351	ROB DX Packaged System, EER=10.8, 30 tons	0.0016
1352	ROB DX Packaged System, EER=11.7, 30 tons	0.0016

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Industrial Electric Measure Inputs		TECHNOLOGY SATURATION (units/square foot)
		All Industrial
Measure #	Measure Description	Building Type 1
1353	Automated Fault Detection	0.0002
1354	VRF Conditioning Systems	1.0000
1400	Base Ventilation	0.0000
1401	Demand Controlled Ventilation	0.0000
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	0.0025
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	0.0025
1504	Upstream 4L4' LED Tube	0.0025
1520	Base Other Fluorescent Fixture	0.0007
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	0.0007
1524	Upstream LED Tube (Base Other Fluorescent)	0.0025
1540	Base Metal Halide, 400W	0.0006
1560	Base Outdoor High Pressure Sodium 250W Lamp	0.0015
1600	Base Other	1.0000

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Industrial Electric Measure Inputs		APPLICABILITY*INCOMPLETE*FEASIBILITY (percent) All Industrial Building Type 1
Measure #	Measure Description	
1000	Base Compressed Air	54%
1001	Compressed Air-Leak Reduction/ Maintenance	17%
1002	Compressed Air- Cold Air Intake	38%
1003	Compressed Air - Controls	14%
1004	Compressed Air - System Optimization	27%
1006	Air compressor zero-loss drains	38%
1007	Compressed Air Low Pressure Drop Filters	38%
1008	High Efficiency Air Compressors	38%
1009	Custom Compressed Air	54%
1050	Base Non-Cycling refrigerated air dryer	21%
1051	Cycling refrigerated dryer	15%
1100	Base <5 HP drive/fan/motor	35%
1101	Replace 1-5 HP motor	30%
1102	Variable Speed Drive Control, <5 HP	31%
1103	Motors - Maintenance (Cost is for predictive maintenance) (<5 HP)	17%
1104	Motors- System Optimization and sizing (<5 HP)	7%
1120	Base 6-20 HP drive/fan/motor	32%
1121	Replace 6-20 HP motor	21%
1122	Variable Speed Drive Control, (6-20 hp)	29%
1123	Motors - Maintenance (Cost is for predictive maintenance), (6-20 hp)	16%
1124	Motors- System Optimization and sizing, (6-20 hp)	6%
1125	Custom Measures--Drives, (6-20 hp)	32%
1140	Base 21-50 HP drive/fan/motor	8%
1141	Replace 21-50 HP motor	5%
1142	Variable speed drive control (21-50 hp)	7%
1143	Motors - Maintenance (Cost is for predictive maintenance) (21-50 hp)	4%
1144	Motors- System Optimization and sizing (21-50 hp)	2%
1145	Custom Measures--Drives (21-50 hp)	8%
1160	Base 51-100 HP drive/fan/motor	15%
1161	Replace 51-100 HP motor	10%
1162	Variable speed drive control (51-100 hp)	13%
1163	Motors - Maintenance (Cost is for predictive maintenance) (51-100 hp)	7%
1164	Motors- System Optimization and sizing (51-100 hp)	3%
1165	Custom Measures--Drives (51-100 hp)	15%
1180	Base 100+ HP drive/fan/motor	20%

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Industrial Electric Measure Inputs		APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)
		All Industrial
Measure #	Measure Description	Building Type 1
1181	Replace 100+ HP motor	5%
1182	Variable speed drive control (100+ hp)	16%
1183	Motors - Maintenance (Cost is for predictive maintenance) (100+ hp)	10%
1184	Motors- System Optimization and sizing (100+ hp)	4%
1185	Custom Measures--Drives (100+ hp)	20%
1190	Base Pumps	15%
1191	Replace motor (pumps)	10%
1192	Variable speed drive (pumps)	11%
1193	Pump system maintenence (coating, mechanical refurbishment, flow paths, pressure switches)	3%
1194	Correct sizing of pumps	3%
1195	Trim or change impeller	11%
1196	Water/Wastewater Custom Projects	8%
1200	Base Process Heating	5%
1201	Custom Measures--Process Heating	5%
1230	Base Process Cooling	15%
1231	Custom Measures--Process Cooling	15%
1260	Base Other Process	4%
1266	Electric Drive Injection Molder (Plastics)	1%
1267	Efficient Hybrid/Servo Drive Injection Molder (Plastics)	1%
1268	Barrel Insulation on Injection Molder (Plastics)	1%
1269	Custom Measures--Other Process	4%
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	51%
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	35%
1302	Cool Roof - Chiller	5%
1304	VSD for Chiller Pumps and Towers	17%
1350	Base DX Packaged System, EER=10.0, 30 tons	19%
1351	ROB DX Packaged System, EER=10.8, 30 tons	19%
1352	ROB DX Packaged System, EER=11.7, 30 tons	19%
1354	Automated Fault Detection	1%
1355	Advanced Controllers for RTUs	13%
1356	Cool Roof - DX	3%
1357	RTU VSD	13%
1358	Dual Enthalpy Economizer Controls	10%
1360	Aerosol Duct Sealing	18%
1400	Base Ventilation	100%

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Industrial Electric Measure Inputs		**APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)**
		All Industrial
Measure #	Measure Description	Building Type 1
1401	Demand Controlled Ventilation	9%
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	41%
1501	RET 4L4' Low Watt High Performance T8 (83 W)	11%
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	25%
1503	RET 4L4' LED Tube	12%
1504	Upstream 4L4' LED Tube	29%
1505	RET LED Troffer (base 4L4'T8)	12%
1506	Occupancy Sensor, 4L4' Fluorescent Fixtures	40%
1507	Advanced Lighting Controls	38%
1508	Daylight Dimming Controls	7%
1520	Base Other Fluorescent Fixture	17%
1521	RET Low Watt High Performance T8 (Base Other Fluorescent)	5%
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	11%
1523	RET LED Tube (Base Other Fluorescent)	5%
1524	Upstream LED Tube (Base Other Fluorescent)	12%
1525	RET LED Troffer (Base Other Fluorescent)	5%
1526	Occupancy Sensor (Base Other Fluorescent)	17%
1527	Advanced Lighting Controls (Base Other Fluorescent)	14%
1528	Daylight Dimming Controls (Base Other Fluorescent)	3%
1540	Base Metal Halide, 400W	16%
1541	High Bay T5 HO (240W)	13%
1542	High Bay Induction Lighting	16%
1543	PSMH with electronic ballast	8%
1544	High Bay LED Lighting	16%
1560	Base Outdoor High Pressure Sodium 250W Lamp	47%
1561	LED Outdoor Area Lighting (other than pole-mounted)	47%
1600	Base Other	100%
1700	Base Whole Building	100%
1701	Energy management Program- Resource Conservation Manager (outside consultant)	9%
1702	Superior energy performance certification	9%
1000	Base Compressed Air	54%
1008	High Efficiency Air Compressors	38%
1009	Custom Compressed Air	54%
1050	Base Non-Cycling refrigerated air dryer	21%
1100	Base <5 HP drive/fan/motor	35%

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Industrial Electric Measure Inputs		APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)
		All Industrial
Measure #	Measure Description	Building Type 1
1120	Base 6-20 HP drive/fan/motor	32%
1125	Custom Measures--Drives, (6-20 hp)	32%
1140	Base 21-50 HP drive/fan/motor	8%
1145	Custom Measures--Drives (21-50 hp)	8%
1160	Base 51-100 HP drive/fan/motor	15%
1165	Custom Measures--Drives (51-100 hp)	15%
1180	Base 100+ HP drive/fan/motor	20%
1185	Custom Measures--Drives (100+ hp)	20%
1190	Base Pumps	15%
1196	Water/Wastewater Custom Projects	8%
1200	Base Process Heating	5%
1201	Custom Measures--Process Heating	5%
1230	Base Process Cooling	15%
1231	Custom Measures--Process Cooling	15%
1260	Base Other Process	4%
1269	Custom Measures--Other Process	4%
1300	Base Screw/Scroll Chiller, 0.54 kW/ton IPLV, 200 tons	19%
1301	Screw/Scroll Chiller, 0.486 kW/ton IPLV, 200 tons	35%
1302	Cool Roof - Chiller	25%
1350	Base DX Packaged System, EER=10.0, 30 tons	19%
1351	ROB DX Packaged System, EER=10.8, 30 tons	19%
1352	ROB DX Packaged System, EER=11.7, 30 tons	19%
1353	Automated Fault Detection	1%
1354	VRF Conditioning Systems	10%
1400	Base Ventilation	100%
1401	Demand Controlled Ventilation	9%
1500	Base Fluorescent Fixture, 4L4'T8, 1EB	41%
1502	Upstream 4L4' Low Watt High Performance T8 (83 W)	25%
1504	Upstream 4L4' LED Tube	29%
1520	Base Other Fluorescent Fixture	17%
1522	Upstream Low Watt High Performance T8 (Base Other Fluorescent)	11%
1524	Upstream LED Tube (Base Other Fluorescent)	29%
1540	Base Metal Halide, 400W	16%
1560	Base Outdoor High Pressure Sodium 250W Lamp	47%
1600	Base Other	100%

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Industrial Gas Measure Inputs		BASE TECHNOLOGY EUIs (therm/square foot)
		All Industrial
Measure #	Measure Description	Building Type 1
1000	Base Hot Water Boiler	0.1
1050	Base Steam Boiler	1.4
1100	Base Furnace	5.8
1120	Base Process Heat	5.8
1140	Base Other Process	3.8
1160	Base HVAC	1.0
1180	Base CHP	2.2
1190	Base Other	0.3
1200	Base Whole Facility	2.0
2000	Base Hot Water Boiler	0.1
2050	Base Steam Boiler	1.4
2100	Base Furnace	5.8
2120	Base Process Heat	5.8
2140	Base Other Process	3.8
2160	Base HVAC	1.0
2180	Base CHP	2.2
2190	Base Other	0.3
2200	Base Whole Facility	2.0

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Industrial Gas Measure Costs

Measure #	Measure Description	First Year	End Year	Savings Units	Cost Units	Unit Equipment Cost	Unit Labor Costs	NPV of Lifetime O&M Cost	Implementation Cost Factor	Implementation Type (RET/ROB)	Initial Cost	Replacement Cost	Measure File Service Life (Yrs)	Full Per Unit Cost
1000	Base Hot Water Boiler	2015	2054	sqft					$0.00	RET	1	1	20.00	$0.00
1001	High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	2015	2054	sqft	MMBtu saved	$30.54			$30.54	ROB	1	1	25.00	$30.54
1002	Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	2015	2054	sqft	MMBtu saved	$28.67			$28.67	ROB	1	1	18.00	$28.67
1003	Direct Fired Make-up Air System (Base Hot Water Boiler)	2015	2054	sqft	MMBtu saved	$53.69			$53.69	ROB	1	1	20.00	$53.69
1004	Process optimization/Load management techniques (Base Hot Water Boiler)	2015	2054	sqft	facility	$37,800.00			$37,800.00	RET	1	1	10.00	$37,800.00
1005	Improved Boiler Combustion Efficiency (Tune up)	2015	2054	sqft	MMBtu saved	$11.69			$11.69	RET	1	1	2.00	$11.69
1006	Properly sized system (Base Hot Water Boiler)	2015	2054	sqft	unit	$1,000.00			$1,000.00	ROB	1	1	20.00	$1,000.00
1007	Improved boiler pipe insulation (Base Hot Water Boiler)	2015	2054	sqft	MMBtu saved	$28.00		($13.50)	$28.00	RET	1	1	15.00	$14.50
1008	Boiler maintenance and fouling reduction (Base Hot Water Boiler)	2015	2054	sqft	unit	$15,000.00			$15,000.00	RET	1	1	2.00	$15,000.00
1009	Boiler Controls (Base Hot Water Boiler)	2015	2054	sqft	unit	$17,900.00			$17,900.00	RET	1	1	10.00	$17,900.00
1010	Boiler reset controls (Base Hot Water Boiler)	2015	2054	sqft	MMBtu saved	$27.95		($13.50)	$27.95	RET	1	1	20.00	$14.45
1011	Flue gas heat recovery (Base Hot Water Boiler)	2015	2054	sqft	MMBtu saved	$35.36			$35.36	RET	1	1	10.00	$35.36
1012	Condensate return (Base Hot Water Boiler)	2015	2054	sqft	unit	$75,000.00			$75,000.00	RET	1	1	10.00	$75,000.00
1013	Blowdown heat recovery (Base Hot Water Boiler)	2015	2054	sqft	MMBtu saved	$42.51			$42.51	RET	1	1	20.00	$42.51
1014	Custom (Base Hot Water Boiler)	2015	2054	sqft	MMBtu saved	$8.36		($1.70)	$8.36	ROB	1	1	5.00	$6.66
1050	Base Steam Boiler	2015	2054	sqft					$0.00	RET	1	1	20.00	$0.00
1051	High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	2015	2054	sqft	MMBtu saved	$38.95			$38.95	ROB	1	1	25.00	$38.95
1052	Direct Fired Make-up Air System (Base Steam Boiler)	2015	2054	sqft	MMBtu saved	$53.69			$53.69	ROB	1	1	20.00	$53.69
1053	Process optimization/Load management techniques (Base Steam Boiler)	2015	2054	sqft	facility	$37,800.00			$37,800.00	RET	1	1	10.00	$37,800.00
1054	Improved Boiler Combustion Efficiency (Tune up) (Base Steam Boiler)	2015	2054	sqft	MMBtu saved	$11.69			$11.69	RET	1	1	2.00	$11.69
1055	Properly sized system (Base Steam Boiler)	2015	2054	sqft	unit	$1,000.00			$1,000.00	ROB	1	1	20.00	$1,000.00
1056	Improved boiler pipe insulation (Base Steam Boiler)	2015	2054	sqft	MMBtu saved	$27.00		($13.50)	$27.00	RET	1	1	15.00	$13.50
1057	Boiler maintenance and fouling reduction (Base Steam Boiler)	2015	2054	sqft	unit	$15,000.00			$15,000.00	RET	1	1	2.00	$15,000.00
1058	Boiler Controls (Base Steam Boiler)	2015	2054	sqft	unit	$17,900.00			$17,900.00	RET	1	1	10.00	$17,900.00
1059	Boiler reset controls (Base Steam Boiler)	2015	2054	sqft	MMBtu saved	$27.95		($13.50)	$27.95	RET	1	1	20.00	$14.45
1060	Flue gas heat recovery (Base Steam Boiler)	2015	2054	sqft	MMBtu saved	$35.36			$35.36	RET	1	1	10.00	$35.36
1061	Condensate return (Base Steam Boiler)	2015	2054	sqft	unit	$38,000.00			$38,000.00	RET	1	1	10.00	$38,000.00
1062	Blowdown heat recovery (Base Steam Boiler)	2015	2054	sqft	MMBtu saved	$42.51			$42.51	RET	1	1	20.00	$42.51
1063	Flash steam Recovery	2015	2054	sqft	unit	$19,050.00			$19,050.00	RET	1	1	20.00	$19,050.00
1064	Improved insulation on steam lines	2015	2054	sqft	MMBtu saved	$14.43			$14.43	RET	1	1	15.00	$14.43
1065	Steam trap improvement/maintenance/monitoring	2015	2054	sqft	MMBtu saved	$7.67		($1.70)	$7.67	RET	1	1	3.00	$5.97
1066	Waste heat recovery (Base Steam Boiler)	2015	2054	sqft	MMBtu saved	$96.21			$96.21	RET	1	1	10.00	$96.21
1067	Direct contact water heating (low temperature only i.e. Food and Beverage)	2015	2054	sqft	MMBtu saved	$22.73			$22.73	RET	1	1	20.00	$22.73
1068	Custom (Base Steam Boiler)	2015	2054	sqft	MMBtu saved	$8.36		($1.70)	$8.36	ROB	1	1	5.00	$6.66
1100	Base Furnace	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
1101	Furnace maintenance	2015	2054	sqft	unit	$1,600.00			$1,600.00	RET	1	1	1.00	$1,600.00
1102	Improved Furnace Combustion Efficiency/Oxygen enrichment	2015	2054	sqft	unit	$5,000.00			$5,000.00	RET	1	1	5.00	$5,000.00
1103	Improve furnace insulation	2015	2054	sqft	unit	$7,750.00			$7,750.00	RET	1	1	10.00	$7,750.00
1104	Resize charging openings or add a movable door on furnace	2015	2054	sqft	unit	$500.00	$1,500.00		$2,000.00	RET	1	1	15.00	$2,000.00
1105	Preheated Combustion Air	2015	2054	sqft	unit	$216,800.00			$216,800.00	RET	1	1	20.00	$216,800.00
1106	Efficient furnace/oven	2015	2054	sqft	unit	$683,250.00			$683,250.00	RET	1	1	20.00	$683,250.00
1107	Custom (Base Furnace)	2015	2054	sqft	MMBtu saved	$66.91		($1.70)	$66.91	ROB	1	1	15.00	$65.21
1120	Base Process Heating	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
1121	Efficient drying systems	2015	2054	sqft	MMBtu saved	$88.14			$88.14	RET	1	1	20.00	$88.14
1122	Process heat recovery	2015	2054	sqft	unit	$48,000.00			$48,000.00	RET	1	1	20.00	$48,000.00
1123	Process integration	2015	2054	sqft	MMBtu saved	$39.48			$39.48	RET	1	1	10.00	$39.48
1124	Improved sensors and process control	2015	2054	sqft	MMBtu saved	$31.20			$31.20	RET	1	1	5.00	$31.20
1125	Custom (Base Process Heating)	2015	2054	sqft	MMBtu saved	$19.53		($1.70)	$19.53	ROB	1	1	12.00	$17.83
1140	Base Other Process	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
1141	Upgrading to steam blanchers (Food)	2015	2054	sqft	unit	$235,000.00			$235,000.00	RET	1	1	20.00	$235,000.00
1142	Mechanical dewatering/Moisture Reduction	2015	2054	sqft	unit	$175,000.00			$175,000.00	RET	1	1	20.00	$175,000.00
1143	Custom (Base Other Process)	2015	2054	sqft	MMBtu saved	$19.53		($1.70)	$19.53	ROB	1	1	12.00	$17.83
1160	Base HVAC	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
1161	Stack heat exchanger	2015	2054	sqft	MMBtu saved	$10.10			$10.10	RET	1	1	20.00	$10.10
1162	Duct insulation	2015	2054	sqft	facility	$11,300.00			$11,300.00	RET	1	1	5.00	$11,300.00
1163	Improve ceiling insulation	2015	2054	sqft	MMBtu saved	$7.11			$7.11	RET	1	1	5.00	$7.11
1164	EMS install	2015	2054	sqft	MMBtu saved	$25.91			$25.91	RET	1	1	10.00	$25.91
1165	EMS optimization	2015	2054	sqft	MMBtu saved	$7.30			$7.30	RET	1	1	10.00	$7.30
1166	Custom (Base HVAC)	2015	2054	sqft	MMBtu saved	$44.52		($1.70)	$44.52	ROB	1	1	16.00	$42.82

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Industrial Gas Measure Costs

Measure #	Measure Description	First Year	End Year	Savings Units	Cost Units	Unit Equipment Cost	Unit Labor Costs	NPV of Lifetime O&M Cost	Implementation Cost Factor	Implementation Type (RET/ROB)	Initial Cost	Replacement Cost	Measure File Service Life (Yrs)	Full Per Unit Cost
1180	Base CHP	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
1190	Base Other	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
1200	Base Whole Facility	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
1201	Energy management Program- Resource Conservation Manager (outside consultant)	2015	2054	sqft	facility	$76,783.50	$76,783.50		$153,566.99	RET	1	1	2.00	$153,566.99
1202	Superior energy performance certification	2015	2054	sqft	facility	$105,000.00	$214,000.00		$319,000.00	RET	1	1	3.00	$319,000.00
1203	Strategic Energy management- SEM (management agreement with outside tech support)	2015	2054	sqft	facility	$40,000.00	$80,000.00		$120,000.00	RET	1	1	4.00	$120,000.00
2000	Base Hot Water Boiler	2015	2054	sqft					$0.00	RET	1	1	20.00	$0.00
2001	High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	2015	2054	sqft	MMBtu saved	$30.54	$0.00		$30.54	ROB	0	1	25.00	$30.54
2002	Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	2015	2054	sqft	MMBtu saved	$28.67	$0.00		$28.67	ROB	0	1	18.00	$28.67
2003	Direct Fired Make-up Air System (Base Hot Water Boiler)	2015	2054	sqft	MMBtu saved	$53.69	$0.00		$53.69	ROB	0	1	20.00	$53.69
2007	Improved boiler pipe insulation (Base Hot Water Boiler)	2015	2054	sqft	MMBtu saved	$28.00	$0.00		$28.00	RET	1	1	15.00	$28.00
2009	Boiler Controls (Base Hot Water Boiler)	2015	2054	sqft	unit	$17,900.00			$17,900.00	RET	1	1	10.00	$17,900.00
2010	Boiler reset controls (Base Hot Water Boiler)	2015	2054	sqft	MMBtu saved	$27.95			$27.95	RET	1	1	20.00	$27.95
2011	Flue gas heat recovery (Base Hot Water Boiler)	2015	2054	sqft	MMBtu saved	$35.36	$0.00		$35.36	RET	1	1	10.00	$35.36
2012	Condensate return (Base Hot Water Boiler)	2015	2054	sqft	unit	$75,000.00	$0.00		$75,000.00	RET	1	1	10.00	$75,000.00
2013	Blowdown heat recovery (Base Hot Water Boiler)	2015	2054	sqft	MMBtu saved	$42.51	$0.00		$42.51	RET	1	1	20.00	$42.51
2014	Custom (Base Hot Water Boiler)	2015	2054	sqft	MMBtu saved	$8.36			$8.36	ROB	1	1	5.00	$8.36
2050	Base Steam Boiler	2015	2054	sqft					$0.00	RET	1	1	20.00	$0.00
2051	High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	2015	2054	sqft	MMBtu saved	$38.95	$0.00		$38.95	ROB	0	1	25.00	$38.95
2052	Direct Fired Make-up Air System (Base Steam Boiler)	2015	2054	sqft	MMBtu saved	$53.69	$0.00		$53.69	ROB	0	1	20.00	$53.69
2056	Improved boiler pipe insulation (Base Steam Boiler)	2015	2054	sqft	MMBtu saved	$27.00	$0.00		$27.00	RET	1	1	15.00	$27.00
2058	Boiler Controls (Base Steam Boiler)	2015	2054	sqft	unit	$17,900.00			$17,900.00	RET	1	1	10.00	$17,900.00
2059	Boiler reset controls (Base Steam Boiler)	2015	2054	sqft	MMBtu saved	$27.95	$0.00		$27.95	RET	1	1	20.00	$27.95
2060	Flue gas heat recovery (Base Steam Boiler)	2015	2054	sqft	MMBtu saved	$35.36	$0.00		$35.36	RET	1	1	10.00	$35.36
2061	Condensate return (Base Steam Boiler)	2015	2054	sqft	unit	$38,000.00	$0.00		$38,000.00	RET	1	1	10.00	$38,000.00
2062	Blowdown heat recovery (Base Steam Boiler)	2015	2054	sqft	MMBtu saved	$42.51	$0.00		$42.51	RET	1	1	20.00	$42.51
2063	Flash steam Recovery	2015	2054	sqft	unit	$19,050.00	$0.00		$19,050.00	RET	1	1	20.00	$19,050.00
2064	Improved insulation on steam lines	2015	2054	sqft	MMBtu saved	$14.43	$0.00		$14.43	RET	1	1	15.00	$14.43
2065	Steam trap improvement/maintenance/monitoring	2015	2054	sqft	MMBtu saved	$7.67	$0.00		$7.67	RET	1	1	3.00	$7.67
2066	Waste heat recovery (Base Steam Boiler)	2015	2054	sqft	MMBtu saved	$96.21	$0.00		$96.21	RET	1	1	10.00	$96.21
2067	Direct contact water heating (low temperature only i.e. Food and Beverage)	2015	2054	sqft	MMBtu saved	$22.73	$0.00		$22.73	RET	1	1	20.00	$22.73
2068	Custom (Base Steam Boiler)	2015	2054	sqft	MMBtu saved	$8.36			$8.36	ROB	1	1	5.00	$8.36
2100	Base Furnace	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
2105	Preheated Combustion Air	2015	2054	sqft	unit	$216,800.00	$0.00		$216,800.00	RET	1	1	20.00	$216,800.00
2107	Custom (Base Furnace)	2015	2054	sqft	MMBtu saved	$66.91			$66.91	ROB	1	1	15.00	$66.91
2120	Base Process Heating	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
2125	Custom (Base Process Heating)	2015	2054	sqft	MMBtu saved	$19.53			$19.53	ROB	1	1	12.00	$19.53
2140	Base Other Process	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
2143	Custom (Base Other Process)	2015	2054	sqft	MMBtu saved	$19.53			$19.53	ROB	1	1	12.00	$19.53
2160	Base HVAC	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
2161	Stack heat exchanger	2015	2054	sqft	MMBtu saved	$10.10	$0.00		$10.10	RET	1	1	20.00	$10.10
2164	EMS install	2015	2054	sqft	MMBtu saved	$25.91	$0.00		$25.91	RET	1	1	10.00	$25.91
2166	Custom (Base HVAC)	2015	2054	sqft	MMBtu saved	$44.52			$44.52	ROB	1	1	16.00	$44.52
2180	Base CHP	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
2190	Base Other	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
2200	Base Whole Facility	2015	2054	sqft					$0.00	RET	1	1	15.00	$0.00
2201	Energy management Program- Resource Conservation Manager (outside consultant)	2015	2054	sqft	facility	$76,783.50	$76,783.50		$153,566.99	RET	1	1	2.00	$153,566.99
2202	Superior energy performance certification	2015	2054	sqft	facility	$105,000.00	$214,000.00		$319,000.00	RET	1	1	3.00	$319,000.00
2203	Strategic Energy management- SEM (management agreement with outside tech support)	2015	2054	sqft	facility	$40,000.00	$80,000.00		$120,000.00	RET	1	1	4.00	$120,000.00

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Industrial Gas Measure Inputs Measure #	 Measure Description	APPLICABILITY FACTOR (percent) All Industrial Building Type 1
1000	Base Hot Water Boiler	44.7%
1001	High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	44.7%
1002	Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	44.7%
1003	Direct Fired Make-up Air System (Base Hot Water Boiler)	44.7%
1004	Process optimization/Load management techniques (Base Hot Water Boiler)	44.7%
1005	Improved Boiler Combustion Efficiency (Tune up)	44.7%
1006	Properly sized system (Base Hot Water Boiler)	44.7%
1007	Improved boiler pipe insulation (Base Hot Water Boiler)	44.7%
1008	Boiler maintenance and fouling reduction (Base Hot Water Boiler)	22.4%
1009	Boiler Controls (Base Hot Water Boiler)	44.7%
1010	Boiler reset controls (Base Hot Water Boiler)	44.7%
1011	Flue gas heat recovery (Base Hot Water Boiler)	44.7%
1012	Condensate return (Base Hot Water Boiler)	22.4%
1013	Blowdown heat recovery (Base Hot Water Boiler)	44.7%
1014	Custom (Base Hot Water Boiler)	44.7%
1050	Base Steam Boiler	20.5%
1051	High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	20.5%
1052	Direct Fired Make-up Air System (Base Steam Boiler)	20.5%
1053	Process optimization/Load management techniques (Base Steam Boiler)	20.5%
1054	Improved Boiler Combustion Efficiency (Tune up) (Base Steam Boiler)	20.5%
1055	Properly sized system (Base Steam Boiler)	20.5%
1056	Improved boiler pipe insulation (Base Steam Boiler)	20.5%
1057	Boiler maintenance and fouling reduction (Base Steam Boiler)	10.3%
1058	Boiler Controls (Base Steam Boiler)	20.5%
1059	Boiler reset controls (Base Steam Boiler)	20.5%
1060	Flue gas heat recovery (Base Steam Boiler)	20.5%
1061	Condensate return (Base Steam Boiler)	10.3%
1062	Blowdown heat recovery (Base Steam Boiler)	20.5%
1063	Flash steam Recovery	20.5%
1064	Improved insulation on steam lines	20.5%
1065	Steam trap improvement/maintenance/monitoring	20.5%
1066	Waste heat recovery (Base Steam Boiler)	20.5%
1067	Direct contact water heating (low temperature only i.e. Food and Beverage)	4.1%
1068	Custom (Base Steam Boiler)	20.5%

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Industrial Gas Measure Inputs Measure #	 Measure Description	APPLICABILITY FACTOR (percent) All Industrial Building Type 1
1100	Base Furnace	2.9%
1101	Furnace maintenance	2.9%
1102	Improved Furnace Combustion Efficiency/Oxygen enrichment	2.9%
1103	Improve furnace insulation	2.9%
1104	Resize charging openings or add a movable door on furnace	2.9%
1105	Preheated Combustion Air	2.9%
1106	Efficient furnace/oven	2.9%
1107	Custom (Base Furnace)	2.9%
1120	Base Process Heating	9.8%
1121	Efficient drying systems	9.8%
1122	Process heat recovery	9.8%
1123	Process integration	9.8%
1124	Improved sensors and process control	9.8%
1125	Custom (Base Process Heating)	9.8%
1140	Base Other Process	2.1%
1141	Upgrading to steam blanchers (Food)	2.1%
1142	Mechanical dewatering/Moisture Reduction	2.1%
1143	Custom (Base Other Process)	2.1%
1160	Base HVAC	32.1%
1161	Stack heat exchanger	32.1%
1162	Duct insulation	32.1%
1163	Improve ceiling insulation	32.1%
1164	EMS install	32.1%
1165	EMS optimization	32.1%
1166	Custom (Base HVAC)	32.1%
1180	Base CHP	20.0%
1190	Base Other	25.2%
1200	Base Whole Facility	100.0%
1201	Energy management Program- Resource Conservation Manager (outside consultant)	5.0%
1202	Superior energy performance certification	5.0%
1203	Strategic Energy management- SEM (management agreement with outside tech support)	5.0%
2000	Base Hot Water Boiler	44.7%
2001	High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	44.7%
2002	Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	44.7%

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Industrial Gas Measure Inputs Measure #	 Measure Description	APPLICABILITY FACTOR (percent) All Industrial Building Type 1
2003	Direct Fired Make-up Air System (Base Hot Water Boiler)	44.7%
2007	Improved boiler pipe insulation (Base Hot Water Boiler)	44.7%
2009	Boiler Controls (Base Hot Water Boiler)	22.4%
2010	Boiler reset controls (Base Hot Water Boiler)	44.7%
2011	Flue gas heat recovery (Base Hot Water Boiler)	44.7%
2012	Condensate return (Base Hot Water Boiler)	22.4%
2013	Blowdown heat recovery (Base Hot Water Boiler)	44.7%
2014	Custom (Base Hot Water Boiler)	44.7%
2050	Base Steam Boiler	20.5%
2051	High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	20.5%
2052	Direct Fired Make-up Air System (Base Steam Boiler)	20.5%
2056	Improved boiler pipe insulation (Base Steam Boiler)	20.5%
2058	Boiler Controls (Base Steam Boiler)	10.3%
2059	Boiler reset controls (Base Steam Boiler)	20.5%
2060	Flue gas heat recovery (Base Steam Boiler)	20.5%
2061	Condensate return (Base Steam Boiler)	10.3%
2062	Blowdown heat recovery (Base Steam Boiler)	20.5%
2063	Flash steam Recovery	20.5%
2064	Improved insulation on steam lines	20.5%
2065	Steam trap improvement/maintenance/monitoring	20.5%
2066	Waste heat recovery (Base Steam Boiler)	20.5%
2067	Direct contact water heating (low temperature only i.e. Food and Beverage)	4.1%
2068	Custom (Base Steam Boiler)	20.5%
2100	Base Furnace	2.9%
2105	Preheated Combustion Air	2.9%
2107	Custom (Base Furnace)	2.9%
2120	Base Process Heating	9.8%
2125	Custom (Base Process Heating)	9.8%
2140	Base Other Process	2.1%
2143	Custom (Base Other Process)	2.1%
2160	Base HVAC	32.1%
2161	Stack heat exchanger	32.1%
2164	EMS install	32.1%
2166	Custom (Base HVAC)	32.1%

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Industrial Gas Measure Inputs		APPLICABILITY FACTOR (percent)
		All Industrial
Measure #	Measure Description	Building Type 1
2180	Base CHP	20.0%
2190	Base Other	25.2%
2200	Base Whole Facility	100.0%
2201	Energy management Program- Resource Conservation Manager (outside consultant)	5.0%
2202	Superior energy performance certification	5.0%
2203	Strategic Energy management- SEM (management agreement with outside tech support)	5.0%

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Industrial Gas Measure Inputs		ENERGY SAVINGS (percent)
Measure #	Measure Description	All Industiral Building Type 1
1000	Base Hot Water Boiler	0%
1001	High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	7%
1002	Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	13%
1003	Direct Fired Make-up Air System (Base Hot Water Boiler)	16%
1004	Process optimization/Load management techniques (Base Hot Water Boiler)	14%
1005	Improved Boiler Combustion Efficiency (Tune up)	5%
1006	Properly sized system (Base Hot Water Boiler)	5%
1007	Improved boiler pipe insulation (Base Hot Water Boiler)	2%
1008	Boiler maintenance and fouling reduction (Base Hot Water Boiler)	5%
1009	Boiler Controls (Base Hot Water Boiler)	3%
1010	Boiler reset controls (Base Hot Water Boiler)	5%
1011	Flue gas heat recovery (Base Hot Water Boiler)	1%
1012	Condensate return (Base Hot Water Boiler)	10%
1013	Blowdown heat recovery (Base Hot Water Boiler)	6%
1014	Custom (Base Hot Water Boiler)	15%
1050	Base Steam Boiler	0%
1051	High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	5%
1052	Direct Fired Make-up Air System (Base Steam Boiler)	16%
1053	Process optimization/Load management techniques (Base Steam Boiler)	14%
1054	Improved Boiler Combustion Efficiency (Tune up) (Base Steam Boiler)	5%
1055	Properly sized system (Base Steam Boiler)	5%
1056	Improved boiler pipe insulation (Base Steam Boiler)	2%
1057	Boiler maintenance and fouling reduction (Base Steam Boiler)	5%
1058	Boiler Controls (Base Steam Boiler)	3%
1059	Boiler reset controls (Base Steam Boiler)	5%
1060	Flue gas heat recovery (Base Steam Boiler)	1%
1061	Condensate return (Base Steam Boiler)	10%
1062	Blowdown heat recovery (Base Steam Boiler)	6%
1063	Flash steam Recovery	20%
1064	Improved insulation on steam lines	2%
1065	Steam trap improvement/maintenance/monitoring	7%
1066	Waste heat recovery (Base Steam Boiler)	6%
1067	Direct contact water heating (low temperature only i.e. Food and Beverage)	34%
1068	Custom (Base Steam Boiler)	15%

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Industrial Gas Measure Inputs		**ENERGY SAVINGS (percent)**
Measure #	Measure Description	All Industiral Building Type 1
1100	Base Furnace	0%
1101	Furnace maintenance	2%
1102	Improved Furnace Combustion Efficiency/Oxygen enrichment	22%
1103	Improve furnace insulation	2%
1104	Resize charging openings or add a movable door on furnace	3%
1105	Preheated Combustion Air	13%
1106	Efficient furnace/oven	10%
1107	Custom (Base Furnace)	15%
1120	Base Process Heating	0%
1121	Efficient drying systems	20%
1122	Process heat recovery	7%
1123	Process integration	25%
1124	Improved sensors and process control	5%
1125	Custom (Base Process Heating)	19%
1140	Base Other Process	0%
1141	Upgrading to steam blanchers (Food)	50%
1142	Mechanical dewatering/Moisture Reduction	20%
1143	Custom (Base Other Process)	19%
1160	Base HVAC	0%
1161	Stack heat exchanger	5%
1162	Duct insulation	11%
1163	Improve ceiling insulation	19%
1164	EMS install	10%
1165	EMS optimization	1%
1166	Custom (Base HVAC)	15%
1180	Base CHP	0%
1190	Base Other	0%
1200	Base Whole Facility	0%
1201	Energy management Program- Resource Conservation Manager (outside consultant)	8%
1202	Superior energy performance certification	6%
1203	Strategic Energy management- SEM (management agreement with outside tech support)	2%
2000	Base Hot Water Boiler	
2001	High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	7%
2002	Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	13%

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Industrial Gas Measure Inputs Measure #	Measure Description	ENERGY SAVINGS (percent) All Industiral Building Type 1
2003	Direct Fired Make-up Air System (Base Hot Water Boiler)	16%
2007	Improved boiler pipe insulation (Base Hot Water Boiler)	2%
2009	Boiler Controls (Base Hot Water Boiler)	3%
2010	Boiler reset controls (Base Hot Water Boiler)	5%
2011	Flue gas heat recovery (Base Hot Water Boiler)	1%
2012	Condensate return (Base Hot Water Boiler)	10%
2013	Blowdown heat recovery (Base Hot Water Boiler)	6%
2014	Custom (Base Hot Water Boiler)	15%
2050	Base Steam Boiler	
2051	High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	5%
2052	Direct Fired Make-up Air System (Base Steam Boiler)	16%
2056	Improved boiler pipe insulation (Base Steam Boiler)	2%
2058	Boiler Controls (Base Steam Boiler)	3%
2059	Boiler reset controls (Base Steam Boiler)	5%
2060	Flue gas heat recovery (Base Steam Boiler)	1%
2061	Condensate return (Base Steam Boiler)	10%
2062	Blowdown heat recovery (Base Steam Boiler)	6%
2063	Flash steam Recovery	20%
2064	Improved insulation on steam lines	2%
2065	Steam trap improvement/maintenance/monitoring	7%
2066	Waste heat recovery (Base Steam Boiler)	6%
2067	Direct contact water heating (low temperature only i.e. Food and Beverage)	34%
2068	Custom (Base Steam Boiler)	15%
2100	Base Furnace	
2105	Preheated Combustion Air	13%
2107	Custom (Base Furnace)	15%
2120	Base Process Heating	
2125	Custom (Base Process Heating)	19%
2140	Base Other Process	
2143	Custom (Base Other Process)	19%
2160	Base HVAC	
2161	Stack heat exchanger	5%
2164	EMS install	10%
2166	Custom (Base HVAC)	15%

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Industrial Gas Measure Inputs		ENERGY SAVINGS (percent)
Measure #	Measure Description	All Industiral Building Type 1
2180	Base CHP	
2190	Base Other	
2200	Base Whole Facility	
2201	Energy management Program- Resource Conservation Manager (outside consultant)	8%
2202	Superior energy performance certification	6%
2203	Strategic Energy management- SEM (management agreement with outside tech support)	2%

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Industrial Gas Measure Inputs		**Standards Adjustment Factor (percent)**
Measure #	Measure Description	All Industrial Building Type 1
1000	Base Hot Water Boiler	100%
1001	High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	100%
1002	Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	100%
1003	Direct Fired Make-up Air System (Base Hot Water Boiler)	100%
1004	Process optimization/Load management techniques (Base Hot Water Boiler)	100%
1005	Improved Boiler Combustion Efficiency (Tune up)	100%
1006	Properly sized system (Base Hot Water Boiler)	100%
1007	Improved boiler pipe insulation (Base Hot Water Boiler)	100%
1008	Boiler maintenance and fouling reduction (Base Hot Water Boiler)	100%
1009	Boiler Controls (Base Hot Water Boiler)	100%
1010	Boiler reset controls (Base Hot Water Boiler)	100%
1011	Flue gas heat recovery (Base Hot Water Boiler)	100%
1012	Condensate return (Base Hot Water Boiler)	100%
1013	Blowdown heat recovery (Base Hot Water Boiler)	100%
1014	Custom (Base Hot Water Boiler)	100%
1050	Base Steam Boiler	100%
1051	High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	100%
1052	Direct Fired Make-up Air System (Base Steam Boiler)	100%
1053	Process optimization/Load management techniques (Base Steam Boiler)	100%
1054	Improved Boiler Combustion Efficiency (Tune up) (Base Steam Boiler)	100%
1055	Properly sized system (Base Steam Boiler)	100%
1056	Improved boiler pipe insulation (Base Steam Boiler)	100%
1057	Boiler maintenance and fouling reduction (Base Steam Boiler)	100%
1058	Boiler Controls (Base Steam Boiler)	100%
1059	Boiler reset controls (Base Steam Boiler)	100%
1060	Flue gas heat recovery (Base Steam Boiler)	100%
1061	Condensate return (Base Steam Boiler)	100%
1062	Blowdown heat recovery (Base Steam Boiler)	100%
1063	Flash steam Recovery	100%
1064	Improved insulation on steam lines	100%
1065	Steam trap improvement/maintenance/monitoring	100%
1066	Waste heat recovery (Base Steam Boiler)	100%
1067	Direct contact water heating (low temperature only i.e. Food and Beverage)	100%
1068	Custom (Base Steam Boiler)	100%

Industrial Gas Measure Inputs		Standards Adjustment Factor (percent)
Measure #	Measure Description	All Industrial Building Type 1
1100	Base Furnace	100%
1101	Furnace maintenance	100%
1102	Improved Furnace Combustion Efficiency/Oxygen enrichment	100%
1103	Improve furnace insulation	100%
1104	Resize charging openings or add a movable door on furnace	100%
1105	Preheated Combustion Air	100%
1106	Efficient furnace/oven	100%
1107	Custom (Base Furnace)	100%
1120	Base Process Heating	100%
1121	Efficient drying systems	100%
1122	Process heat recovery	100%
1123	Process integration	100%
1124	Improved sensors and process control	100%
1125	Custom (Base Process Heating)	100%
1140	Base Other Process	100%
1141	Upgrading to steam blanchers (Food)	100%
1142	Mechanical dewatering/Moisture Reduction	100%
1143	Custom (Base Other Process)	100%
1160	Base HVAC	100%
1161	Stack heat exchanger	100%
1162	Duct insulation	100%
1163	Improve ceiling insulation	100%
1164	EMS install	100%
1165	EMS optimization	100%
1166	Custom (Base HVAC)	100%
1180	Base CHP	100%
1190	Base Other	100%
1200	Base Whole Facility	100%
1201	Energy management Program- Resource Conservation Manager (outside consultant)	100%
1202	Superior energy performance certification	100%
1203	Strategic Energy management- SEM (management agreement with outside tech support)	100%
2000	Base Hot Water Boiler	100%
2001	High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	100%
2002	Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	100%

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Industrial Gas Measure Inputs		Standards Adjustment Factor (percent)
Measure #	Measure Description	All Industrial Building Type 1
2003	Direct Fired Make-up Air System (Base Hot Water Boiler)	100%
2007	Improved boiler pipe insulation (Base Hot Water Boiler)	100%
2009	Boiler Controls (Base Hot Water Boiler)	100%
2010	Boiler reset controls (Base Hot Water Boiler)	100%
2011	Flue gas heat recovery (Base Hot Water Boiler)	100%
2012	Condensate return (Base Hot Water Boiler)	100%
2013	Blowdown heat recovery (Base Hot Water Boiler)	100%
2014	Custom (Base Hot Water Boiler)	100%
2050	Base Steam Boiler	100%
2051	High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	100%
2052	Direct Fired Make-up Air System (Base Steam Boiler)	100%
2056	Improved boiler pipe insulation (Base Steam Boiler)	100%
2058	Boiler Controls (Base Steam Boiler)	100%
2059	Boiler reset controls (Base Steam Boiler)	100%
2060	Flue gas heat recovery (Base Steam Boiler)	100%
2061	Condensate return (Base Steam Boiler)	100%
2062	Blowdown heat recovery (Base Steam Boiler)	100%
2063	Flash steam Recovery	100%
2064	Improved insulation on steam lines	100%
2065	Steam trap improvement/maintenance/monitoring	100%
2066	Waste heat recovery (Base Steam Boiler)	100%
2067	Direct contact water heating (low temperature only i.e. Food and Beverage)	100%
2068	Custom (Base Steam Boiler)	100%
2100	Base Furnace	100%
2105	Preheated Combustion Air	100%
2107	Custom (Base Furnace)	100%
2120	Base Process Heating	100%
2125	Custom (Base Process Heating)	100%
2140	Base Other Process	100%
2143	Custom (Base Other Process)	100%
2160	Base HVAC	100%
2161	Stack heat exchanger	100%
2164	EMS install	100%
2166	Custom (Base HVAC)	100%

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Industrial Gas Measure Inputs		**Standards Adjustment Factor (percent)**
		All Industrial
Measure #	Measure Description	Building Type 1
2180	Base CHP	100%
2190	Base Other	100%
2200	Base Whole Facility	100%
2201	Energy management Program- Resource Conservation Manager (outside consultant)	100%
2202	Superior energy performance certification	100%
2203	Strategic Energy management- SEM (management agreement with outside tech support)	100%

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Industrial Gas Measure Inputs Measure #	Measure Description	INCOMPLETE FACTOR (percent) All Industrial Building Type 1
1000	Base Hot Water Boiler	100%
1001	High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	99%
1002	Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	75%
1003	Direct Fired Make-up Air System (Base Hot Water Boiler)	80%
1004	Process optimization/Load management techniques (Base Hot Water Boiler)	100%
1005	Improved Boiler Combustion Efficiency (Tune up)	100%
1006	Properly sized system (Base Hot Water Boiler)	100%
1007	Improved boiler pipe insulation (Base Hot Water Boiler)	100%
1008	Boiler maintenance and fouling reduction (Base Hot Water Boiler)	100%
1009	Boiler Controls (Base Hot Water Boiler)	80%
1010	Boiler reset controls (Base Hot Water Boiler)	80%
1011	Flue gas heat recovery (Base Hot Water Boiler)	100%
1012	Condensate return (Base Hot Water Boiler)	100%
1013	Blowdown heat recovery (Base Hot Water Boiler)	100%
1014	Custom (Base Hot Water Boiler)	100%
1050	Base Steam Boiler	100%
1051	High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	90%
1052	Direct Fired Make-up Air System (Base Steam Boiler)	100%
1053	Process optimization/Load management techniques (Base Steam Boiler)	100%
1054	Improved Boiler Combustion Efficiency (Tune up) (Base Steam Boiler)	100%
1055	Properly sized system (Base Steam Boiler)	100%
1056	Improved boiler pipe insulation (Base Steam Boiler)	100%
1057	Boiler maintenance and fouling reduction (Base Steam Boiler)	100%
1058	Boiler Controls (Base Steam Boiler)	80%
1059	Boiler reset controls (Base Steam Boiler)	100%
1060	Flue gas heat recovery (Base Steam Boiler)	95%
1061	Condensate return (Base Steam Boiler)	100%
1062	Blowdown heat recovery (Base Steam Boiler)	100%
1063	Flash steam Recovery	100%
1064	Improved insulation on steam lines	100%
1065	Steam trap improvement/maintenance/monitoring	88%
1066	Waste heat recovery (Base Steam Boiler)	96%

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Industrial Gas Measure Inputs		INCOMPLETE FACTOR (percent)
Measure #	Measure Description	All Industrial Building Type 1
1067	Direct contact water heating (low temperature only i.e. Food and Beverage)	100%
1068	Custom (Base Steam Boiler)	100%
1100	Base Furnace	100%
1101	Furnace maintenance	100%
1102	Improved Furnace Combustion Efficiency/Oxygen enrichment	97%
1103	Improve furnace insulation	95%
1104	Resize charging openings or add a movable door on furnace	99%
1105	Preheated Combustion Air	97%
1106	Efficient furnace/oven	99%
1107	Custom (Base Furnace)	100%
1120	Base Process Heating	100%
1121	Efficient drying systems	87%
1122	Process heat recovery	82%
1123	Process integration	80%
1124	Improved sensors and process control	81%
1125	Custom (Base Process Heating)	100%
1140	Base Other Process	100%
1141	Upgrading to steam blanchers (Food)	97%
1142	Mechanical dewatering/Moisture Reduction	95%
1143	Custom (Base Other Process)	100%
1160	Base HVAC	100%
1161	Stack heat exchanger	100%
1162	Duct insulation	100%
1163	Improve ceiling insulation	100%
1164	EMS install	83%
1165	EMS optimization	100%
1166	Custom (Base HVAC)	100%
1180	Base CHP	100%
1190	Base Other	100%
1200	Base Whole Facility	100%
1201	Energy management Program- Resource Conservation Manager (outside consultant)	100%
1202	Superior energy performance certification	100%

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Industrial Gas Measure Inputs Measure #	Measure Description	**INCOMPLETE FACTOR (percent)** All Industrial Building Type 1
1203	Strategic Energy management- SEM (management agreement with outside tech support)	100%
2000	Base Hot Water Boiler	100%
2001	High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	99%
2002	Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	75%
2003	Direct Fired Make-up Air System (Base Hot Water Boiler)	80%
2007	Improved boiler pipe insulation (Base Hot Water Boiler)	100%
2009	Boiler Controls (Base Hot Water Boiler)	80%
2010	Boiler reset controls (Base Hot Water Boiler)	80%
2011	Flue gas heat recovery (Base Hot Water Boiler)	100%
2012	Condensate return (Base Hot Water Boiler)	100%
2013	Blowdown heat recovery (Base Hot Water Boiler)	100%
2014	Custom (Base Hot Water Boiler)	100%
2050	Base Steam Boiler	100%
2051	High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	90%
2052	Direct Fired Make-up Air System (Base Steam Boiler)	100%
2056	Improved boiler pipe insulation (Base Steam Boiler)	100%
2058	Boiler Controls (Base Steam Boiler)	80.0%
2059	Boiler reset controls (Base Steam Boiler)	100%
2060	Flue gas heat recovery (Base Steam Boiler)	95%
2061	Condensate return (Base Steam Boiler)	100.0%
2062	Blowdown heat recovery (Base Steam Boiler)	100%
2063	Flash steam Recovery	100%
2064	Improved insulation on steam lines	100.0%
2065	Steam trap improvement/maintenance/monitoring	88%
2066	Waste heat recovery (Base Steam Boiler)	96%
2067	Direct contact water heating (low temperature only i.e. Food and Beverage)	100.0%
2068	Custom (Base Steam Boiler)	100%
2100	Base Furnace	100%
2105	Preheated Combustion Air	97.3%
2107	Custom (Base Furnace)	100%
2120	Base Process Heating	100%
2125	Custom (Base Process Heating)	100.0%

Industrial Gas Measure Inputs		INCOMPLETE FACTOR (percent)
Measure #	Measure Description	All Industrial Building Type 1
2140	Base Other Process	100%
2143	Custom (Base Other Process)	100%
2160	Base HVAC	100.0%
2161	Stack heat exchanger	100%
2164	EMS install	83%
2166	Custom (Base HVAC)	100.0%
2180	Base CHP	100%
2190	Base Other	100%
2200	Base Whole Facility	100.0%
2201	Energy management Program- Resource Conservation Manager (outside consultant)	100%
2202	Superior energy performance certification	100%
2203	Strategic Energy management- SEM (management agreement with outside tech support)	100.0%

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Industrial Gas Measure Inputs Measure #	Measure Description	**FEASIBILITY FACTOR (percent)** All Industrial Building Type 1
1000	Base Hot Water Boiler	100%
1001	High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	100%
1002	Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	100%
1003	Direct Fired Make-up Air System (Base Hot Water Boiler)	100%
1004	Process optimization/Load management techniques (Base Hot Water Boiler)	59%
1005	Improved Boiler Combustion Efficiency (Tune up)	20%
1006	Properly sized system (Base Hot Water Boiler)	100%
1007	Improved boiler pipe insulation (Base Hot Water Boiler)	100%
1008	Boiler maintenance and fouling reduction (Base Hot Water Boiler)	20%
1009	Boiler Controls (Base Hot Water Boiler)	100%
1010	Boiler reset controls (Base Hot Water Boiler)	100%
1011	Flue gas heat recovery (Base Hot Water Boiler)	50%
1012	Condensate return (Base Hot Water Boiler)	2%
1013	Blowdown heat recovery (Base Hot Water Boiler)	41%
1014	Custom (Base Hot Water Boiler)	100%
1050	Base Steam Boiler	100%
1051	High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	100%
1052	Direct Fired Make-up Air System (Base Steam Boiler)	100%
1053	Process optimization/Load management techniques (Base Steam Boiler)	59%
1054	Improved Boiler Combustion Efficiency (Tune up) (Base Steam Boiler)	20%
1055	Properly sized system (Base Steam Boiler)	100%
1056	Improved boiler pipe insulation (Base Steam Boiler)	100%
1057	Boiler maintenance and fouling reduction (Base Steam Boiler)	20%
1058	Boiler Controls (Base Steam Boiler)	100%
1059	Boiler reset controls (Base Steam Boiler)	100%
1060	Flue gas heat recovery (Base Steam Boiler)	50%
1061	Condensate return (Base Steam Boiler)	2%
1062	Blowdown heat recovery (Base Steam Boiler)	41%
1063	Flash steam Recovery	41%
1064	Improved insulation on steam lines	100%
1065	Steam trap improvement/maintenance/monitoring	50%
1066	Waste heat recovery (Base Steam Boiler)	100%

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Industrial Gas Measure Inputs		FEASIBILITY FACTOR (percent)
Measure #	Measure Description	All Industrial Building Type 1
1067	Direct contact water heating (low temperature only i.e. Food and Beverage)	100%
1068	Custom (Base Steam Boiler)	100%
1100	Base Furnace	100%
1101	Furnace maintenance	90%
1102	Improved Furnace Combustion Efficiency/Oxygen enrichment	38%
1103	Improve furnace insulation	80%
1104	Resize charging openings or add a movable door on furnace	56%
1105	Preheated Combustion Air	15%
1106	Efficient furnace/oven	30%
1107	Custom (Base Furnace)	100%
1120	Base Process Heating	100%
1121	Efficient drying systems	32%
1122	Process heat recovery	41%
1123	Process integration	52%
1124	Improved sensors and process control	69%
1125	Custom (Base Process Heating)	100%
1140	Base Other Process	100%
1141	Upgrading to steam blanchers (Food)	52%
1142	Mechanical dewatering/Moisture Reduction	40%
1143	Custom (Base Other Process)	100%
1160	Base HVAC	100%
1161	Stack heat exchanger	1%
1162	Duct insulation	15%
1163	Improve ceiling insulation	15%
1164	EMS install	15%
1165	EMS optimization	15%
1166	Custom (Base HVAC)	100%
1180	Base CHP	100%
1190	Base Other	100%
1200	Base Whole Facility	100%
1201	Energy management Program- Resource Conservation Manager (outside consultant)	100%
1202	Superior energy performance certification	100%

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Industrial Gas Measure Inputs		FEASIBILITY FACTOR (percent)
		All Industrial
Measure #	Measure Description	Building Type 1
1203	Strategic Energy management- SEM (management agreement with outside tech support)	100%
2000	Base Hot Water Boiler	100%
2001	High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	100%
2002	Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	100%
2003	Direct Fired Make-up Air System (Base Hot Water Boiler)	100%
2007	Improved boiler pipe insulation (Base Hot Water Boiler)	100%
2009	Boiler Controls (Base Hot Water Boiler)	100%
2010	Boiler reset controls (Base Hot Water Boiler)	100%
2011	Flue gas heat recovery (Base Hot Water Boiler)	50%
2012	Condensate return (Base Hot Water Boiler)	2%
2013	Blowdown heat recovery (Base Hot Water Boiler)	41%
2014	Custom (Base Hot Water Boiler)	100%
2050	Base Steam Boiler	100%
2051	High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	100%
2052	Direct Fired Make-up Air System (Base Steam Boiler)	100%
2056	Improved boiler pipe insulation (Base Steam Boiler)	100%
2058	Boiler Controls (Base Steam Boiler)	100%
2059	Boiler reset controls (Base Steam Boiler)	100%
2060	Flue gas heat recovery (Base Steam Boiler)	50%
2061	Condensate return (Base Steam Boiler)	2%
2062	Blowdown heat recovery (Base Steam Boiler)	41%
2063	Flash steam Recovery	41%
2064	Improved insulation on steam lines	100%
2065	Steam trap improvement/maintenance/monitoring	50%
2066	Waste heat recovery (Base Steam Boiler)	100%
2067	Direct contact water heating (low temperature only i.e. Food and Beverage)	100%
2068	Custom (Base Steam Boiler)	100%
2100	Base Furnace	100%
2105	Preheated Combustion Air	15%
2107	Custom (Base Furnace)	100%
2120	Base Process Heating	100%
2125	Custom (Base Process Heating)	100%

Industrial Gas Measure Inputs Measure #	Measure Description	FEASIBILITY FACTOR (percent) All Industrial Building Type 1
2140	Base Other Process	100%
2143	Custom (Base Other Process)	100%
2160	Base HVAC	100%
2161	Stack heat exchanger	1%
2164	EMS install	15%
2166	Custom (Base HVAC)	100%
2180	Base CHP	100%
2190	Base Other	100%
2200	Base Whole Facility	100%
2201	Energy management Program- Resource Conservation Manager (outside consultant)	100%
2202	Superior energy performance certification	100%
2203	Strategic Energy management- SEM (management agreement with outside tech support)	100%

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Industrial Gas Measure Inputs Measure #	 Measure Description	TECHNOLOGY SATURATION (units/square foot) All Industrial Building Type 1
1000	Base Hot Water Boiler	0.0118
1001	High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	0.0009
1002	Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	0.0018
1003	Direct Fired Make-up Air System (Base Hot Water Boiler)	0.0022
1004	Process optimization/Load management techniques (Base Hot Water Boiler)	0.0000
1005	Improved Boiler Combustion Efficiency (Tune up)	0.0007
1006	Properly sized system (Base Hot Water Boiler)	0.0000
1007	Improved boiler pipe insulation (Base Hot Water Boiler)	0.0003
1008	Boiler maintenance and fouling reduction (Base Hot Water Boiler)	0.0000
1009	Boiler Controls (Base Hot Water Boiler)	0.0000
1010	Boiler reset controls (Base Hot Water Boiler)	0.0007
1011	Flue gas heat recovery (Base Hot Water Boiler)	0.0001
1012	Condensate return (Base Hot Water Boiler)	0.0000
1013	Blowdown heat recovery (Base Hot Water Boiler)	0.0008
1014	Custom (Base Hot Water Boiler)	0.0020
1050	Base Steam Boiler	0.1330
1051	High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	0.0072
1052	Direct Fired Make-up Air System (Base Steam Boiler)	0.0231
1053	Process optimization/Load management techniques (Base Steam Boiler)	0.0000
1054	Improved Boiler Combustion Efficiency (Tune up) (Base Steam Boiler)	0.0072
1055	Properly sized system (Base Steam Boiler)	0.0003
1056	Improved boiler pipe insulation (Base Steam Boiler)	0.0029
1057	Boiler maintenance and fouling reduction (Base Steam Boiler)	0.0001
1058	Boiler Controls (Base Steam Boiler)	0.0000
1059	Boiler reset controls (Base Steam Boiler)	0.0072
1060	Flue gas heat recovery (Base Steam Boiler)	0.0014
1061	Condensate return (Base Steam Boiler)	0.0000
1062	Blowdown heat recovery (Base Steam Boiler)	0.0086
1063	Flash steam Recovery	0.0000
1064	Improved insulation on steam lines	0.0022
1065	Steam trap improvement/maintenance/monitoring	0.0102
1066	Waste heat recovery (Base Steam Boiler)	0.0087

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Industrial Gas Measure Inputs		TECHNOLOGY SATURATION (units/square foot)
Measure #	Measure Description	All Industrial Building Type 1
1067	Direct contact water heating (low temperature only i.e. Food and Beverage)	0.0490
1068	Custom (Base Steam Boiler)	0.0216
1100	Base Furnace	2.1769
1101	Furnace maintenance	0.0001
1102	Improved Furnace Combustion Efficiency/Oxygen enrichment	0.0001
1103	Improve furnace insulation	0.0001
1104	Resize charging openings or add a movable door on furnace	0.0001
1105	Preheated Combustion Air	0.0001
1106	Efficient furnace/oven	0.0001
1107	Custom (Base Furnace)	0.0876
1120	Base Process Heating	0.0002
1121	Efficient drying systems	0.1199
1122	Process heat recovery	0.0000
1123	Process integration	0.1535
1124	Improved sensors and process control	0.0295
1125	Custom (Base Process Heating)	0.1109
1140	Base Other Process	0.0001
1141	Upgrading to steam blanchers (Food)	0.0000
1142	Mechanical dewatering/Moisture Reduction	0.0000
1143	Custom (Base Other Process)	0.0718
1160	Base HVAC	0.0014
1161	Stack heat exchanger	0.0049
1162	Duct insulation	0.0000
1163	Improve ceiling insulation	0.0182
1164	EMS install	0.0100
1165	EMS optimization	0.0010
1166	Custom (Base HVAC)	0.0147
1180	Base CHP	0.0000
1190	Base Other	0.0000
1200	Base Whole Facility	0.0000
1201	Energy management Program- Resource Conservation Manager (outside consultant)	0.0000

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Industrial Gas Measure Inputs Measure #	 Measure Description	TECHNOLOGY SATURATION (units/square foot) All Industrial Building Type 1
1202	Superior energy performance certification	0.0000
1203	Strategic Energy management- SEM (management agreement with outside tech support)	0.0000
2000	Base Hot Water Boiler	0.0118
2001	High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	0.0009
2002	Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	0.0018
2003	Direct Fired Make-up Air System (Base Hot Water Boiler)	0.0022
2007	Improved boiler pipe insulation (Base Hot Water Boiler)	0.0003
2009	Boiler Controls (Base Hot Water Boiler)	0.0000
2010	Boiler reset controls (Base Hot Water Boiler)	0.0007
2011	Flue gas heat recovery (Base Hot Water Boiler)	0.0001
2012	Condensate return (Base Hot Water Boiler)	0.0000
2013	Blowdown heat recovery (Base Hot Water Boiler)	0.0008
2014	Custom (Base Hot Water Boiler)	0.0020
2050	Base Steam Boiler	0.1330
2051	High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	0.0072
2052	Direct Fired Make-up Air System (Base Steam Boiler)	0.0231
2056	Improved boiler pipe insulation (Base Steam Boiler)	0.0029
2058	Boiler Controls (Base Steam Boiler)	0.0000
2059	Boiler reset controls (Base Steam Boiler)	0.0072
2060	Flue gas heat recovery (Base Steam Boiler)	0.0014
2061	Condensate return (Base Steam Boiler)	0.0000
2062	Blowdown heat recovery (Base Steam Boiler)	0.0086
2063	Flash steam Recovery	0.0000
2064	Improved insulation on steam lines	0.0022
2065	Steam trap improvement/maintenance/monitoring	0.0102
2066	Waste heat recovery (Base Steam Boiler)	0.0087
2067	Direct contact water heating (low temperature only i.e. Food and Beverage)	0.0490
2068	Custom (Base Steam Boiler)	0.0216
2100	Base Furnace	2.1769
2105	Preheated Combustion Air	0.0001
2107	Custom (Base Furnace)	0.0876
2120	Base Process Heating	0.0002

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Industrial Gas Measure Inputs		TECHNOLOGY SATURATION (units/square foot)
Measure #	Measure Description	All Industrial Building Type 1
2125	Custom (Base Process Heating)	0.1109
2140	Base Other Process	0.0001
2143	Custom (Base Other Process)	0.0718
2160	Base HVAC	0.0014
2161	Stack heat exchanger	0.0049
2164	EMS install	0.0100
2166	Custom (Base HVAC)	0.0147
2180	Base CHP	0.0000
2190	Base Other	0.0000
2200	Base Whole Facility	0.0000
2201	Energy management Program- Resource Conservation Manager (outside consultant)	0.0000
2202	Superior energy performance certification	0.0000
2203	Strategic Energy management- SEM (management agreement with outside tech support)	0.0000

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Industrial Gas Measure Inputs		APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)
		All Industrial
Measure #	Measure Description	Building Type 1
1000	Base Hot Water Boiler	45%
1001	High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	44%
1002	Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	34%
1003	Direct Fired Make-up Air System (Base Hot Water Boiler)	36%
1004	Process optimization/Load management techniques (Base Hot Water Boiler)	26%
1005	Improved Boiler Combustion Efficiency (Tune up)	9%
1006	Properly sized system (Base Hot Water Boiler)	45%
1007	Improved boiler pipe insulation (Base Hot Water Boiler)	45%
1008	Boiler maintenance and fouling reduction (Base Hot Water Boiler)	4%
1009	Boiler Controls (Base Hot Water Boiler)	36%
1010	Boiler reset controls (Base Hot Water Boiler)	36%
1011	Flue gas heat recovery (Base Hot Water Boiler)	22%
1012	Condensate return (Base Hot Water Boiler)	0%
1013	Blowdown heat recovery (Base Hot Water Boiler)	18%
1014	Custom (Base Hot Water Boiler)	45%
1050	Base Steam Boiler	21%
1051	High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	18%
1052	Direct Fired Make-up Air System (Base Steam Boiler)	21%
1053	Process optimization/Load management techniques (Base Steam Boiler)	12%
1054	Improved Boiler Combustion Efficiency (Tune up) (Base Steam Boiler)	4%
1055	Properly sized system (Base Steam Boiler)	21%
1056	Improved boiler pipe insulation (Base Steam Boiler)	21%
1057	Boiler maintenance and fouling reduction (Base Steam Boiler)	2%
1058	Boiler Controls (Base Steam Boiler)	16%
1059	Boiler reset controls (Base Steam Boiler)	21%
1060	Flue gas heat recovery (Base Steam Boiler)	10%
1061	Condensate return (Base Steam Boiler)	0%
1062	Blowdown heat recovery (Base Steam Boiler)	8%
1063	Flash steam Recovery	8%
1064	Improved insulation on steam lines	21%
1065	Steam trap improvement/maintenance/monitoring	9%
1066	Waste heat recovery (Base Steam Boiler)	20%
1067	Direct contact water heating (low temperature only i.e. Food and Beverage)	4%
1068	Custom (Base Steam Boiler)	21%
1100	Base Furnace	3%

DNV·GL

Industrial Gas Measure Inputs		APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)
		All Industrial
Measure #	Measure Description	Building Type 1
1101	Furnace maintenance	3%
1102	Improved Furnace Combustion Efficiency/Oxygen enrichment	1%
1103	Improve furnace insulation	2%
1104	Resize charging openings or add a movable door on furnace	2%
1105	Preheated Combustion Air	0%
1106	Efficient furnace/oven	1%
1107	Custom (Base Furnace)	3%
1120	Base Process Heating	10%
1121	Efficient drying systems	3%
1122	Process heat recovery	3%
1123	Process integration	4%
1124	Improved sensors and process control	5%
1125	Custom (Base Process Heating)	10%
1140	Base Other Process	2%
1141	Upgrading to steam blanchers (Food)	1%
1142	Mechanical dewatering/Moisture Reduction	1%
1143	Custom (Base Other Process)	2%
1160	Base HVAC	32%
1161	Stack heat exchanger	0%
1162	Duct insulation	5%
1163	Improve ceiling insulation	5%
1164	EMS install	4%
1165	EMS optimization	5%
1166	Custom (Base HVAC)	32%
1180	Base CHP	20%
1190	Base Other	25%
1200	Base Whole Facility	100%
1201	Energy management Program- Resource Conservation Manager (outside consultant)	5%
1202	Superior energy performance certification	5%
1203	Strategic Energy management- SEM (management agreement with outside tech support)	5%
2000	Base Hot Water Boiler	45%
2001	High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	44%
2002	Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	34%
2003	Direct Fired Make-up Air System (Base Hot Water Boiler)	36%
2007	Improved boiler pipe insulation (Base Hot Water Boiler)	45%

DNV·GL

Industrial Gas Measure Inputs		APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)
		All Industrial
Measure #	Measure Description	Building Type 1
2009	Boiler Controls (Base Hot Water Boiler)	18%
2010	Boiler reset controls (Base Hot Water Boiler)	36%
2011	Flue gas heat recovery (Base Hot Water Boiler)	22%
2012	Condensate return (Base Hot Water Boiler)	0%
2013	Blowdown heat recovery (Base Hot Water Boiler)	18%
2014	Custom (Base Hot Water Boiler)	45%
2050	Base Steam Boiler	21%
2051	High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	18%
2052	Direct Fired Make-up Air System (Base Steam Boiler)	21%
2056	Improved boiler pipe insulation (Base Steam Boiler)	21%
2058	Boiler Controls (Base Steam Boiler)	8%
2059	Boiler reset controls (Base Steam Boiler)	21%
2060	Flue gas heat recovery (Base Steam Boiler)	10%
2061	Condensate return (Base Steam Boiler)	0%
2062	Blowdown heat recovery (Base Steam Boiler)	8%
2063	Flash steam Recovery	8%
2064	Improved insulation on steam lines	21%
2065	Steam trap improvement/maintenance/monitoring	9%
2066	Waste heat recovery (Base Steam Boiler)	20%
2067	Direct contact water heating (low temperature only i.e. Food and Beverage)	4%
2068	Custom (Base Steam Boiler)	21%
2100	Base Furnace	3%
2105	Preheated Combustion Air	0%
2107	Custom (Base Furnace)	3%
2120	Base Process Heating	10%
2125	Custom (Base Process Heating)	10%
2140	Base Other Process	2%
2143	Custom (Base Other Process)	2%
2160	Base HVAC	32%
2161	Stack heat exchanger	0%
2164	EMS install	4%
2166	Custom (Base HVAC)	32%
2180	Base CHP	20%
2190	Base Other	25%
2200	Base Whole Facility	100%

Industrial Gas Measure Inputs		**APPLICABILITY*INCOMPLETE*FEASIBILITY (percent)**
		All Industrial
Measure #	Measure Description	Building Type 1
2201	Energy management Program- Resource Conservation Manager (outside consultant)	5%
2202	Superior energy performance certification	5%
2203	Strategic Energy management- SEM (management agreement with outside tech support)	5%

E. ACHIEVABLE RESULTS

DNV·GL

APPENDIX E System DSM ASSYST OUTPUT FILES

Electricity
All Segments
Total
BAU

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cumulative Gross Energy - kWh	279,098,549	546,027,368	784,827,628	999,287,504	1,186,515,645	1,351,116,259	1,498,305,299	1,631,635,374	1,754,079,561	1,867,839,786
Cumulative Gross Peak Demand - kW	52,981	102,230	146,349	186,080	221,377	252,753	281,400	307,865	332,601	355,934
Cumulative Net Energy Savings - kWh	266,662,480	522,173,770	748,203,854	952,873,308	1,129,501,632	1,286,130,054	1,424,842,480	1,549,296,240	1,662,555,503	1,766,900,413
Cumulative Net Peak Demand Savings - kW	50,756	98,012	139,892	178,104	211,728	241,908	269,261	294,348	317,639	339,471
New Net Energy Savings - kWh	266,662,480	255,511,290	226,030,084	204,669,454	176,628,324	156,628,422	138,712,427	124,453,759	113,259,264	104,344,909
New Net Peak Demand Savings - kW	50,756	47,257	41,879	38,212	33,624	30,180	27,353	25,087	23,291	21,832
Administration Costs	$ 5,039,972	$ 3,951,958	$ 3,721,635	$ 3,539,601	$ 3,395,677	$ 3,238,302	$ 3,146,037	$ 3,050,412	$ 2,986,364	$ 2,910,685
Marketing Costs	$ 10,998,099	$ 14,878,341	$ 14,872,229	$ 14,866,250	$ 14,860,400	$ 14,854,678	$ 14,849,079	$ 14,843,602	$ 14,838,244	$ 14,833,002
Incentives Costs	$ 58,297,276	$ 57,888,341	$ 54,153,978	$ 48,196,654	$ 43,143,329	$ 38,169,104	$ 34,714,658	$ 31,883,642	$ 29,624,491	$ 27,810,579
Total Costs	$ 74,335,347	$ 76,718,640	$ 72,747,843	$ 66,602,505	$ 61,399,406	$ 56,262,083	$ 52,709,774	$ 49,777,657	$ 47,449,099	$ 45,554,266
PV Net Avoided Cost Benefits	$ 555,966,611	$ 518,993,409	$ 460,910,534	$ 422,303,372	$ 372,323,086	$ 338,370,006	$ 307,742,163	$ 284,056,373	$ 265,220,311	$ 250,166,252
PV Annual Program Marketing and Admin Costs	$ 16,038,071	$ 18,727,299	$ 18,391,007	$ 18,105,465	$ 17,859,906	$ 17,603,528	$ 17,412,543	$ 17,220,004	$ 17,059,386	$ 16,889,049
PV Net Measure Costs	$ 85,334,736	$ 88,585,006	$ 84,159,508	$ 77,022,805	$ 70,277,282	$ 64,112,355	$ 59,161,436	$ 54,929,227	$ 51,449,193	$ 48,564,006
TRC Ratio	5.48	4.84	4.49	4.44	4.22	4.14	4.02	3.94	3.87	3.82
Free Riders - kWh	12,033,302	23,249,022	35,915,391	45,709,355	56,312,696	64,288,395	72,768,497	81,648,284	90,836,662	100,255,415
Free Riders - kW	2,155	4,114	6,338	7,857	9,531	10,727	12,022	13,400	14,847	16,348
Other Naturally Occurring - kWh	402,766	604,575	708,383	704,841	701,317	697,810	694,321	690,850	687,395	683,958
Other Naturally Occurring - kW	70	103	119	119	118	118	117	116	116	115
Present Value Participant Costs	$ 29,677,960	$ 33,703,043	$ 33,673,763	$ 32,257,741	$ 30,942,209	$ 29,615,990	$ 28,371,484	$ 27,185,831	$ 26,159,897	$ 25,269,364
Incentive Subtotal - Free Riders Only	$ 1,886,611	$ 1,683,840	$ 1,859,475	$ 1,385,903	$ 1,456,982	$ 1,135,476	$ 1,172,124	$ 1,201,632	$ 1,225,592	$ 1,245,173
Cost per First-Year Net kWh	$0.28	$0.30	$0.32	$0.33	$0.35	$0.36	$0.38	$0.40	$0.42	$0.44
PV Annual Program Costs	$ 74,335,347	$ 76,298,996	$ 71,954,170	$ 65,515,542	$ 60,066,990	$ 54,740,081	$ 51,003,351	$ 47,902,692	$ 45,412,078	$ 43,360,110
PV Lost Revenue	$ 535,495,357	$ 483,402,527	$ 417,316,432	$ 370,535,351	$ 313,964,805	$ 273,612,656	$ 238,128,441	$ 209,783,337	$ 187,201,636	$ 168,894,157
RIM	0.91	0.93	0.94	0.97	1.00	1.03	1.06	1.10	1.14	1.18

Electricity
All Segments
Total
BAU

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Cumulative Gross Energy - kWh	1,973,678,643	2,073,700,043	2,168,362,168	2,258,821,731	2,345,329,406	2,423,401,264	2,498,397,323	2,570,660,864	2,640,432,785	2,707,939,596
Cumulative Gross Peak Demand - kW	377,987	399,059	419,220	438,645	457,278	473,750	489,635	504,992	519,865	534,296
Cumulative Net Energy Savings - kWh	1,863,164,823	1,953,497,882	2,038,395,901	2,119,038,172	2,195,686,946	2,263,863,362	2,328,914,747	2,391,170,800	2,450,855,498	2,508,177,035
Cumulative Net Peak Demand Savings - kW	359,981	379,477	398,035	415,835	432,825	447,637	461,842	475,500	488,648	501,329
New Net Energy Savings - kWh	96,264,410	90,333,059	84,898,019	80,642,271	76,648,775	68,176,416	65,051,385	62,256,053	59,684,698	57,321,536
New Net Peak Demand Savings - kW	20,510	19,496	18,558	17,801	16,990	14,812	14,205	13,657	13,149	12,680
Administration Costs	$ 2,727,556	$ 2,679,119	$ 2,637,680	$ 2,601,115	$ 2,568,651	$ 2,465,234	$ 2,436,821	$ 2,411,228	$ 2,387,877	$ 2,354,603
Marketing Costs	$ 14,827,873	$ 14,822,857	$ 14,817,948	$ 14,813,147	$ 14,808,449	$ 14,803,854	$ 14,799,358	$ 14,794,960	$ 14,790,657	$ 14,786,447
Incentives Costs	$ 26,231,220	$ 25,023,054	$ 23,920,006	$ 23,062,677	$ 22,222,136	$ 20,420,786	$ 19,789,843	$ 19,243,453	$ 18,754,253	$ 18,315,922
Total Costs	$ 43,786,649	$ 42,525,030	$ 41,375,634	$ 40,476,939	$ 39,599,236	$ 37,689,874	$ 37,026,022	$ 36,449,641	$ 35,932,786	$ 35,456,973
PV Net Avoided Cost Benefits	$ 236,298,717	$ 225,842,547	$ 216,358,895	$ 208,799,954	$ 200,753,622	$ 178,422,297	$ 171,613,754	$ 165,428,005	$ 159,521,248	$ 153,904,209
PV Annual Program Marketing and Admin Costs	$ 16,618,457	$ 16,477,232	$ 16,343,707	$ 16,215,789	$ 16,092,676	$ 15,905,168	$ 15,788,025	$ 15,674,345	$ 15,563,553	$ 15,444,648
PV Net Measure Costs	$ 45,959,002	$ 43,907,464	$ 42,013,483	$ 40,448,221	$ 38,827,793	$ 36,048,971	$ 34,844,294	$ 33,777,918	$ 32,800,488	$ 31,909,161
TRC Ratio	3.78	3.74	3.71	3.68	3.66	3.43	3.39	3.35	3.30	3.25
Free Riders - kWh	109,833,282	119,525,025	129,292,517	139,113,178	148,975,430	158,874,208	168,822,199	178,832,990	188,923,498	199,112,042
Free Riders - kW	17,891	19,468	21,072	22,697	24,340	26,001	27,681	29,382	31,106	32,857
Other Naturally Occurring - kWh	680,539	677,136	673,750	670,381	667,030	663,694	660,376	657,074	653,789	650,520
Other Naturally Occurring - kW	115	114	114	113	112	112	111	111	110	110
Present Value Participant Costs	$ 24,402,692	$ 23,721,452	$ 23,077,869	$ 22,518,834	$ 21,864,423	$ 20,892,663	$ 20,438,194	$ 20,037,311	$ 19,665,425	$ 19,327,400
Incentive Subtotal - Free Riders Only	$ 1,260,587	$ 1,273,922	$ 1,284,985	$ 1,294,607	$ 1,302,926	$ 1,309,413	$ 1,316,624	$ 1,323,619	$ 1,330,551	$ 1,337,557
Cost per First-Year Net kWh	$0.45	$0.47	$0.49	$0.50	$0.52	$0.55	$0.57	$0.59	$0.60	$0.62
PV Annual Program Costs	$ 41,449,659	$ 40,035,182	$ 38,740,013	$ 37,691,262	$ 36,672,267	$ 34,713,113	$ 33,915,159	$ 33,204,580	$ 32,554,689	$ 31,947,893
PV Lost Revenue	$ 152,671,175	$ 140,078,870	$ 128,906,329	$ 119,699,379	$ 111,173,436	$ 96,549,514	$ 90,157,070	$ 84,481,915	$ 79,350,413	$ 74,744,610
RIM	1.22	1.25	1.29	1.33	1.36	1.36	1.38	1.41	1.43	1.44

Electricity
Commerical
Total
BAU

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cumulative Gross Energy - kWh	239,570,779	456,351,449	643,862,169	810,987,644	956,550,768	1,085,017,677	1,201,093,595	1,307,399,157	1,405,893,256	1,497,957,972
Cumulative Gross Peak Demand - kW	48,293	91,597	129,617	163,687	193,970	221,002	245,889	269,074	290,893	311,575
Cumulative Net Energy Savings - kWh	229,814,841	437,960,800	615,536,468	775,725,007	913,537,656	1,036,862,931	1,147,264,738	1,247,462,794	1,339,503,896	1,424,846,780
Cumulative Net Peak Demand Savings - kW	46,396	88,049	124,177	157,080	186,041	212,227	236,168	258,320	279,034	298,554
New Net Energy Savings - kWh	229,814,841	208,145,959	177,575,668	160,188,539	137,812,649	123,325,275	110,401,807	100,198,056	92,041,101	85,342,885
New Net Peak Demand Savings - kW	46,396	41,654	36,127	32,903	28,961	26,186	23,941	22,152	20,714	19,519
Administration Costs	$ 3,928,015	$ 3,086,364	$ 2,957,532	$ 2,850,314	$ 2,760,034	$ 2,682,884	$ 2,617,053	$ 2,540,049	$ 2,489,625	$ 2,423,703
Marketing Costs	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031
Incentives Costs	$ 49,615,486	$ 46,766,192	$ 42,650,624	$ 37,444,397	$ 33,542,303	$ 29,708,527	$ 27,319,795	$ 25,361,003	$ 23,745,040	$ 22,390,575
Total Costs	$ 62,202,532	$ 58,511,587	$ 54,267,188	$ 48,953,743	$ 44,961,368	$ 41,050,442	$ 38,595,879	$ 36,560,084	$ 34,893,696	$ 33,473,309
PV Net Avoided Cost Benefits	$ 504,382,924	$ 451,164,167	$ 391,346,685	$ 357,608,906	$ 314,880,771	$ 287,998,361	$ 263,724,636	$ 245,153,106	$ 230,157,311	$ 217,837,974
PV Annual Program Marketing and Admin Costs	$ 12,587,046	$ 11,681,149	$ 11,489,828	$ 11,321,512	$ 11,171,263	$ 11,035,094	$ 10,911,033	$ 10,777,247	$ 10,670,037	$ 10,548,926
PV Net Measure Costs	$ 72,971,098	$ 72,364,153	$ 66,997,169	$ 60,557,853	$ 55,143,156	$ 50,370,292	$ 46,799,325	$ 43,779,905	$ 41,237,439	$ 39,050,380
TRC Ratio	5.90	5.37	4.99	4.98	4.75	4.69	4.57	4.49	4.43	4.39
Free Riders - kWh	9,353,171	17,786,073	27,617,318	34,557,796	42,311,795	47,456,936	53,134,536	59,245,513	65,701,965	72,427,234
Free Riders - kW	1,827	3,446	5,321	6,489	7,811	8,657	9,604	10,637	11,742	12,906
Other Naturally Occurring - kWh	402,766	604,575	708,383	704,841	701,317	697,810	694,321	690,850	687,395	683,958
Other Naturally Occurring - kW	70	103	119	119	118	118	117	116	116	115
Present Value Participant Costs	$ 25,250,265	$ 27,736,858	$ 27,023,997	$ 25,453,769	$ 24,243,374	$ 23,113,868	$ 22,146,029	$ 21,273,890	$ 20,517,749	$ 19,840,613
Incentive Subtotal - Free Riders Only	$ 1,445,089	$ 1,222,784	$ 1,385,194	$ 902,821	$ 968,200	$ 643,165	$ 677,808	$ 706,382	$ 730,161	$ 750,092
Cost per First-Year Net kWh	$0.27	$0.28	$0.31	$0.31	$0.33	$0.33	$0.35	$0.36	$0.38	$0.39
PV Annual Program Costs	$ 62,202,532	$ 58,191,534	$ 53,675,138	$ 48,154,810	$ 43,985,671	$ 39,939,945	$ 37,346,378	$ 35,182,983	$ 33,395,687	$ 31,861,042
PV Lost Revenue	$ 481,557,838	$ 415,319,875	$ 348,906,669	$ 308,784,135	$ 260,908,054	$ 228,739,451	$ 200,508,662	$ 178,012,806	$ 159,830,630	$ 144,780,753
RIM	0.93	0.95	0.97	1.00	1.03	1.07	1.11	1.15	1.19	1.23

DNV·GL

APPENDIX E System DSM ASSYST OUTPUT FILES

Electricity
Commerical
Total
BAU

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Cumulative Gross Energy - kWh	1,584,475,609	1,666,390,006	1,743,849,509	1,817,825,239	1,888,396,012	1,952,129,190	2,013,319,669	2,072,219,812	2,129,022,299	2,183,915,993
Cumulative Gross Peak Demand - kW	331,265	350,121	368,175	385,579	402,257	416,973	431,167	444,888	458,172	471,059
Cumulative Net Energy Savings - kWh	1,504,443,103	1,579,283,562	1,649,555,331	1,716,253,036	1,779,468,293	1,835,772,136	1,889,450,682	1,940,744,062	1,989,829,334	2,036,878,303
Cumulative Net Peak Demand Savings - kW	317,035	334,644	351,421	367,523	382,877	396,248	409,074	421,404	433,270	444,709
New Net Energy Savings - kWh	79,596,323	74,840,459	70,271,769	66,697,705	63,215,257	56,303,843	53,678,545	51,293,381	49,085,272	47,048,969
New Net Peak Demand Savings - kW	18,481	17,609	16,777	16,102	15,354	13,371	12,826	12,330	11,867	11,439
Administration Costs	$ 2,264,194	$ 2,223,906	$ 2,188,594	$ 2,157,183	$ 2,129,148	$ 2,045,832	$ 2,021,129	$ 1,998,918	$ 1,978,751	$ 1,948,419
Marketing Costs	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031
Incentives Costs	$ 21,225,233	$ 20,243,980	$ 19,300,611	$ 18,563,053	$ 17,806,948	$ 16,360,786	$ 15,826,051	$ 15,351,558	$ 14,925,195	$ 14,542,891
Total Costs	$ 32,148,459	$ 31,126,918	$ 30,148,235	$ 29,379,267	$ 28,595,127	$ 27,065,649	$ 26,506,212	$ 26,009,507	$ 25,562,978	$ 25,150,341
PV Net Avoided Cost Benefits	$ 207,055,955	$ 198,008,098	$ 189,515,744	$ 182,694,632	$ 175,181,429	$ 155,591,917	$ 149,541,366	$ 143,979,287	$ 138,651,739	$ 133,585,184
PV Annual Program Marketing and Admin Costs	$ 10,340,229	$ 10,245,740	$ 10,156,633	$ 10,071,828	$ 9,990,773	$ 9,859,389	$ 9,782,832	$ 9,709,087	$ 9,637,708	$ 9,557,660
PV Net Measure Costs	$ 37,122,534	$ 35,457,494	$ 33,857,736	$ 32,548,267	$ 31,116,824	$ 28,979,171	$ 27,990,178	$ 27,094,103	$ 26,270,990	$ 25,521,290
TRC Ratio	4.36	4.33	4.31	4.29	4.26	4.01	3.96	3.91	3.86	3.81
Free Riders - kWh	79,351,967	86,429,308	93,620,427	100,901,822	108,260,689	115,693,359	123,208,612	130,818,676	138,539,177	146,387,170
Free Riders - kW	14,116	15,363	16,640	17,943	19,268	20,613	21,981	23,373	24,792	26,240
Other Naturally Occurring - kWh	680,539	677,136	673,750	670,381	667,030	663,694	660,376	657,074	653,789	650,520
Other Naturally Occurring - kW	115	114	114	113	112	112	111	111	110	110
Present Value Participant Costs	$ 19,219,446	$ 18,669,903	$ 18,131,375	$ 17,679,623	$ 17,098,658	$ 16,423,878	$ 16,067,363	$ 15,741,374	$ 15,437,740	$ 15,162,433
Incentive Subtotal - Free Riders Only	$ 766,410	$ 780,738	$ 792,979	$ 803,915	$ 813,622	$ 822,173	$ 830,881	$ 839,369	$ 847,798	$ 856,297
Cost per First-Year Net kWh	$0.40	$0.42	$0.43	$0.44	$0.45	$0.48	$0.49	$0.51	$0.52	$0.53
PV Annual Program Costs	$ 30,432,624	$ 29,304,431	$ 28,227,798	$ 27,357,347	$ 26,481,525	$ 24,927,994	$ 24,279,205	$ 23,693,916	$ 23,159,762	$ 22,661,281
PV Lost Revenue	$ 131,839,489	$ 121,079,459	$ 111,326,077	$ 103,284,700	$ 95,693,320	$ 83,190,238	$ 77,633,014	$ 72,660,165	$ 68,150,986	$ 64,100,694
RIM	1.28	1.32	1.36	1.40	1.43	1.44	1.47	1.49	1.52	1.54

Electricity
Industrial
Total
BAU

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cumulative Gross Energy - kWh	39,527,770	89,675,919	140,965,458	188,299,860	229,964,877	266,098,581	297,211,703	324,236,217	348,186,304	369,881,813
Cumulative Gross Peak Demand - kW	4,688	10,632	16,732	22,392	27,407	31,751	35,510	38,791	41,709	44,359
Cumulative Net Energy Savings - kWh	36,847,639	84,212,970	132,667,386	177,148,301	215,963,976	249,267,123	277,577,742	301,833,445	323,051,608	342,053,633
Cumulative Net Peak Demand Savings - kW	4,360	9,963	15,715	21,024	25,687	29,681	33,092	36,028	38,604	40,917
New Net Energy Savings - kWh	36,847,639	47,365,331	48,454,415	44,480,915	38,815,675	33,303,147	28,310,619	24,255,703	21,218,163	19,002,025
New Net Peak Demand Savings - kW	4,360	5,603	5,752	5,309	4,663	3,994	3,412	2,935	2,576	2,313
Administration Costs	$ 1,111,957	$ 865,594	$ 764,103	$ 689,287	$ 635,643	$ 555,418	$ 528,984	$ 510,363	$ 496,740	$ 486,982
Marketing Costs	$ 2,339,068	$ 6,219,310	$ 6,213,198	$ 6,207,218	$ 6,201,369	$ 6,195,646	$ 6,190,048	$ 6,184,571	$ 6,179,212	$ 6,173,970
Incentives Costs	$ 8,681,790	$ 11,122,149	$ 11,503,354	$ 10,752,256	$ 9,601,026	$ 8,460,577	$ 7,394,864	$ 6,522,639	$ 5,879,451	$ 5,420,004
Total Costs	$ 12,132,815	$ 18,207,053	$ 18,480,655	$ 17,648,762	$ 16,438,038	$ 15,211,641	$ 14,113,895	$ 13,217,573	$ 12,555,403	$ 12,080,956
PV Net Avoided Cost Benefits	$ 51,583,687	$ 67,829,241	$ 69,563,849	$ 64,694,466	$ 57,442,315	$ 50,371,644	$ 44,017,527	$ 38,903,267	$ 35,063,000	$ 32,328,278
PV Annual Program Marketing and Admin Costs	$ 3,451,025	$ 7,046,150	$ 6,901,179	$ 6,783,953	$ 6,688,643	$ 6,568,434	$ 6,501,510	$ 6,442,757	$ 6,389,349	$ 6,340,122
PV Net Measure Costs	$ 12,363,638	$ 16,220,853	$ 17,162,339	$ 16,464,951	$ 15,134,126	$ 13,742,063	$ 12,362,111	$ 11,149,322	$ 10,211,754	$ 9,513,627
TRC Ratio	3.26	2.92	2.89	2.78	2.63	2.48	2.33	2.21	2.11	2.04
Free Riders - kWh	2,680,131	5,462,949	8,298,073	11,151,559	14,000,901	16,831,458	19,633,961	22,402,771	25,134,697	27,828,181
Free Riders - kW	328	669	1,017	1,368	1,720	2,070	2,418	2,763	3,104	3,442
Other Naturally Occurring - kWh										
Other Naturally Occurring - kW										
Present Value Participant Costs	$ 4,427,694	$ 5,966,185	$ 6,649,766	$ 6,803,972	$ 6,698,835	$ 6,502,122	$ 6,225,455	$ 5,911,941	$ 5,642,148	$ 5,428,750
Incentive Subtotal - Free Riders Only	$ 441,522	$ 461,055	$ 474,281	$ 483,082	$ 488,783	$ 492,311	$ 494,315	$ 495,250	$ 495,430	$ 495,081
Cost per First-Year Net kWh	$0.33	$0.38	$0.38	$0.40	$0.42	$0.46	$0.50	$0.54	$0.59	$0.64
PV Annual Program Costs	$ 12,132,815	$ 18,107,462	$ 18,279,033	$ 17,360,731	$ 16,081,319	$ 14,800,136	$ 13,656,973	$ 12,719,709	$ 12,016,391	$ 11,499,068
PV Lost Revenue	$ 53,937,519	$ 68,082,652	$ 68,409,763	$ 61,751,216	$ 53,056,751	$ 44,873,205	$ 37,619,779	$ 31,770,532	$ 27,371,006	$ 24,113,404
RIM	0.78	0.79	0.80	0.82	0.83	0.84	0.86	0.87	0.89	0.91

Electricity
Industrial
Total
BAU

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Cumulative Gross Energy - kWh	389,203,034	407,310,037	424,512,659	440,996,492	456,933,394	471,272,075	485,077,653	498,441,052	511,410,486	524,023,603
Cumulative Gross Peak Demand - kW	46,721	48,938	51,045	53,066	55,021	56,777	58,468	60,105	61,693	63,237
Cumulative Net Energy Savings - kWh	358,721,720	374,214,319	388,840,569	402,785,136	416,218,653	428,091,226	439,464,066	450,426,738	461,026,165	471,298,732
Cumulative Net Peak Demand Savings - kW	42,946	44,832	46,614	48,312	49,948	51,389	52,768	54,096	55,378	56,619
New Net Energy Savings - kWh	16,668,087	15,492,600	14,626,250	13,944,566	13,433,518	11,872,573	11,372,839	10,962,672	10,599,427	10,272,567
New Net Peak Demand Savings - kW	2,028	1,887	1,781	1,699	1,636	1,441	1,379	1,328	1,282	1,241
Administration Costs	$ 463,362	$ 455,213	$ 449,086	$ 443,932	$ 439,504	$ 419,402	$ 415,692	$ 412,310	$ 409,125	$ 406,185
Marketing Costs	$ 6,168,842	$ 6,163,825	$ 6,158,917	$ 6,154,115	$ 6,149,418	$ 6,144,822	$ 6,140,327	$ 6,135,928	$ 6,131,625	$ 6,127,416
Incentives Costs	$ 5,005,986	$ 4,779,074	$ 4,619,395	$ 4,499,624	$ 4,415,187	$ 4,060,000	$ 3,963,792	$ 3,891,896	$ 3,829,058	$ 3,773,031
Total Costs	$ 11,638,190	$ 11,398,112	$ 11,227,398	$ 11,097,671	$ 11,004,109	$ 10,624,225	$ 10,519,810	$ 10,440,134	$ 10,369,808	$ 10,306,631
PV Net Avoided Cost Benefits	$ 29,242,762	$ 27,834,449	$ 26,843,150	$ 26,105,323	$ 25,572,194	$ 22,830,380	$ 22,072,388	$ 21,448,718	$ 20,869,510	$ 20,319,025
PV Annual Program Marketing and Admin Costs	$ 6,278,228	$ 6,231,492	$ 6,187,074	$ 6,143,961	$ 6,101,903	$ 6,045,780	$ 6,005,193	$ 5,965,258	$ 5,925,845	$ 5,886,988
PV Net Measure Costs	$ 8,836,468	$ 8,449,970	$ 8,155,747	$ 7,899,953	$ 7,710,969	$ 7,069,800	$ 6,854,115	$ 6,683,816	$ 6,529,497	$ 6,387,871
TRC Ratio	1.93	1.90	1.87	1.86	1.85	1.74	1.72	1.70	1.68	1.66
Free Riders - kWh	30,481,315	33,095,718	35,672,089	38,211,356	40,714,741	43,180,849	45,613,588	48,014,314	50,384,321	52,724,871
Free Riders - kW	3,775	4,105	4,431	4,754	5,073	5,388	5,700	6,009	6,315	6,618
Other Naturally Occurring - kWh										
Other Naturally Occurring - kW										
Present Value Participant Costs	$ 5,183,246	$ 5,051,549	$ 4,946,495	$ 4,839,211	$ 4,765,765	$ 4,468,786	$ 4,370,830	$ 4,295,937	$ 4,227,684	$ 4,164,967
Incentive Subtotal - Free Riders Only	$ 494,178	$ 493,184	$ 492,007	$ 490,691	$ 489,304	$ 487,241	$ 485,743	$ 484,250	$ 482,753	$ 481,261
Cost per First-Year Net kWh	$0.70	$0.74	$0.77	$0.80	$0.82	$0.89	$0.92	$0.95	$0.98	$1.00
PV Annual Program Costs	$ 11,017,034	$ 10,730,751	$ 10,512,215	$ 10,333,915	$ 10,190,743	$ 9,785,119	$ 9,635,954	$ 9,510,664	$ 9,394,926	$ 9,286,612
PV Lost Revenue	$ 20,831,686	$ 18,999,411	$ 17,580,253	$ 16,414,679	$ 15,480,116	$ 13,359,276	$ 12,524,056	$ 11,821,750	$ 11,199,428	$ 10,643,916
RIM	0.92	0.94	0.96	0.98	1.00	0.99	1.00	1.01	1.01	1.02

Natural Gas
All Segments
Total
BAU

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cumulative Gross Energy - Therm	9,873,577	18,695,254	26,689,638	33,999,362	40,727,896	46,956,886	52,748,800	58,156,056	63,225,962	67,999,042
Cumulative Gross Peak Demand - Therm per Day										
Cumulative Net Energy Savings - Therm	4,936,788	9,347,627	13,344,819	16,999,681	20,363,948	23,478,443	26,374,400	29,078,028	31,612,981	33,999,521
Cumulative Net Peak Demand Savings - Therm per Day										
New Net Energy Savings - Therm	4,936,788	4,410,839	3,997,192	3,654,862	3,364,267	3,114,495	2,895,957	2,703,628	2,534,953	2,386,540
New Net Peak Demand Savings - Therm per Day										
Administration Costs	$ 1,936,756	$ 1,655,934	$ 1,608,599	$ 1,565,814	$ 1,527,010	$ 1,491,630	$ 1,459,345	$ 1,407,022	$ 1,379,243	$ 1,353,647
Marketing Costs	$ 4,916,310	$ 6,142,727	$ 6,142,727	$ 6,142,727	$ 6,142,727	$ 6,142,727	$ 6,142,727	$ 6,142,727	$ 6,142,727	$ 6,142,727
Incentives Costs	$ 8,315,564	$ 7,677,620	$ 7,169,107	$ 6,742,686	$ 6,374,015	$ 6,049,448	$ 5,757,528	$ 5,492,818	$ 5,253,702	$ 5,036,843
Total Costs	$ 15,168,631	$ 15,476,280	$ 14,920,433	$ 14,451,226	$ 14,043,751	$ 13,683,805	$ 13,359,600	$ 13,042,566	$ 12,775,672	$ 12,533,217
PV Net Avoided Cost Benefits	$ 43,028,204	$ 39,171,807	$ 35,935,126	$ 33,225,821	$ 30,846,618	$ 28,818,286	$ 27,183,713	$ 25,743,849	$ 24,479,803	$ 23,387,084
PV Annual Program Marketing and Admin Costs	$ 3,873,513	$ 3,293,752	$ 3,182,098	$ 3,080,519	$ 2,987,745	$ 2,902,558	$ 2,824,200	$ 2,708,047	$ 2,640,063	$ 2,576,895
PV Net Measure Costs	$ 18,005,856	$ 16,614,419	$ 15,367,928	$ 14,240,801	$ 13,220,894	$ 12,299,761	$ 11,466,068	$ 10,712,254	$ 10,033,212	$ 9,420,993
TRC Ratio	1.97	1.97	1.94	1.92	1.90	1.90	1.90	1.92	1.93	1.95
Free Riders - Therm	329,275	665,973	1,007,795	1,352,953	1,700,046	2,047,960	2,395,807	2,742,870	3,088,568	3,432,425
Free Riders - Therm per Day										
Other Naturally Occurring - Therm										
Other Naturally Occurring - Therm per Day										
Present Value Participant Costs	$ 10,483,083	$ 9,841,667	$ 9,197,194	$ 8,574,401	$ 7,987,951	$ 7,445,179	$ 6,947,927	$ 6,495,591	$ 6,086,068	$ 5,715,828
Incentive Subtotal - Free Riders Only	$ 335,082	$ 344,117	$ 350,905	$ 355,931	$ 359,565	$ 362,086	$ 363,712	$ 364,608	$ 364,910	$ 364,721
Cost per First-Year Net Therm	$3.07	$3.51	$3.73	$3.95	$4.17	$4.39	$4.61	$4.82	$5.04	$5.25
PV Annual Program Costs	$ 15,168,631	$ 15,391,626	$ 14,757,652	$ 14,215,380	$ 13,738,991	$ 13,313,631	$ 12,927,097	$ 12,551,294	$ 12,227,204	$ 11,929,545
PV Lost Revenue	$ 65,121,294	$ 58,544,781	$ 52,862,933	$ 48,403,455	$ 44,625,465	$ 41,341,104	$ 38,499,767	$ 36,134,256	$ 34,084,738	$ 32,294,588
RIM	0.54	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53

Natural Gas
All Segments
Total
BAU

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Cumulative Gross Energy - Therm	72,508,660	76,784,153	80,654,072	84,331,622	87,835,490	91,073,471	94,163,149	97,121,288	99,866,638	102,502,219
Cumulative Gross Peak Demand - Therm per Day										
Cumulative Net Energy Savings - Therm	36,254,330	38,392,076	40,327,036	42,165,811	43,917,745	45,536,735	47,081,575	48,560,644	49,933,319	51,251,110
Cumulative Net Peak Demand Savings - Therm per Day										
New Net Energy Savings - Therm	2,254,809	2,137,746	1,934,960	1,838,775	1,751,934	1,618,990	1,544,839	1,479,069	1,372,675	1,317,791
New Net Peak Demand Savings - Therm per Day										
Administration Costs	$ 1,315,779	$ 1,293,069	$ 1,272,580	$ 1,245,223	$ 1,227,663	$ 1,184,331	$ 1,169,036	$ 1,154,755	$ 1,141,399	$ 1,116,407
Marketing Costs	$ 6,142,727	$ 6,142,727	$ 6,142,727	$ 6,142,727	$ 6,142,727	$ 6,142,727	$ 6,142,727	$ 6,142,727	$ 6,142,727	$ 6,142,727
Incentives Costs	$ 4,839,091	$ 4,658,521	$ 4,370,980	$ 4,215,154	$ 4,071,545	$ 3,873,182	$ 3,745,518	$ 3,630,664	$ 3,485,888	$ 3,387,889
Total Costs	$ 12,297,596	$ 12,094,317	$ 11,786,286	$ 11,603,104	$ 11,441,934	$ 11,200,240	$ 11,057,281	$ 10,928,146	$ 10,770,014	$ 10,647,023
PV Net Avoided Cost Benefits	$ 22,413,620	$ 21,545,362	$ 19,830,453	$ 19,102,610	$ 18,445,824	$ 17,242,300	$ 16,634,929	$ 16,089,114	$ 14,893,763	$ 14,418,229
PV Annual Program Marketing and Admin Costs	$ 2,491,105	$ 2,434,720	$ 2,383,034	$ 2,319,050	$ 2,273,840	$ 2,181,584	$ 2,141,632	$ 2,103,898	$ 2,068,189	$ 2,011,839
PV Net Measure Costs	$ 8,866,277	$ 8,366,489	$ 7,774,985	$ 7,363,909	$ 6,991,412	$ 6,594,021	$ 6,276,318	$ 5,994,489	$ 5,695,881	$ 5,461,959
TRC Ratio	1.97	1.99	1.95	1.97	1.99	1.96	1.98	1.99	1.92	1.93
Free Riders - Therm	3,774,054	4,113,133	4,449,259	4,782,356	5,112,246	5,438,739	5,761,756	6,081,205	6,396,745	6,708,583
Free Riders - Therm per Day										
Other Naturally Occurring - Therm										
Other Naturally Occurring - Therm per Day										
Present Value Participant Costs	$ 5,379,484	$ 5,077,342	$ 4,777,832	$ 4,533,295	$ 4,313,142	$ 4,116,112	$ 3,930,586	$ 3,767,801	$ 3,612,815	$ 3,479,468
Incentive Subtotal - Free Riders Only	$ 364,125	$ 363,192	$ 361,851	$ 360,402	$ 358,756	$ 356,899	$ 354,946	$ 352,886	$ 350,544	$ 348,312
Cost per First-Year Net Therm	$5.45	$5.66	$6.09	$6.31	$6.53	$6.92	$7.16	$7.39	$7.85	$8.08
PV Annual Program Costs	$ 11,641,246	$ 11,386,193	$ 11,035,502	$ 10,804,563	$ 10,596,206	$ 10,315,640	$ 10,128,267	$ 9,955,228	$ 9,757,508	$ 9,593,317
PV Lost Revenue	$ 30,731,039	$ 29,346,277	$ 26,990,772	$ 25,870,473	$ 24,867,405	$ 23,123,575	$ 22,269,605	$ 21,490,888	$ 19,825,320	$ 19,151,248
RIM	0.53	0.53	0.52	0.52	0.52	0.52	0.51	0.51	0.50	0.50

Natural Gas
Commercial
Total
BAU

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cumulative Gross Energy - Therm	8,899,109	16,603,511	23,443,650	29,624,453	35,279,642	40,501,234	45,355,863	49,894,007	54,155,368	58,172,102
Cumulative Gross Peak Demand - Therm per Day										
Cumulative Net Energy Savings - Therm	4,449,555	8,301,755	11,721,825	14,812,227	17,639,821	20,250,617	22,677,932	24,947,004	27,077,684	29,086,051
Cumulative Net Peak Demand Savings - Therm per Day										
New Net Energy Savings - Therm	4,449,555	3,852,201	3,420,070	3,090,401	2,827,594	2,610,796	2,427,314	2,269,072	2,130,680	2,008,367
New Net Peak Demand Savings - Therm per Day										
Administration Costs	$ 1,842,207	$ 1,546,309	$ 1,503,279	$ 1,464,429	$ 1,429,103	$ 1,396,811	$ 1,367,170	$ 1,328,129	$ 1,302,909	$ 1,279,565
Marketing Costs	$ 4,668,234	$ 4,668,234	$ 4,668,234	$ 4,668,234	$ 4,668,234	$ 4,668,234	$ 4,668,234	$ 4,668,234	$ 4,668,234	$ 4,668,234
Incentives Costs	$ 7,814,203	$ 7,117,655	$ 6,585,107	$ 6,156,034	$ 5,796,199	$ 5,485,577	$ 5,211,954	$ 4,967,513	$ 4,746,975	$ 4,546,580
Total Costs	$ 14,324,645	$ 13,332,199	$ 12,756,620	$ 12,288,697	$ 11,893,537	$ 11,550,622	$ 11,247,358	$ 10,963,877	$ 10,718,118	$ 10,494,380
PV Net Avoided Cost Benefits	$ 38,203,085	$ 33,495,838	$ 29,950,462	$ 27,304,216	$ 25,176,472	$ 23,456,045	$ 22,136,967	$ 21,020,045	$ 20,045,199	$ 19,199,598
PV Annual Program Marketing and Admin Costs	$ 3,684,414	$ 3,075,701	$ 2,973,756	$ 2,881,058	$ 2,796,181	$ 2,718,049	$ 2,645,818	$ 2,556,205	$ 2,493,949	$ 2,435,869
PV Net Measure Costs	$ 16,924,393	$ 15,336,388	$ 13,996,358	$ 12,842,388	$ 11,835,059	$ 10,947,641	$ 10,160,865	$ 9,460,078	$ 8,833,650	$ 8,272,055
TRC Ratio	1.85	1.82	1.76	1.74	1.72	1.72	1.73	1.75	1.77	1.79
Free Riders - Therm	306,016	618,271	934,943	1,254,579	1,576,010	1,898,286	2,220,632	2,542,409	2,863,091	3,182,241
Free Riders - Therm per Day										
Other Naturally Occurring - Therm										
Other Naturally Occurring - Therm per Day										
Present Value Participant Costs	$ 9,850,682	$ 9,061,350	$ 8,337,346	$ 7,681,061	$ 7,090,081	$ 6,559,844	$ 6,085,004	$ 5,660,127	$ 5,280,015	$ 4,939,863
Incentive Subtotal - Free Riders Only	$ 315,475	$ 323,494	$ 329,619	$ 334,233	$ 337,631	$ 340,042	$ 341,646	$ 342,584	$ 342,972	$ 342,902
Cost per First-Year Net Therm	$3.22	$3.46	$3.73	$3.98	$4.21	$4.42	$4.63	$4.83	$5.03	$5.23
PV Annual Program Costs	$ 14,324,645	$ 13,259,272	$ 12,617,447	$ 12,088,143	$ 11,635,437	$ 11,238,155	$ 10,883,237	$ 10,550,903	$ 10,257,982	$ 9,988,910
PV Lost Revenue	$ 57,839,396	$ 50,312,030	$ 44,511,713	$ 40,398,164	$ 37,175,443	$ 34,500,151	$ 32,268,735	$ 30,470,795	$ 28,918,671	$ 27,551,573
RIM	0.53	0.53	0.52	0.52	0.52	0.51	0.51	0.51	0.51	0.51

Natural Gas
Commercial
Total
BAU

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Cumulative Gross Energy - Therm	61,970,857	65,574,090	68,899,851	72,066,187	75,087,559	77,868,780	80,528,691	83,077,301	85,433,803	87,694,059
Cumulative Gross Peak Demand - Therm per Day										
Cumulative Net Energy Savings - Therm	30,985,428	32,787,045	34,449,926	36,033,094	37,543,780	38,934,390	40,264,345	41,538,651	42,716,901	43,847,029
Cumulative Net Peak Demand Savings - Therm per Day										
New Net Energy Savings - Therm	1,899,377	1,801,617	1,662,881	1,583,168	1,510,686	1,390,611	1,329,955	1,274,305	1,178,251	1,130,128
New Net Peak Demand Savings - Therm per Day										
Administration Costs	$ 1,243,763	$ 1,223,514	$ 1,204,675	$ 1,178,624	$ 1,162,057	$ 1,120,075	$ 1,105,648	$ 1,092,151	$ 1,079,508	$ 1,060,889
Marketing Costs	$ 4,668,234	$ 4,668,234	$ 4,668,234	$ 4,668,234	$ 4,668,234	$ 4,668,234	$ 4,668,234	$ 4,668,234	$ 4,668,234	$ 4,668,234
Incentives Costs	$ 4,363,519	$ 4,195,601	$ 3,986,924	$ 3,844,275	$ 3,712,337	$ 3,524,812	$ 3,410,690	$ 3,304,594	$ 3,166,643	$ 3,073,692
Total Costs	$ 10,275,516	$ 10,087,349	$ 9,859,833	$ 9,691,133	$ 9,542,628	$ 9,313,121	$ 9,184,573	$ 9,064,980	$ 8,914,385	$ 8,802,816
PV Net Avoided Cost Benefits	$ 18,441,842	$ 17,757,537	$ 16,711,578	$ 16,149,416	$ 15,638,727	$ 14,569,623	$ 14,109,503	$ 13,675,872	$ 12,604,654	$ 12,208,016
PV Annual Program Marketing and Admin Costs	$ 2,354,760	$ 2,303,754	$ 2,255,874	$ 2,195,019	$ 2,152,327	$ 2,063,221	$ 2,025,507	$ 1,989,836	$ 1,956,043	$ 1,911,792
PV Net Measure Costs	$ 7,767,312	$ 7,312,630	$ 6,842,600	$ 6,471,589	$ 6,135,364	$ 5,772,297	$ 5,494,234	$ 5,240,840	$ 4,967,123	$ 4,754,975
TRC Ratio	1.82	1.85	1.84	1.86	1.89	1.86	1.88	1.89	1.82	1.83
Free Riders - Therm	3,499,493	3,814,545	4,127,021	4,436,832	4,743,806	5,047,753	5,348,597	5,646,241	5,940,347	6,231,112
Free Riders - Therm per Day										
Other Naturally Occurring - Therm										
Other Naturally Occurring - Therm per Day										
Present Value Participant Costs	$ 4,635,303	$ 4,362,408	$ 4,108,048	$ 3,888,311	$ 3,690,828	$ 3,515,603	$ 3,355,384	$ 3,210,828	$ 3,072,413	$ 2,954,233
Incentive Subtotal - Free Riders Only	$ 342,448	$ 341,673	$ 340,521	$ 339,249	$ 337,787	$ 336,118	$ 334,361	$ 332,492	$ 330,342	$ 328,301
Cost per First-Year Net Therm	$5.41	$5.60	$5.93	$6.12	$6.32	$6.70	$6.91	$7.11	$7.57	$7.79
PV Annual Program Costs	$ 9,727,089	$ 9,496,733	$ 9,231,763	$ 9,024,177	$ 8,837,287	$ 8,577,567	$ 8,412,901	$ 8,257,937	$ 8,076,330	$ 7,931,626
PV Lost Revenue	$ 26,350,906	$ 25,272,774	$ 23,688,031	$ 22,804,046	$ 22,004,422	$ 20,439,886	$ 19,763,703	$ 19,124,064	$ 17,598,629	$ 17,022,489
RIM	0.51	0.51	0.51	0.51	0.51	0.50	0.50	0.50	0.49	0.49

Natural Gas
Industrial
Total
BAU

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cumulative Gross Energy - Therm	974,467	2,091,743	3,245,987	4,374,908	5,448,254	6,455,652	7,392,937	8,262,049	9,070,594	9,826,940
Cumulative Gross Peak Demand - Therm per Day										
Cumulative Net Energy Savings - Therm	487,234	1,045,871	1,622,994	2,187,454	2,724,127	3,227,826	3,696,468	4,131,024	4,535,297	4,913,470
Cumulative Net Peak Demand Savings - Therm per Day										
New Net Energy Savings - Therm	487,234	558,638	577,122	564,460	536,673	503,699	468,643	434,556	404,273	378,173
New Net Peak Demand Savings - Therm per Day										
Administration Costs	$ 94,549	$ 109,625	$ 105,320	$ 101,385	$ 97,907	$ 94,819	$ 92,175	$ 78,893	$ 76,334	$ 74,082
Marketing Costs	$ 248,076	$ 1,474,492	$ 1,474,492	$ 1,474,492	$ 1,474,492	$ 1,474,492	$ 1,474,492	$ 1,474,492	$ 1,474,492	$ 1,474,492
Incentives Costs	$ 501,361	$ 559,964	$ 584,000	$ 586,652	$ 577,816	$ 563,871	$ 545,574	$ 525,304	$ 506,728	$ 490,264
Total Costs	$ 843,986	$ 2,144,082	$ 2,163,812	$ 2,162,529	$ 2,150,215	$ 2,133,183	$ 2,112,241	$ 2,078,689	$ 2,057,554	$ 2,038,837
PV Net Avoided Cost Benefits	$ 4,825,120	$ 5,675,970	$ 5,984,665	$ 5,921,604	$ 5,670,146	$ 5,362,241	$ 5,046,746	$ 4,723,804	$ 4,434,604	$ 4,187,486
PV Annual Program Marketing and Admin Costs	$ 189,099	$ 218,051	$ 208,342	$ 199,461	$ 191,565	$ 184,509	$ 178,382	$ 151,842	$ 146,114	$ 141,027
PV Net Measure Costs	$ 1,081,463	$ 1,278,031	$ 1,371,570	$ 1,398,413	$ 1,385,835	$ 1,352,120	$ 1,305,203	$ 1,252,176	$ 1,199,562	$ 1,148,938
TRC Ratio	3.80	3.79	3.79	3.71	3.59	3.49	3.40	3.36	3.30	3.25
Free Riders - Therm	23,259	47,702	72,852	98,375	124,036	149,675	175,176	200,461	225,477	250,185
Free Riders - Therm per Day										
Other Naturally Occurring - Therm										
Other Naturally Occurring - Therm per Day										
Present Value Participant Costs	$ 632,401	$ 780,316	$ 859,848	$ 893,339	$ 897,871	$ 885,335	$ 862,922	$ 835,464	$ 806,053	$ 775,965
Incentive Subtotal - Free Riders Only	$ 19,607	$ 20,623	$ 21,286	$ 21,698	$ 21,934	$ 22,044	$ 22,066	$ 22,024	$ 21,938	$ 21,819
Cost per First-Year Net Therm	$1.73	$3.84	$3.75	$3.83	$4.01	$4.24	$4.51	$4.78	$5.09	$5.39
PV Annual Program Costs	$ 843,986	$ 2,132,354	$ 2,140,206	$ 2,127,236	$ 2,103,554	$ 2,075,476	$ 2,043,860	$ 2,000,392	$ 1,969,222	$ 1,940,635
PV Lost Revenue	$ 7,281,898	$ 8,232,752	$ 8,351,220	$ 8,005,292	$ 7,450,022	$ 6,840,954	$ 6,231,032	$ 5,663,462	$ 5,166,067	$ 4,743,015
RIM	0.59	0.55	0.57	0.58	0.59	0.60	0.61	0.62	0.62	0.63

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APPENDIX E System DSM ASSYST OUTPUT FILES

Natural Gas
Industrial
Total
BAU

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Cumulative Gross Energy - Therm	10,537,803	11,210,062	11,754,221	12,265,434	12,747,931	13,204,690	13,634,459	14,043,987	14,432,835	14,808,161
Cumulative Gross Peak Demand - Therm per Day										
Cumulative Net Energy Savings - Therm	5,268,902	5,605,031	5,877,111	6,132,717	6,373,966	6,602,345	6,817,229	7,021,993	7,216,418	7,404,080
Cumulative Net Peak Demand Savings - Therm per Day										
New Net Energy Savings - Therm	355,432	336,130	272,079	255,606	241,248	228,380	214,884	204,764	194,424	187,663
New Net Peak Demand Savings - Therm per Day										
Administration Costs	$ 72,016	$ 69,555	$ 67,905	$ 66,599	$ 65,606	$ 64,256	$ 63,388	$ 62,604	$ 61,892	$ 55,518
Marketing Costs	$ 1,474,492	$ 1,474,492	$ 1,474,492	$ 1,474,492	$ 1,474,492	$ 1,474,492	$ 1,474,492	$ 1,474,492	$ 1,474,492	$ 1,474,492
Incentives Costs	$ 475,572	$ 462,921	$ 384,056	$ 370,880	$ 359,208	$ 348,371	$ 334,828	$ 326,070	$ 319,245	$ 314,197
Total Costs	$ 2,022,080	$ 2,006,968	$ 1,926,453	$ 1,911,971	$ 1,899,306	$ 1,887,119	$ 1,872,708	$ 1,863,166	$ 1,855,629	$ 1,844,207
PV Net Avoided Cost Benefits	$ 3,971,779	$ 3,787,825	$ 3,118,875	$ 2,953,194	$ 2,807,097	$ 2,672,677	$ 2,525,426	$ 2,413,242	$ 2,289,109	$ 2,210,213
PV Annual Program Marketing and Admin Costs	$ 136,345	$ 130,965	$ 127,159	$ 124,031	$ 121,513	$ 118,362	$ 116,125	$ 114,062	$ 112,146	$ 100,047
PV Net Measure Costs	$ 1,098,965	$ 1,053,859	$ 932,385	$ 892,320	$ 856,048	$ 821,724	$ 782,084	$ 753,649	$ 728,758	$ 706,985
TRC Ratio	3.22	3.20	2.94	2.91	2.87	2.84	2.81	2.78	2.72	2.74
Free Riders - Therm	274,561	298,587	322,239	345,524	368,440	390,986	413,159	434,964	456,398	477,470
Free Riders - Therm per Day										
Other Naturally Occurring - Therm										
Other Naturally Occurring - Therm per Day										
Present Value Participant Costs	$ 744,180	$ 714,935	$ 669,785	$ 644,984	$ 622,314	$ 600,509	$ 575,202	$ 556,973	$ 540,402	$ 525,235
Incentive Subtotal - Free Riders Only	$ 21,677	$ 21,519	$ 21,331	$ 21,153	$ 20,969	$ 20,781	$ 20,585	$ 20,394	$ 20,202	$ 20,011
Cost per First-Year Net Therm	$5.69	$5.97	$7.08	$7.48	$7.87	$8.26	$8.71	$9.10	$9.54	$9.83
PV Annual Program Costs	$ 1,914,157	$ 1,889,460	$ 1,803,739	$ 1,780,386	$ 1,758,919	$ 1,738,074	$ 1,715,367	$ 1,697,291	$ 1,681,178	$ 1,661,691
PV Lost Revenue	$ 4,380,134	$ 4,073,503	$ 3,302,741	$ 3,066,427	$ 2,862,983	$ 2,683,690	$ 2,505,902	$ 2,366,824	$ 2,226,691	$ 2,128,758
RIM	0.63	0.64	0.61	0.61	0.61	0.60	0.60	0.59	0.59	0.58

Electricity
All Segments
Total
25 Percent

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cumulative Gross Energy - kWh	280,620,993	578,602,168	842,503,186	1,075,777,467	1,276,228,215	1,451,253,138	1,606,511,003	1,746,623,812	1,875,166,958	1,994,667,868
Cumulative Gross Peak Demand - kW	53,242	108,015	156,701	200,168	238,288	272,036	302,628	330,770	357,017	381,755
Cumulative Net Energy Savings - kWh	268,184,924	554,749,641	805,881,610	1,029,456,933	1,219,403,261	1,386,538,114	1,533,403,224	1,664,723,697	1,784,164,899	1,894,331,706
Cumulative Net Peak Demand Savings - kW	51,017	103,798	150,244	192,200	228,656	261,216	290,521	317,294	342,104	365,350
New Net Energy Savings - kWh	268,184,924	286,564,717	251,131,969	223,575,323	189,946,328	167,134,853	146,865,110	131,320,473	119,441,203	110,166,806
New Net Peak Demand Savings - kW	51,017	52,781	46,446	41,956	36,456	32,561	29,305	26,773	24,810	23,246
Administration Costs	$ 5,039,972	$ 4,589,519	$ 4,296,508	$ 4,076,068	$ 3,907,658	$ 3,717,694	$ 3,607,411	$ 3,492,536	$ 3,414,720	$ 3,322,244
Marketing Costs	$ 10,998,099	$ 14,878,341	$ 14,872,229	$ 14,866,250	$ 14,860,400	$ 14,854,678	$ 14,849,079	$ 14,843,602	$ 14,838,244	$ 14,833,002
Incentives Costs	$ 58,771,445	$ 77,848,804	$ 71,662,932	$ 62,710,491	$ 54,945,074	$ 48,290,851	$ 43,458,812	$ 39,710,337	$ 36,833,701	$ 34,587,747
Total Costs	$ 74,809,516	$ 97,316,663	$ 90,831,669	$ 81,652,809	$ 73,713,132	$ 66,863,223	$ 61,915,301	$ 58,046,475	$ 55,086,664	$ 52,742,993
PV Net Avoided Cost Benefits	$ 558,834,560	$ 581,963,784	$ 513,546,873	$ 465,550,145	$ 405,132,246	$ 366,221,851	$ 330,429,289	$ 303,513,566	$ 282,618,361	$ 266,276,560
PV Annual Program Marketing and Admin Costs	$ 16,038,071	$ 19,361,372	$ 18,959,608	$ 18,633,176	$ 18,360,776	$ 18,069,952	$ 17,858,980	$ 17,645,475	$ 17,469,352	$ 17,280,785
PV Net Measure Costs	$ 86,008,239	$ 103,189,723	$ 96,383,707	$ 86,920,074	$ 77,788,762	$ 70,428,433	$ 64,328,233	$ 59,393,899	$ 55,475,394	$ 52,307,361
TRC Ratio	5.48	4.75	4.45	4.41	4.21	4.14	4.02	3.94	3.87	3.83
Free Riders - kWh	12,033,302	23,248,059	35,913,356	45,615,856	56,123,799	64,017,375	72,413,618	81,209,425	90,314,822	99,652,362
Free Riders - kW	2,155	4,114	6,338	7,849	9,514	10,703	11,990	13,360	14,798	16,291
Other Naturally Occurring - kWh	402,766	604,468	708,220	704,679	701,155	697,650	694,161	690,690	687,237	683,801
Other Naturally Occurring - kW	70	103	119	119	118	118	117	116	116	115
Present Value Participant Costs	$ 22,460,550	$ 28,419,246	$ 28,519,174	$ 27,786,960	$ 26,799,096	$ 25,967,288	$ 24,947,289	$ 23,978,102	$ 23,136,509	$ 22,403,651
Incentive Subtotal - Free Riders Only	$ 2,103,930	$ 1,903,032	$ 2,096,073	$ 1,577,738	$ 1,657,270	$ 1,315,490	$ 1,357,413	$ 1,391,601	$ 1,419,760	$ 1,443,138
Cost per First-Year Net kWh	$0.28	$0.34	$0.36	$0.37	$0.39	$0.40	$0.42	$0.44	$0.46	$0.48
PV Annual Program Costs	$ 74,809,516	$ 96,784,349	$ 89,840,704	$ 80,320,223	$ 72,113,498	$ 65,054,438	$ 59,910,858	$ 55,860,051	$ 52,721,758	$ 50,202,587
PV Lost Revenue	$ 538,272,054	$ 541,633,009	$ 464,396,133	$ 406,944,508	$ 340,125,237	$ 294,629,913	$ 254,368,722	$ 223,047,830	$ 198,569,064	$ 179,017,787
RIM	0.91	0.91	0.93	0.96	0.98	1.02	1.05	1.09	1.12	1.16

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APPENDIX E System DSM ASSYST OUTPUT FILES

Electricity
All Segments
Total
25 Percent

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Cumulative Gross Energy - kWh	2,105,972,899	2,211,272,995	2,311,052,529	2,406,443,898	2,497,755,613	2,579,823,324	2,658,534,278	2,734,473,782	2,807,899,789	2,879,042,478
Cumulative Gross Peak Demand - kW	405,134	427,479	448,868	469,481	489,263	506,675	523,405	539,594	555,289	570,536
Cumulative Net Energy Savings - kWh	1,996,141,218	2,091,829,285	2,181,918,196	2,267,562,810	2,349,083,169	2,421,319,989	2,490,147,872	2,556,138,614	2,619,533,347	2,680,544,049
Cumulative Net Peak Demand Savings - kW	387,194	407,971	427,766	446,763	464,910	480,670	495,729	510,226	524,205	537,709
New Net Energy Savings - kWh	101,809,512	95,688,066	90,088,912	85,644,614	81,520,359	72,236,820	68,827,883	65,990,742	63,394,733	61,010,702
New Net Peak Demand Savings - kW	21,845	20,777	19,795	18,997	18,148	15,760	15,059	14,497	13,979	13,504
Administration Costs	$ 3,100,469	$ 3,032,433	$ 2,983,801	$ 2,941,366	$ 2,903,860	$ 2,769,264	$ 2,713,079	$ 2,681,837	$ 2,653,784	$ 2,613,485
Marketing Costs	$ 14,827,873	$ 14,822,857	$ 14,817,948	$ 14,813,147	$ 14,808,449	$ 14,803,854	$ 14,799,358	$ 14,794,960	$ 14,790,657	$ 14,786,447
Incentives Costs	$ 32,651,780	$ 31,189,874	$ 29,850,306	$ 28,802,210	$ 27,780,366	$ 25,483,514	$ 24,641,745	$ 23,998,366	$ 23,429,803	$ 22,922,309
Total Costs	$ 50,580,123	$ 49,045,163	$ 47,652,056	$ 46,556,723	$ 45,492,675	$ 43,056,632	$ 42,154,182	$ 41,475,162	$ 40,874,244	$ 40,322,242
PV Net Avoided Cost Benefits	$ 251,470,852	$ 240,397,824	$ 230,495,094	$ 222,555,792	$ 214,174,344	$ 189,542,759	$ 181,945,801	$ 175,686,703	$ 169,755,237	$ 164,128,683
PV Annual Program Marketing and Admin Costs	$ 16,971,468	$ 16,809,859	$ 16,667,781	$ 16,532,624	$ 16,403,108	$ 16,185,186	$ 16,041,072	$ 15,920,861	$ 15,804,461	$ 15,677,909
PV Net Measure Costs	$ 49,491,786	$ 47,285,906	$ 45,262,421	$ 43,575,531	$ 41,845,225	$ 38,747,865	$ 37,367,029	$ 36,251,061	$ 35,238,094	$ 34,314,997
TRC Ratio	3.78	3.75	3.72	3.70	3.68	3.45	3.41	3.37	3.33	3.28
Free Riders - kWh	109,151,299	118,766,730	128,460,738	138,210,860	148,005,568	157,839,793	167,726,182	177,678,246	187,712,804	197,848,059
Free Riders - kW	17,825	19,394	20,988	22,605	24,240	25,893	27,565	29,258	30,974	32,717
Other Naturally Occurring - kWh	680,382	676,980	673,595	670,227	666,876	663,542	660,224	656,923	653,638	650,370
Other Naturally Occurring - kW	115	114	113	113	112	112	111	111	110	110
Present Value Participant Costs	$ 21,692,563	$ 21,121,538	$ 20,595,863	$ 20,116,089	$ 19,542,875	$ 18,738,790	$ 18,319,077	$ 17,976,041	$ 17,659,387	$ 17,370,233
Incentive Subtotal - Free Riders Only	$ 1,461,854	$ 1,478,346	$ 1,492,292	$ 1,504,611	$ 1,515,411	$ 1,524,057	$ 1,533,515	$ 1,542,666	$ 1,551,677	$ 1,560,708
Cost per First-Year Net kWh	$0.50	$0.51	$0.53	$0.54	$0.56	$0.60	$0.61	$0.63	$0.64	$0.66
PV Annual Program Costs	$ 47,880,550	$ 46,173,560	$ 44,616,627	$ 43,352,628	$ 42,130,094	$ 39,656,002	$ 38,612,459	$ 37,782,685	$ 37,031,592	$ 36,331,660
PV Lost Revenue	$ 161,841,760	$ 148,558,426	$ 136,839,842	$ 127,130,689	$ 118,203,485	$ 102,223,721	$ 95,360,311	$ 89,531,599	$ 84,283,405	$ 79,580,201
RIM	1.20	1.23	1.27	1.31	1.34	1.34	1.36	1.38	1.40	1.42

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APPENDIX E System DSM ASSYST OUTPUT FILES

Electricity
Commerical
Total
25 Percent

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cumulative Gross Energy - kWh	240,445,070	478,469,394	683,573,408	865,105,193	1,021,818,686	1,159,969,067	1,283,899,178	1,396,694,239	1,500,669,730	1,597,481,364
Cumulative Gross Peak Demand - kW	48,480	96,211	137,956	175,269	208,143	237,470	264,288	289,130	312,403	334,393
Cumulative Net Energy Savings - kWh	230,689,133	460,079,817	655,249,905	829,936,217	978,994,633	1,112,085,501	1,230,425,360	1,337,196,896	1,434,802,368	1,524,973,382
Cumulative Net Peak Demand Savings - kW	46,583	92,663	132,516	168,669	200,231	228,720	254,599	278,416	300,594	321,429
New Net Energy Savings - kWh	230,689,133	229,390,684	195,170,088	174,686,312	149,058,416	133,090,868	118,339,859	106,771,536	97,605,472	90,171,014
New Net Peak Demand Savings - kW	46,583	46,080	39,853	36,153	31,562	28,489	25,879	23,817	22,177	20,835
Administration Costs	$ 3,928,015	$ 3,643,241	$ 3,463,135	$ 3,316,516	$ 3,195,954	$ 3,095,433	$ 3,011,810	$ 2,912,264	$ 2,846,850	$ 2,763,553
Marketing Costs	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031
Incentives Costs	$ 49,919,916	$ 61,332,676	$ 55,399,972	$ 48,296,406	$ 42,597,095	$ 37,682,844	$ 34,250,514	$ 31,485,683	$ 29,249,096	$ 27,415,678
Total Costs	$ 62,506,962	$ 73,634,949	$ 67,522,139	$ 60,271,954	$ 54,452,080	$ 49,437,309	$ 45,921,356	$ 43,056,978	$ 40,754,978	$ 38,838,263
PV Net Avoided Cost Benefits	$ 506,447,775	$ 501,768,111	$ 434,183,883	$ 394,598,864	$ 344,199,463	$ 314,024,943	$ 285,386,469	$ 263,565,947	$ 246,131,291	$ 232,027,362
PV Annual Program Marketing and Admin Costs	$ 12,587,046	$ 12,234,980	$ 11,989,915	$ 11,780,105	$ 11,597,723	$ 11,436,483	$ 11,293,011	$ 11,135,442	$ 11,011,927	$ 10,872,407
PV Net Measure Costs	$ 73,403,673	$ 83,220,924	$ 76,199,376	$ 68,449,454	$ 61,411,039	$ 55,891,397	$ 51,363,299	$ 47,623,960	$ 44,543,833	$ 41,959,253
TRC Ratio	5.89	5.26	4.92	4.92	4.71	4.66	4.55	4.49	4.43	4.39
Free Riders - kWh	9,353,171	17,785,110	27,615,283	34,464,297	42,122,898	47,185,916	52,779,657	58,806,653	65,180,125	71,824,181
Free Riders - kW	1,827	3,445	5,321	6,481	7,794	8,633	9,572	10,597	11,694	12,849
Other Naturally Occurring - kWh	402,766	604,468	708,220	704,679	701,155	697,650	694,161	690,690	687,237	683,801
Other Naturally Occurring - kW	70	103	119	119	118	118	117	116	116	115
Present Value Participant Costs	$ 19,685,357	$ 24,078,480	$ 23,573,689	$ 22,605,872	$ 21,576,032	$ 20,795,519	$ 19,912,276	$ 19,123,267	$ 18,447,420	$ 17,850,257
Incentive Subtotal - Free Riders Only	$ 1,576,691	$ 1,352,513	$ 1,529,427	$ 1,000,017	$ 1,072,043	$ 725,280	$ 764,014	$ 796,294	$ 823,460	$ 846,509
Cost per First-Year Net kWh	$0.27	$0.32	$0.35	$0.35	$0.37	$0.37	$0.39	$0.40	$0.42	$0.43
PV Annual Program Costs	$ 62,506,962	$ 73,232,172	$ 66,785,478	$ 59,288,306	$ 53,270,426	$ 48,099,930	$ 44,434,700	$ 41,435,161	$ 39,005,340	$ 36,967,589
PV Lost Revenue	$ 483,470,965	$ 460,681,793	$ 386,017,791	$ 339,075,874	$ 283,841,518	$ 248,198,316	$ 215,931,728	$ 190,454,086	$ 170,080,665	$ 153,434,551
RIM	0.93	0.94	0.96	0.99	1.02	1.06	1.10	1.14	1.18	1.22

Electricity
Commerical
Total
25 Percent

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Cumulative Gross Energy - kWh	1,688,204,810	1,773,951,648	1,854,911,523	1,932,151,104	2,005,839,866	2,072,054,357	2,135,616,289	2,196,883,874	2,256,070,976	2,313,380,202
Cumulative Gross Peak Demand - kW	355,282	375,260	394,370	412,784	430,431	445,926	460,825	475,240	489,214	502,787
Cumulative Net Energy Savings - kWh	1,608,854,444	1,687,603,656	1,761,449,280	1,831,481,373	1,897,882,163	1,956,731,871	2,012,843,471	2,066,563,020	2,118,088,855	2,167,606,644
Cumulative Net Peak Demand Savings - kW	341,117	359,857	377,699	394,820	411,151	425,309	438,849	451,881	464,444	476,578
New Net Energy Savings - kWh	83,881,062	78,749,212	73,845,624	70,032,093	66,400,790	58,849,707	56,111,600	53,719,550	51,525,835	49,517,789
New Net Peak Demand Savings - kW	19,688	18,740	17,842	17,121	16,331	14,158	13,540	13,032	12,563	12,134
Administration Costs	$ 2,572,794	$ 2,517,307	$ 2,476,360	$ 2,440,648	$ 2,409,362	$ 2,299,193	$ 2,250,133	$ 2,223,881	$ 2,200,485	$ 2,164,536
Marketing Costs	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031	$ 8,659,031
Incentives Costs	$ 25,874,678	$ 24,608,384	$ 23,401,562	$ 22,474,161	$ 21,541,901	$ 19,746,080	$ 19,085,541	$ 18,545,006	$ 18,068,682	$ 17,649,415
Total Costs	$ 37,106,503	$ 35,784,723	$ 34,536,954	$ 33,573,841	$ 32,610,294	$ 30,704,305	$ 29,994,705	$ 29,427,918	$ 28,928,199	$ 28,472,983
PV Net Avoided Cost Benefits	$ 219,923,414	$ 209,960,931	$ 200,749,324	$ 193,446,833	$ 185,545,301	$ 163,968,291	$ 157,448,802	$ 151,862,853	$ 146,569,016	$ 141,571,356
PV Annual Program Marketing and Admin Costs	$ 10,632,358	$ 10,521,962	$ 10,426,069	$ 10,335,785	$ 10,250,275	$ 10,092,740	$ 9,992,595	$ 9,914,021	$ 9,838,596	$ 9,752,389
PV Net Measure Costs	$ 39,736,990	$ 37,860,570	$ 36,087,013	$ 34,652,311	$ 33,116,998	$ 30,756,679	$ 29,688,743	$ 28,773,836	$ 27,943,985	$ 27,195,811
TRC Ratio	4.37	4.34	4.32	4.30	4.28	4.01	3.97	3.93	3.88	3.83
Free Riders - kWh	78,669,984	85,671,013	92,788,648	99,999,504	107,290,827	114,658,945	122,112,594	129,663,931	137,328,483	145,123,188
Free Riders - kW	14,050	15,289	16,557	17,851	19,168	20,505	21,865	23,249	24,660	26,100
Other Naturally Occurring - kWh	680,382	676,980	673,595	670,227	666,876	663,542	660,224	656,923	653,638	650,370
Other Naturally Occurring - kW	115	114	113	113	112	112	111	111	110	110
Present Value Participant Costs	$ 17,310,328	$ 16,836,379	$ 16,389,685	$ 16,006,409	$ 15,501,938	$ 14,947,040	$ 14,640,891	$ 14,370,620	$ 14,119,812	$ 13,893,488
Incentive Subtotal - Free Riders Only	$ 865,601	$ 882,602	$ 897,315	$ 910,602	$ 922,492	$ 933,102	$ 943,849	$ 954,311	$ 964,667	$ 975,064
Cost per First-Year Net kWh	$0.44	$0.45	$0.47	$0.48	$0.49	$0.52	$0.53	$0.55	$0.56	$0.58
PV Annual Program Costs	$ 35,126,047	$ 33,689,521	$ 32,336,956	$ 31,263,245	$ 30,199,912	$ 28,279,267	$ 27,474,601	$ 26,807,991	$ 26,208,613	$ 25,655,090
PV Lost Revenue	$ 139,311,861	$ 127,717,473	$ 117,288,749	$ 108,755,648	$ 100,803,004	$ 87,193,137	$ 81,397,924	$ 76,343,398	$ 71,788,487	$ 67,716,126
RIM	1.26	1.30	1.34	1.38	1.42	1.42	1.45	1.47	1.50	1.52

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APPENDIX E System DSM ASSYST OUTPUT FILES

Electricity
Industrial
Total
25 Percent

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cumulative Gross Energy - kWh	40,175,922	100,132,774	158,929,778	210,672,275	254,409,529	291,284,072	322,611,825	349,929,572	374,497,228	397,186,505
Cumulative Gross Peak Demand - kW	4,762	11,803	18,745	24,899	30,145	34,566	38,340	41,640	44,614	47,363
Cumulative Net Energy Savings - kWh	37,495,791	94,669,825	150,631,705	199,520,716	240,408,628	274,452,613	302,977,864	327,526,801	349,362,531	369,358,324
Cumulative Net Peak Demand Savings - kW	4,434	11,134	17,728	23,531	28,425	32,496	35,922	38,878	41,510	43,921
New Net Energy Savings - kWh	37,495,791	57,174,033	55,961,880	48,889,011	40,887,912	34,043,985	28,525,250	24,548,937	21,835,730	19,995,793
New Net Peak Demand Savings - kW	4,434	6,700	6,593	5,803	4,894	4,072	3,426	2,956	2,632	2,411
Administration Costs	$ 1,111,957	$ 946,277	$ 833,373	$ 759,552	$ 711,704	$ 622,261	$ 595,600	$ 580,272	$ 567,870	$ 558,691
Marketing Costs	$ 2,339,068	$ 6,219,310	$ 6,213,198	$ 6,207,218	$ 6,201,369	$ 6,195,646	$ 6,190,048	$ 6,184,571	$ 6,179,212	$ 6,173,970
Incentives Costs	$ 8,851,529	$ 16,516,128	$ 16,262,960	$ 14,414,085	$ 12,347,980	$ 10,608,006	$ 9,208,298	$ 8,224,654	$ 7,584,604	$ 7,172,069
Total Costs	$ 12,302,554	$ 23,681,715	$ 23,309,531	$ 21,380,855	$ 19,261,052	$ 17,425,914	$ 15,993,946	$ 14,989,497	$ 14,331,686	$ 13,904,730
PV Net Avoided Cost Benefits	$ 52,386,785	$ 80,195,673	$ 79,362,991	$ 70,951,281	$ 60,932,783	$ 52,196,908	$ 45,042,820	$ 39,947,619	$ 36,487,071	$ 34,249,198
PV Annual Program Marketing and Admin Costs	$ 3,451,025	$ 7,126,392	$ 6,969,693	$ 6,853,072	$ 6,763,054	$ 6,633,469	$ 6,565,970	$ 6,510,033	$ 6,457,425	$ 6,408,378
PV Net Measure Costs	$ 12,604,566	$ 19,968,799	$ 20,184,330	$ 18,470,619	$ 16,377,723	$ 14,537,035	$ 12,964,934	$ 11,769,939	$ 10,931,560	$ 10,348,108
TRC Ratio	3.26	2.96	2.92	2.80	2.63	2.47	2.31	2.19	2.10	2.04
Free Riders - kWh	2,680,131	5,462,949	8,298,073	11,151,559	14,000,901	16,831,458	19,633,961	22,402,771	25,134,697	27,828,181
Free Riders - kW	328	669	1,017	1,368	1,720	2,070	2,418	2,763	3,104	3,442
Other Naturally Occurring - kWh										
Other Naturally Occurring - kW										
Present Value Participant Costs	$ 2,775,192	$ 4,340,766	$ 4,945,485	$ 5,181,088	$ 5,223,064	$ 5,171,769	$ 5,035,012	$ 4,854,835	$ 4,689,089	$ 4,553,394
Incentive Subtotal - Free Riders Only	$ 527,239	$ 550,519	$ 566,645	$ 577,720	$ 585,228	$ 590,210	$ 593,399	$ 595,308	$ 596,299	$ 596,629
Cost per First-Year Net kWh	$0.33	$0.41	$0.42	$0.44	$0.47	$0.51	$0.56	$0.61	$0.66	$0.70
PV Annual Program Costs	$ 12,302,554	$ 23,552,178	$ 23,055,226	$ 21,031,917	$ 18,843,072	$ 16,954,508	$ 15,476,158	$ 14,424,891	$ 13,716,418	$ 13,234,998
PV Lost Revenue	$ 54,801,089	$ 80,951,217	$ 78,378,341	$ 67,868,634	$ 56,283,718	$ 46,431,597	$ 38,436,995	$ 32,593,744	$ 28,488,399	$ 25,583,236
RIM	0.78	0.77	0.78	0.80	0.81	0.82	0.84	0.85	0.86	0.88

APPENDIX E System DSM ASSYST OUTPUT FILES

Electricity
Industrial
Total
25 Percent

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Cumulative Gross Energy - kWh	417,768,089	437,321,346	456,141,006	474,292,793	491,915,747	507,768,967	522,917,989	537,589,908	551,828,813	565,662,276
Cumulative Gross Peak Demand - kW	49,853	52,219	54,498	56,697	58,832	60,749	62,580	64,354	66,076	67,749
Cumulative Net Energy Savings - kWh	387,286,774	404,225,629	420,468,916	436,081,437	451,201,006	464,588,118	477,304,401	489,575,593	501,444,492	512,937,405
Cumulative Net Peak Demand Savings - kW	46,077	48,114	50,066	51,943	53,760	55,361	56,880	58,345	59,761	61,131
New Net Energy Savings - kWh	17,928,450	16,938,855	16,243,287	15,612,521	15,119,569	13,387,112	12,716,283	12,271,192	11,868,899	11,492,913
New Net Peak Demand Savings - kW	2,156	2,037	1,952	1,877	1,817	1,602	1,519	1,465	1,416	1,370
Administration Costs	$ 527,676	$ 515,126	$ 507,440	$ 500,718	$ 494,498	$ 470,070	$ 462,946	$ 457,956	$ 453,299	$ 448,949
Marketing Costs	$ 6,168,842	$ 6,163,825	$ 6,158,917	$ 6,154,115	$ 6,149,418	$ 6,144,822	$ 6,140,327	$ 6,135,928	$ 6,131,625	$ 6,127,416
Incentives Costs	$ 6,777,103	$ 6,581,489	$ 6,448,744	$ 6,328,049	$ 6,238,465	$ 5,737,434	$ 5,556,204	$ 5,453,360	$ 5,361,121	$ 5,272,894
Total Costs	$ 13,473,621	$ 13,260,441	$ 13,115,101	$ 12,982,882	$ 12,882,381	$ 12,352,327	$ 12,159,477	$ 12,047,244	$ 11,946,045	$ 11,849,259
PV Net Avoided Cost Benefits	$ 31,547,438	$ 30,436,893	$ 29,745,770	$ 29,108,958	$ 28,629,043	$ 25,574,468	$ 24,496,999	$ 23,823,850	$ 23,186,220	$ 22,557,326
PV Annual Program Marketing and Admin Costs	$ 6,339,110	$ 6,287,897	$ 6,241,712	$ 6,196,839	$ 6,152,832	$ 6,092,446	$ 6,048,477	$ 6,006,839	$ 5,965,865	$ 5,925,520
PV Net Measure Costs	$ 9,754,797	$ 9,425,336	$ 9,175,408	$ 8,923,220	$ 8,728,227	$ 7,991,186	$ 7,678,286	$ 7,477,225	$ 7,294,109	$ 7,119,186
TRC Ratio	1.96	1.94	1.93	1.93	1.92	1.82	1.78	1.77	1.75	1.73
Free Riders - kWh	30,481,315	33,095,718	35,672,089	38,211,356	40,714,741	43,180,849	45,613,588	48,014,314	50,384,321	52,724,871
Free Riders - kW	3,775	4,105	4,431	4,754	5,073	5,388	5,700	6,009	6,315	6,618
Other Naturally Occurring - kWh										
Other Naturally Occurring - kW										
Present Value Participant Costs	$ 4,382,235	$ 4,285,159	$ 4,206,178	$ 4,109,680	$ 4,040,937	$ 3,791,750	$ 3,678,186	$ 3,605,421	$ 3,539,575	$ 3,476,745
Incentive Subtotal - Free Riders Only	$ 596,254	$ 595,743	$ 594,977	$ 594,009	$ 592,919	$ 590,955	$ 589,666	$ 588,355	$ 587,010	$ 585,644
Cost per First-Year Net kWh	$0.75	$0.78	$0.81	$0.83	$0.85	$0.92	$0.96	$0.98	$1.01	$1.03
PV Annual Program Costs	$ 12,754,504	$ 12,484,039	$ 12,279,672	$ 12,089,383	$ 11,930,183	$ 11,376,735	$ 11,137,859	$ 10,974,694	$ 10,822,979	$ 10,676,570
PV Lost Revenue	$ 22,529,899	$ 20,840,952	$ 19,551,092	$ 18,375,041	$ 17,400,481	$ 15,030,584	$ 13,962,387	$ 13,188,201	$ 12,494,918	$ 11,864,076
RIM	0.89	0.91	0.93	0.96	0.98	0.97	0.98	0.99	0.99	1.00

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APPENDIX E

System

DSM ASSYST OUTPUT FILES

Electricity
All Segments
Total
75 Percent

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cumulative Gross Energy - kWh	281,865,157	619,390,950	918,482,105	1,182,442,340	1,407,166,667	1,602,368,122	1,773,847,405	1,927,630,802	2,068,206,454	2,198,553,135
Cumulative Gross Peak Demand - kW	53,464	115,079	169,924	219,142	262,086	300,216	334,603	366,164	395,588	423,327
Cumulative Net Energy Savings - kWh	269,429,088	595,539,092	881,861,902	1,136,179,509	1,350,457,645	1,537,830,160	1,700,978,939	1,846,032,213	1,977,567,312	2,098,639,947
Cumulative Net Peak Demand Savings - kW	51,239	110,863	163,468	211,180	252,464	289,412	322,518	352,716	380,709	406,963
New Net Energy Savings - kWh	269,429,088	326,110,004	286,322,810	254,317,607	214,278,136	187,372,515	163,148,779	145,053,273	131,535,099	121,072,636
New Net Peak Demand Savings - kW	51,239	59,624	52,605	47,712	41,284	36,947	33,106	30,198	27,993	26,254
Administration Costs	5,039,972	5,800,505	5,371,047	5,055,600	4,818,815	4,539,459	4,368,568	4,227,789	4,131,844	3,997,063
Marketing Costs	10,998,099	14,878,341	14,872,229	14,866,250	14,860,400	14,854,678	14,849,079	14,843,602	14,838,244	14,833,002
Incentives Costs	59,117,786	107,438,627	99,173,512	88,250,779	77,032,613	68,187,202	60,876,319	55,370,113	51,245,662	48,053,286
Total Costs	75,155,857	128,117,473	119,416,788	108,172,628	96,711,829	87,581,339	80,093,966	74,441,504	70,215,750	66,883,351
PV Net Avoided Cost Benefits	561,327,007	664,050,386	587,086,701	532,709,313	460,146,348	414,881,132	371,275,936	339,341,297	315,204,868	296,578,145
PV Annual Program Marketing and Admin Costs	16,038,071	20,565,734	20,022,424	19,596,722	19,252,161	18,869,487	18,595,496	18,353,033	18,155,689	17,923,100
PV Net Measure Costs	86,641,653	126,239,446	117,340,968	105,784,532	93,513,942	84,010,634	75,786,182	69,401,839	64,483,151	60,570,638
TRC Ratio	5.47	4.52	4.27	4.25	4.08	4.03	3.93	3.87	3.81	3.78
Free Riders - kWh	12,033,302	23,247,456	35,912,085	45,558,254	56,007,967	63,840,412	72,174,405	80,907,999	89,952,004	99,229,485
Free Riders - kW	2,155	4,114	6,337	7,844	9,503	10,687	11,968	13,331	14,763	16,249
Other Naturally Occurring - kWh	402,766	604,401	708,118	704,577	701,054	697,549	694,061	690,591	687,138	683,702
Other Naturally Occurring - kW	70	103	119	119	118	118	117	116	116	115
Present Value Participant Costs	15,080,476	21,996,954	22,192,111	21,405,373	20,765,823	20,009,142	19,348,267	18,694,355	18,112,168	17,594,981
Incentive Subtotal - Free Riders Only	2,355,587	2,216,337	2,434,538	1,875,226	1,969,367	1,588,855	1,638,554	1,679,672	1,714,078	1,743,138
Cost per First-Year Net kWh	$0.28	$0.39	$0.42	$0.43	$0.45	$0.47	$0.49	$0.51	$0.53	$0.55
PV Annual Program Costs	75,155,857	127,416,681	118,113,961	106,407,235	94,613,105	85,212,088	77,501,008	71,637,532	67,201,341	63,661,863
PV Lost Revenue	540,638,656	617,416,293	530,108,276	463,720,354	384,131,639	330,940,465	282,898,123	246,451,364	218,574,837	196,565,407
RIM	0.91	0.89	0.91	0.93	0.96	1.00	1.03	1.07	1.10	1.14

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APPENDIX E **System** **DSM ASSYST OUTPUT FILES**

Electricity
All Segments
Total
75 Percent

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Cumulative Gross Energy - kWh	2,319,704,411	2,434,068,288	2,542,548,422	2,646,445,507	2,746,011,398	2,834,594,153	2,918,723,402	2,999,859,678	3,078,315,701	3,154,348,310
Cumulative Gross Peak Demand - kW	449,562	474,649	498,721	521,982	544,325	563,847	582,387	600,320	617,706	634,596
Cumulative Net Energy Savings - kWh	2,210,354,107	2,315,162,506	2,414,006,623	2,508,209,579	2,598,034,764	2,676,835,346	2,751,128,364	2,822,360,913	2,890,828,970	2,956,771,259
Cumulative Net Peak Demand Savings - kW	431,670	455,196	477,681	499,332	520,047	537,924	554,798	571,045	586,721	601,875
New Net Energy Savings - kWh	111,714,159	104,808,399	98,844,117	94,202,955	89,825,185	78,800,582	74,293,018	71,232,549	68,468,058	65,942,289
New Net Peak Demand Savings - kW	24,707	23,526	22,485	21,651	20,715	17,876	16,874	16,247	15,676	15,154
Administration Costs	3,681,323	3,543,005	3,474,774	3,416,755	3,366,218	3,212,165	3,141,771	3,101,739	3,066,478	3,021,753
Marketing Costs	14,827,873	14,822,857	14,817,948	14,813,147	14,808,449	14,803,854	14,799,358	14,794,960	14,790,657	14,786,447
Incentives Costs	45,312,942	43,273,701	41,543,965	40,215,620	38,834,698	35,386,552	33,757,893	32,862,831	32,093,229	31,413,697
Total Costs	63,822,138	61,639,563	59,836,688	58,445,522	57,009,366	53,402,571	51,699,022	50,759,530	49,950,364	49,221,898
PV Net Avoided Cost Benefits	279,958,628	267,523,603	257,026,865	248,855,251	239,842,506	210,301,566	199,885,919	193,083,616	186,721,721	180,709,488
PV Annual Program Marketing and Admin Costs	17,521,320	17,290,537	17,127,479	16,975,296	16,831,291	16,593,106	16,433,746	16,303,380	16,178,358	16,045,772
PV Net Measure Costs	57,168,052	54,519,286	52,214,809	50,338,150	48,360,384	44,519,184	42,494,824	41,199,428	40,052,135	39,016,241
TRC Ratio	3.75	3.73	3.71	3.70	3.68	3.44	3.39	3.36	3.32	3.28
Free Riders - kWh	108,670,021	118,228,899	127,868,300	137,565,798	147,309,854	157,095,361	166,934,909	176,841,937	186,833,187	196,926,774
Free Riders - kW	17,777	19,339	20,927	22,537	24,166	25,812	27,477	29,164	30,875	32,612
Other Naturally Occurring - kWh	680,284	676,883	673,498	670,131	666,780	663,446	660,129	656,828	653,544	650,276
Other Naturally Occurring - kW	115	114	113	113	112	112	111	111	110	110
Present Value Participant Costs	17,115,692	16,696,061	16,302,675	15,940,226	15,498,897	15,077,280	14,776,503	14,519,124	14,285,283	14,072,375
Incentive Subtotal - Free Riders Only	1,766,807	1,788,081	1,806,458	1,822,915	1,837,526	1,849,491	1,862,450	1,874,972	1,887,242	1,899,451
Cost per First-Year Net kWh	$0.57	$0.59	$0.61	$0.62	$0.63	$0.68	$0.70	$0.71	$0.73	$0.75
PV Annual Program Costs	60,415,810	58,030,556	56,025,101	54,423,224	52,795,531	49,184,815	47,355,358	46,240,478	45,254,452	44,350,542
PV Lost Revenue	177,437,383	162,667,682	150,082,622	139,785,688	130,195,337	111,444,580	103,118,474	96,892,354	91,331,524	86,361,873
RIM	1.18	1.21	1.25	1.28	1.31	1.31	1.33	1.35	1.37	1.38

Electricity
Commerical
Total
75 Percent

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cumulative Gross Energy - kWh	241,089,898	502,999,360	728,696,594	929,077,713	1,100,906,516	1,252,560,285	1,387,390,865	1,509,242,126	1,620,990,596	1,724,704,650
Cumulative Gross Peak Demand - kW	48,627	101,741	148,322	190,339	227,230	260,346	290,454	318,230	344,189	368,694
Cumulative Net Energy Savings - kWh	231,333,961	484,610,452	700,374,464	893,966,441	1,058,198,396	1,204,853,782	1,334,156,361	1,450,046,307	1,555,486,150	1,652,619,643
Cumulative Net Peak Demand Savings - kW	46,731	98,193	142,882	183,745	219,329	251,612	280,787	307,545	332,415	355,772
New Net Energy Savings - kWh	231,333,961	253,276,491	215,764,012	193,591,978	164,231,955	146,655,386	129,302,578	115,889,947	105,439,843	97,133,493
New Net Peak Demand Savings - kW	46,731	51,462	44,689	40,863	35,584	32,284	29,175	26,758	24,869	23,357
Administration Costs	3,928,015	4,531,776	4,267,338	4,059,419	3,894,393	3,761,375	3,654,233	3,536,558	3,458,108	3,336,289
Marketing Costs	8,659,031	8,659,031	8,659,031	8,659,031	8,659,031	8,659,031	8,659,031	8,659,031	8,659,031	8,659,031
Incentives Costs	50,138,745	82,125,537	73,966,789	65,636,596	57,386,197	51,309,036	46,083,049	41,996,430	38,793,341	36,253,268
Total Costs	62,725,791	95,316,344	86,893,158	78,355,046	69,939,621	63,729,443	58,396,313	54,192,020	50,910,480	48,248,588
PV Net Avoided Cost Benefits	508,004,748	560,738,417	486,422,636	444,588,556	385,958,456	352,976,859	318,296,763	292,212,482	271,784,756	255,669,595
PV Annual Program Marketing and Admin Costs	12,587,046	13,118,655	12,785,344	12,510,883	12,281,005	12,084,410	11,914,635	11,736,221	11,596,942	11,417,556
PV Net Measure Costs	73,800,435	99,487,671	90,492,036	81,494,959	72,233,655	65,566,420	59,514,847	54,683,885	50,829,832	47,704,333
TRC Ratio	5.88	4.98	4.71	4.73	4.57	4.55	4.46	4.40	4.35	4.32
Free Riders - kWh	9,353,171	17,784,507	27,614,012	34,406,695	42,007,066	47,008,954	52,540,444	58,505,227	64,817,307	71,401,304
Free Riders - kW	1,827	3,445	5,320	6,475	7,783	8,616	9,550	10,569	11,659	12,807
Other Naturally Occurring - kWh	402,766	604,401	708,118	704,577	701,054	697,549	694,061	690,591	687,138	683,702
Other Naturally Occurring - kW	70	103	119	119	118	118	117	116	116	115
Present Value Participant Costs	13,888,499	19,632,869	19,452,275	18,508,888	17,829,882	17,091,718	16,481,203	15,925,144	15,446,949	15,023,910
Incentive Subtotal - Free Riders Only	1,688,490	1,520,041	1,717,484	1,143,421	1,227,094	839,184	883,699	921,241	953,249	980,782
Cost per First-Year Net kWh	$0.27	$0.38	$0.40	$0.40	$0.43	$0.43	$0.45	$0.47	$0.48	$0.50
PV Annual Program Costs	62,725,791	94,794,971	85,945,161	77,076,280	68,421,875	62,005,434	56,505,794	52,150,781	48,724,860	45,924,659
PV Lost Revenue	484,881,759	511,938,172	429,393,314	378,208,032	314,588,704	275,126,955	237,207,296	207,743,099	184,585,914	166,024,640
RIM	0.93	0.92	0.94	0.98	1.01	1.05	1.08	1.12	1.16	1.21

DNV·GL

Electricity
Commerical
Total
75 Percent

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Cumulative Gross Energy - kWh	1,821,724,867	1,913,383,541	2,000,010,887	2,082,767,880	2,161,767,879	2,232,032,175	2,299,386,964	2,364,416,664	2,427,352,509	2,488,405,365
Cumulative Gross Peak Demand - kW	391,977	414,271	435,643	456,281	476,067	493,309	509,758	525,683	541,132	556,152
Cumulative Net Energy Savings - kWh	1,742,855,877	1,827,573,476	1,907,141,178	1,982,743,307	2,054,505,986	2,117,454,216	2,177,405,514	2,234,932,213	2,290,250,100	2,343,553,186
Cumulative Net Peak Demand Savings - kW	377,861	398,923	419,033	438,385	456,862	472,773	487,870	502,417	516,462	530,048
New Net Energy Savings - kWh	90,236,234	84,717,599	79,567,701	75,602,130	71,762,679	62,948,230	59,951,298	57,526,698	55,317,887	53,303,086
New Net Peak Demand Savings - kW	22,089	21,062	20,110	19,351	18,477	15,912	15,096	14,547	14,045	13,586
Administration Costs	3,074,645	2,976,421	2,923,421	2,877,910	2,838,586	2,710,391	2,653,813	2,622,449	2,594,622	2,554,093
Marketing Costs	8,659,031	8,659,031	8,659,031	8,659,031	8,659,031	8,659,031	8,659,031	8,659,031	8,659,031	8,659,031
Incentives Costs	34,182,285	32,532,855	31,039,489	29,902,838	28,668,683	26,155,763	25,221,220	24,572,626	24,008,509	23,517,399
Total Costs	45,915,961	44,168,307	42,621,942	41,439,780	40,166,300	37,525,186	36,534,064	35,854,107	35,262,162	34,730,523
PV Net Avoided Cost Benefits	242,173,962	231,340,086	221,604,409	214,016,126	205,456,058	179,808,564	172,063,491	166,281,857	160,842,448	155,720,412
PV Annual Program Marketing and Admin Costs	11,107,424	10,954,194	10,844,652	10,742,954	10,647,773	10,471,461	10,362,358	10,277,106	10,195,680	10,103,392
PV Net Measure Costs	45,099,550	42,959,379	41,003,400	39,442,395	37,715,339	34,867,705	33,604,033	32,632,033	31,758,458	30,974,699
TRC Ratio	4.31	4.29	4.27	4.26	4.25	3.97	3.91	3.88	3.83	3.79
Free Riders - kWh	78,188,706	85,133,182	92,196,211	99,354,442	106,595,113	113,914,512	121,321,321	128,827,623	136,448,865	144,201,903
Free Riders - kW	14,002	15,234	16,496	17,783	19,093	20,424	21,778	23,155	24,560	25,994
Other Naturally Occurring - kWh	680,284	676,883	673,498	670,131	666,780	663,446	660,129	656,828	653,544	650,276
Other Naturally Occurring - kW	115	114	113	113	112	112	111	111	110	110
Present Value Participant Costs	14,642,856	14,302,937	13,977,712	13,696,958	13,315,703	12,976,217	12,755,064	12,553,837	12,366,018	12,195,369
Incentive Subtotal - Free Riders Only	1,003,888	1,024,793	1,043,173	1,059,942	1,075,067	1,088,801	1,102,621	1,116,074	1,129,358	1,142,644
Cost per First-Year Net kWh	$0.51	$0.52	$0.54	$0.55	$0.56	$0.60	$0.61	$0.62	$0.64	$0.65
PV Annual Program Costs	43,465,325	41,582,245	39,906,931	38,587,839	37,197,417	34,561,432	33,464,534	32,662,065	31,947,111	31,293,339
PV Lost Revenue	150,537,812	138,019,831	126,948,446	117,953,272	109,459,668	93,684,813	87,403,645	82,187,489	77,504,436	73,323,195
RIM	1.25	1.29	1.33	1.37	1.40	1.40	1.42	1.45	1.47	1.49

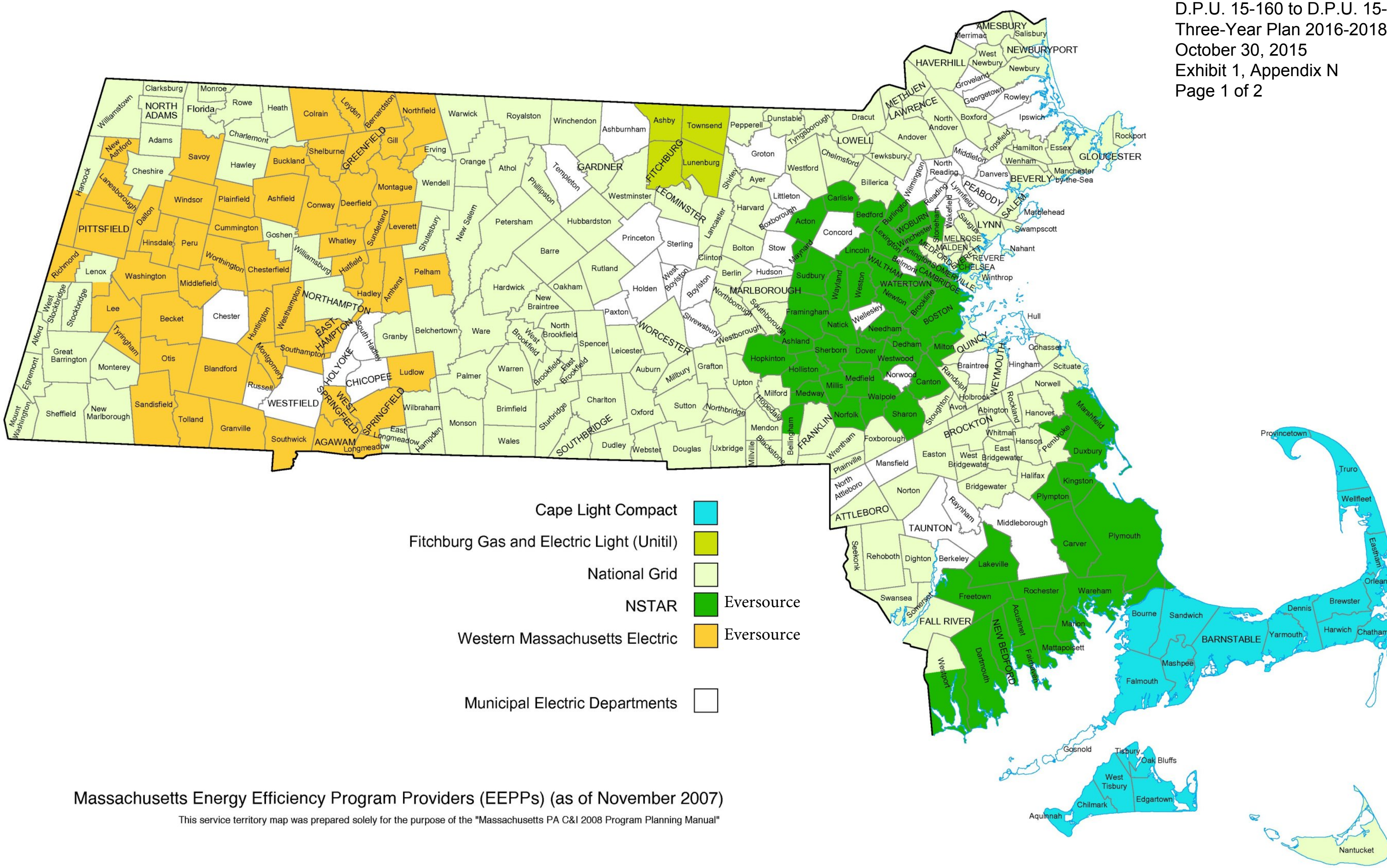
Electricity
Industrial
Total
75 Percent

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cumulative Gross Energy - kWh	40,775,259	116,391,589	189,785,511	253,364,627	306,260,150	349,807,837	386,456,540	418,388,677	447,215,858	473,848,485
Cumulative Gross Peak Demand - kW	4,836	13,338	21,603	28,803	34,855	39,869	44,149	47,934	51,398	54,633
Cumulative Net Energy Savings - kWh	38,095,128	110,928,640	181,487,438	242,213,068	292,259,249	332,976,378	366,822,579	395,985,905	422,081,161	446,020,304
Cumulative Net Peak Demand Savings - kW	4,508	12,669	20,586	27,435	33,136	37,799	41,731	45,171	48,294	51,192
New Net Energy Savings - kWh	38,095,128	72,833,513	70,558,798	60,725,630	50,046,181	40,717,129	33,846,200	29,163,327	26,095,256	23,939,143
New Net Peak Demand Savings - kW	4,508	8,161	7,916	6,849	5,701	4,664	3,931	3,441	3,123	2,897
Administration Costs	1,111,957	1,268,729	1,103,709	996,181	924,423	778,084	714,335	691,231	673,736	660,774
Marketing Costs	2,339,068	6,219,310	6,213,198	6,207,218	6,201,369	6,195,646	6,190,048	6,184,571	6,179,212	6,173,970
Incentives Costs	8,979,041	25,313,090	25,206,723	22,614,183	19,646,416	16,878,166	14,793,270	13,373,682	12,452,321	11,800,018
Total Costs	12,430,066	32,801,129	32,523,630	29,817,582	26,772,208	23,851,896	21,697,653	20,249,484	19,305,269	18,634,762
PV Net Avoided Cost Benefits	53,322,258	103,311,969	100,664,065	88,120,757	74,187,892	61,904,273	52,979,173	47,128,815	43,420,112	40,908,551
PV Annual Program Marketing and Admin Costs	3,451,025	7,447,080	7,237,080	7,085,839	6,971,156	6,785,077	6,680,861	6,616,812	6,558,747	6,505,544
PV Net Measure Costs	12,841,218	26,751,775	26,848,932	24,289,573	21,280,288	18,444,214	16,271,335	14,717,955	13,653,319	12,866,305
TRC Ratio	3.27	3.02	2.95	2.81	2.63	2.45	2.31	2.21	2.15	2.11
Free Riders - kWh	2,680,131	5,462,949	8,298,073	11,151,559	14,000,901	16,831,458	19,633,961	22,402,771	25,134,697	27,828,181
Free Riders - kW	328	669	1,017	1,368	1,720	2,070	2,418	2,763	3,104	3,442
Other Naturally Occurring - kWh										
Other Naturally Occurring - kW										
Present Value Participant Costs	1,191,977	2,364,086	2,739,835	2,896,485	2,935,942	2,917,424	2,867,064	2,769,211	2,665,219	2,571,071
Incentive Subtotal - Free Riders Only	667,097	696,296	717,054	731,806	742,273	749,670	754,854	758,431	760,829	762,356
Cost per First-Year Net kWh	$0.33	$0.45	$0.46	$0.49	$0.53	$0.59	$0.64	$0.69	$0.74	$0.78
PV Annual Program Costs	12,430,066	32,621,709	32,168,800	29,330,955	26,191,230	23,206,654	20,995,214	19,486,751	18,476,481	17,737,205
PV Lost Revenue	55,756,897	105,478,122	100,714,963	85,512,322	69,542,935	55,813,510	45,690,827	38,708,265	33,988,923	30,540,767
RIM	0.78	0.75	0.76	0.77	0.77	0.78	0.79	0.81	0.83	0.85

Electricity
Industrial
Total
75 Percent

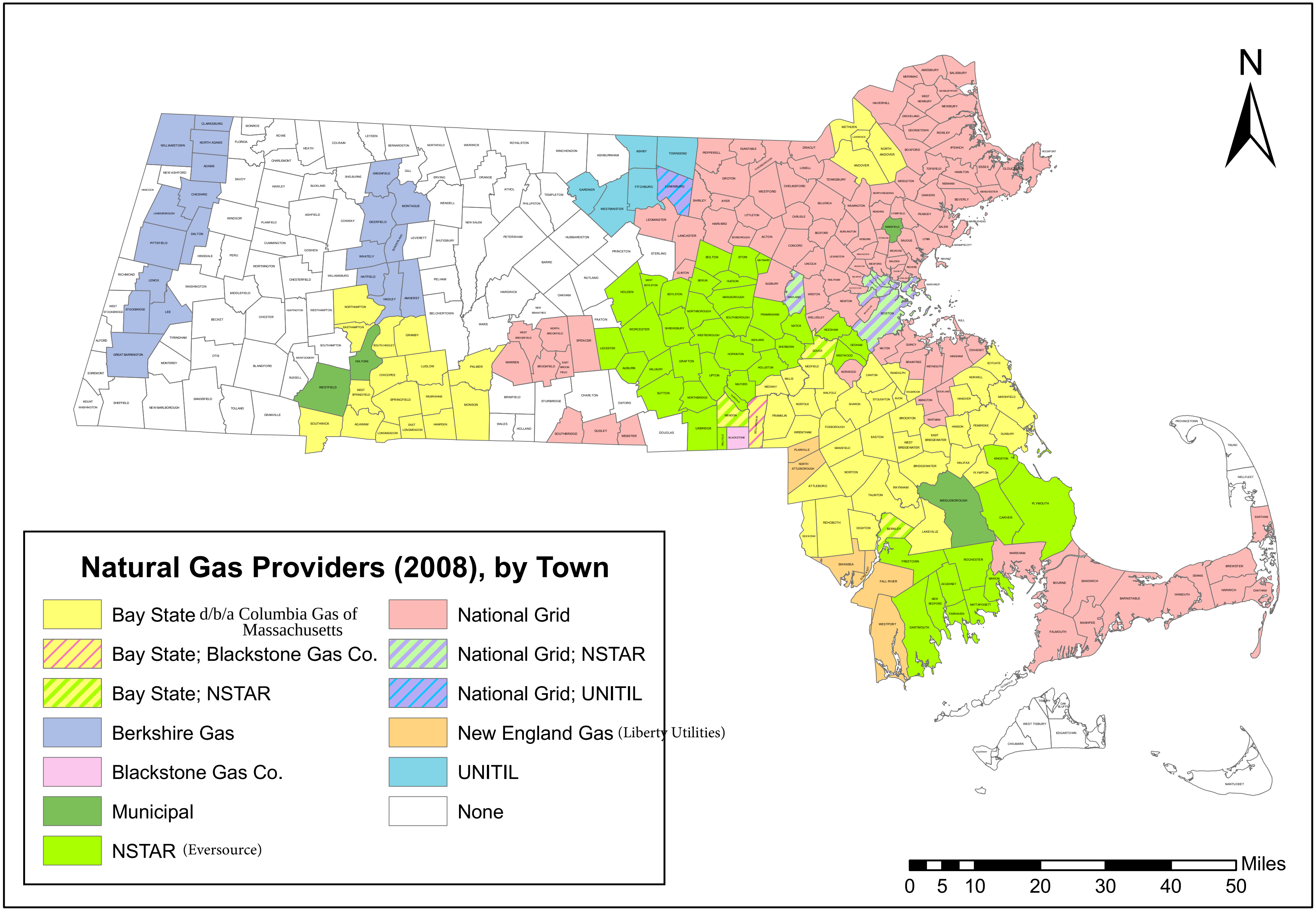
	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Cumulative Gross Energy - kWh	497,979,544	520,684,747	542,537,535	563,677,628	584,243,519	602,561,978	619,336,437	635,443,014	650,963,192	665,942,945
Cumulative Gross Peak Demand - kW	57,584	60,378	63,079	65,701	68,258	70,538	72,628	74,637	76,574	78,444
Cumulative Net Energy Savings - kWh	467,498,229	487,589,030	506,865,446	525,466,271	543,528,778	559,381,130	573,722,850	587,428,700	600,578,870	613,218,074
Cumulative Net Peak Demand Savings - kW	53,809	56,273	58,648	60,947	63,185	65,150	66,928	68,628	70,259	71,827
New Net Energy Savings - kWh	21,477,925	20,090,800	19,276,416	18,600,826	18,062,507	15,852,352	14,341,720	13,705,850	13,150,171	12,639,203
New Net Peak Demand Savings - kW	2,617	2,464	2,375	2,300	2,238	1,965	1,778	1,700	1,631	1,567
Administration Costs	606,678	566,584	551,353	538,845	527,633	501,773	487,958	479,289	471,856	467,660
Marketing Costs	6,168,842	6,163,825	6,158,917	6,154,115	6,149,418	6,144,822	6,140,327	6,135,928	6,131,625	6,127,416
Incentives Costs	11,130,657	10,740,847	10,504,476	10,312,782	10,166,015	9,230,789	8,536,673	8,290,205	8,084,720	7,896,298
Total Costs	17,906,177	17,471,256	17,214,746	17,005,742	16,843,066	15,877,385	15,164,958	14,905,423	14,688,202	14,491,375
PV Net Avoided Cost Benefits	37,784,666	36,183,518	35,422,456	34,839,125	34,386,448	30,493,002	27,822,428	26,801,759	25,879,273	24,989,075
PV Annual Program Marketing and Admin Costs	6,413,896	6,336,343	6,282,827	6,232,342	6,183,518	6,121,645	6,071,387	6,026,274	5,982,678	5,942,380
PV Net Measure Costs	12,068,502	11,559,907	11,211,409	10,895,755	10,645,045	9,651,479	8,890,791	8,567,395	8,293,677	8,041,542
TRC Ratio	2.04	2.02	2.02	2.03	2.04	1.93	1.86	1.84	1.81	1.79
Free Riders - kWh	30,481,315	33,095,718	35,672,089	38,211,356	40,714,741	43,180,849	45,613,588	48,014,314	50,384,321	52,724,871
Free Riders - kW	3,775	4,105	4,431	4,754	5,073	5,388	5,700	6,009	6,315	6,618
Other Naturally Occurring - kWh										
Other Naturally Occurring - kW										
Present Value Participant Costs	2,472,836	2,393,125	2,324,963	2,243,268	2,183,194	2,101,063	2,021,439	1,965,287	1,919,264	1,877,005
Incentive Subtotal - Free Riders Only	762,918	763,289	763,285	762,973	762,459	760,691	759,828	758,898	757,884	756,807
Cost per First-Year Net kWh	$0.83	$0.87	$0.89	$0.91	$0.93	$1.00	$1.06	$1.09	$1.12	$1.15
PV Annual Program Costs	16,950,485	16,448,311	16,118,170	15,835,385	15,598,114	14,623,383	13,890,824	13,578,414	13,307,341	13,057,203
PV Lost Revenue	26,899,571	24,647,851	23,134,176	21,832,416	20,735,668	17,759,767	15,714,829	14,704,865	13,827,087	13,038,678
RIM	0.86	0.88	0.90	0.92	0.95	0.94	0.94	0.95	0.95	0.96

N. **<u>Maps of Service Areas</u>**



Massachusetts Energy Efficiency Program Providers (EEPPs) (as of November 2007)

This service territory map was prepared solely for the purpose of the "Massachusetts PA C&I 2008 Program Planning Manual"


N
Natural Gas Providers (2008), by Town
Bay State d/b/a Columbia Gas of Massachusetts
Bay State; Blackstone Gas Co.
Bay State; NSTAR
Berkshire Gas
Blackstone Gas Co.
Municipal
NSTAR (Eversource)
National Grid
National Grid; NSTAR
National Grid; UNITIL
New England Gas (Liberty Utilities)
UNITIL
None
Miles
0 5 10 20 30 40 50

O. **Unique Service Area Challenges Presentations**

berkshire gas
A UIL HOLDINGS COMPANY

THE BERKSHIRE GAS COMPANY

2016-2018 ENERGY EFFICIENCY PLAN

UIL HOLDINGS CORPORATION

D.P.U. 15-160 to D.P.U. 15-169
Three-Year Plan 2016-2018
October 30, 2015
Exhibit 1, Appendix O - Part 1 (Berkshire)

Quick Summary

- **Unique Territory**
  - Covers two non-contiguous rural areas, making in-the-field efficiencies challenging
  - Company serves 20 cities and towns with combined population of 190,000
- **Unique Customers**
  - Berkshire Gas serves approx. 32,000 heating customers, approx. 5000 commercial customers, only 2% are large C&I
  - Large C&I customers account for only 0.31% of heating customers, yet they contribute 45 % to annual portfolio savings goals
  - Many customers use readily available and low cost alternative fuel sources, such as wood, rather then taking advantage of our energy efficiency programs
- **Economy**
  - In the past few years, the Company experienced certain plants or parts of plants closing, moving or simply shutting down
  - Some commercial customers have been uncertain about the future of some satellite locations in the area, making it challenging for them to commit to energy efficiency projects
- **Budget increase since 2010**
  - Berkshire's 2016 energy efficiency budget is more than double its 2010 budget

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berkshire gas
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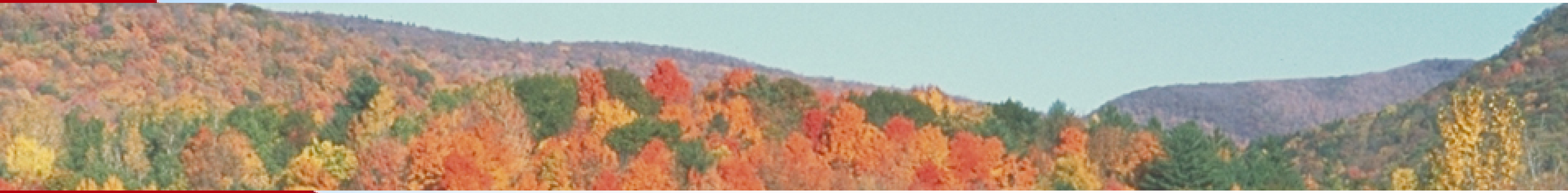
What Makes Berkshire's Territory Unique?

- Berkshire Gas serves approximately 32,000 heating customers
- Located in pastoral western Massachusetts, an area renowned for its natural beauty
- This unique geographic area presents unique challenges
- There is a small commercial & industrial (C&I) customer base
- Out of 5,000 commercial customers, only 2% (about 100) are large C&I customers
- Large C&I customers account for only 0.31% of all heating customers yet they contribute 45% to the annual portfolio savings goal
- In the past few years, the Company experienced certain plants or parts of plants closing, moving or simply shutting down.



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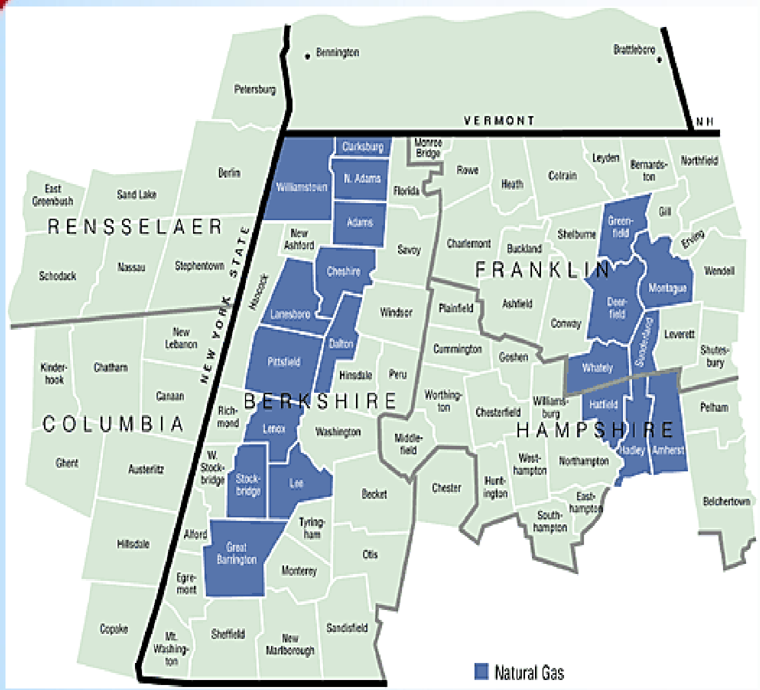
Service Territory Challenges



- Berkshire's service territory covers two non-contiguous rural areas, making in-the-field efficiencies challenging
- Berkshire Gas serves 20 cities and towns with a combined population of 190,000
- 40% or 8 of these municipalities are Green Communities that have actively pursued energy efficiency opportunities
- For three decades, The Center for EcoTechnology, Berkshire's current residential lead vendor, has promoted sustainability and increased awareness of energy efficiency in Berkshire County and the Pioneer Valley
- These efforts increase the challenge of identifying cost-effective energy efficiency opportunities

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ADDITIONAL BACKGROUND

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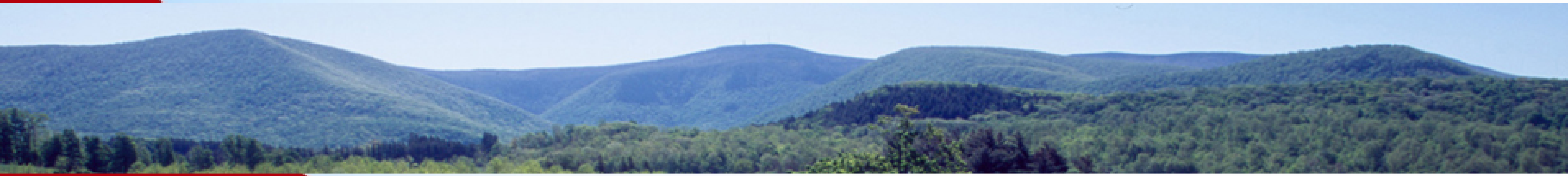
- Challenging economic conditions have not turned around as rapidly as eastern MA.
- The previous 3- Year Plan was built on the premise that the economy would bounce back at the end of the third year.
- Of our 30,450 residential heating customers,18% or 5,553 are Low-Income heating customers.
- Many customers use readily available and low cost alternative fuel sources, such as wood or wood pellets, rather than taking advantage of our energy efficiency programs.
- During 2015 the gas companies experienced evaluation study results that have been a significant factor in reducing annual savings goals.
- The new avoided gas costs for 2016 are lower than the previous study by some 21%



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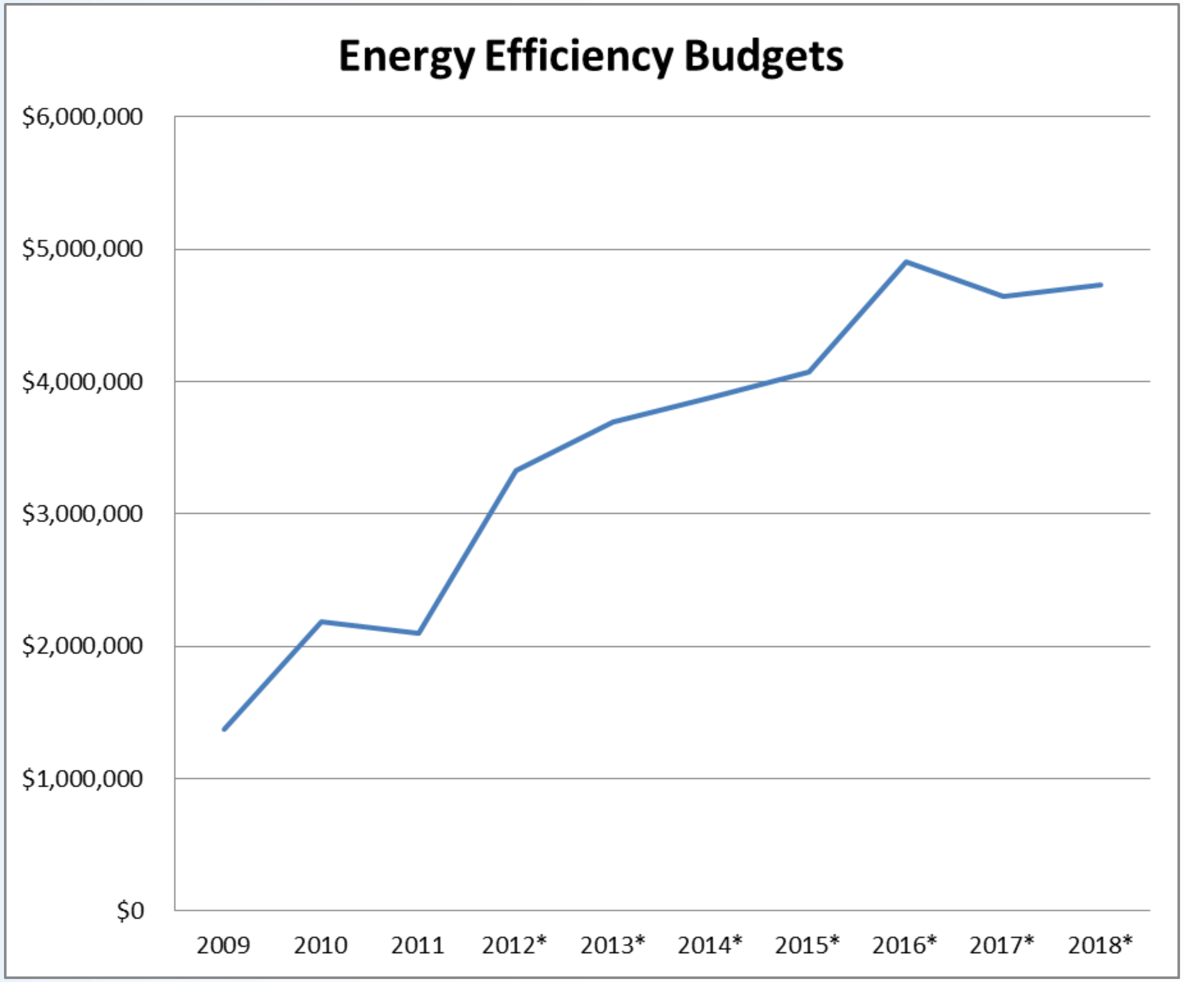

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What's Driving Berkshire's Costs/Benefits?

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- Residential
  - New Multifamily realization rate of 60% down from 100%
  - The higher commercial and residential building code with higher baseline efficient equipment results in less fuel savings available for custom measures.

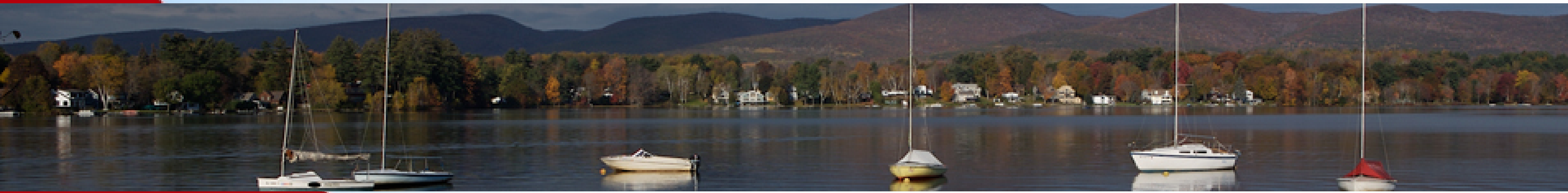
UIL HOLDINGS CORPORATION

D.P.U. 15-160 to D.P.U. 15-169
Three-Year Plan 2016-2018
October 30, 2015
Exhibit 1, Appendix O - Part 1 (Berkshire)
Page 7 of 9

Other Cost/Benefit Drivers

Commercial & Industrial

- New NTG numbers decreased WH savings from 103% to 62% (lost 40% of savings).
- Thermostat savings cut 50%, i.e. 77 therms to 32
- Lower gas prices contributing to yet even longer payback periods



THE FUTURE

- Fully committed to providing the best possible energy efficiency programs and services to our customers.
- Fully committed to continuing to be a valuable and trusted partner in the Western Massachusetts community and building on the Company's many years of excellent service
- Fully committed to continuing to collaborate with fellow PAs to identify best practices and better understand differences driving costs and savings relative to other Pas
- Fully committed to continuing our successful integration efforts with our electric PA partners

Liberty Utilities℠

Massachusetts Energy Efficiency Programs
2016-2018 Plan Background

September 25, 2015

Key Takeaways

- The economy in Greater Fall River is in dire condition.
- Businesses continue to be recruited to other states and foreign countries. Perceived pro-business climate elsewhere.
- Company has been informed of concerns that more stringent Codes and Standards will hurt the construction industry and trades, and ultimately consumers.
- Fully committed to providing the best possible energy efficiency programs and services to our customers.
- Unique economic conditions make goal setting/goal attainment a real challenge.
- Customers (especially C&I) are very sensitive to bill impacts.
- Challenging economic conditions which have not turned around. The original 3 Year Plan was built on the premise that the economy would bounce back at the end of the third year.

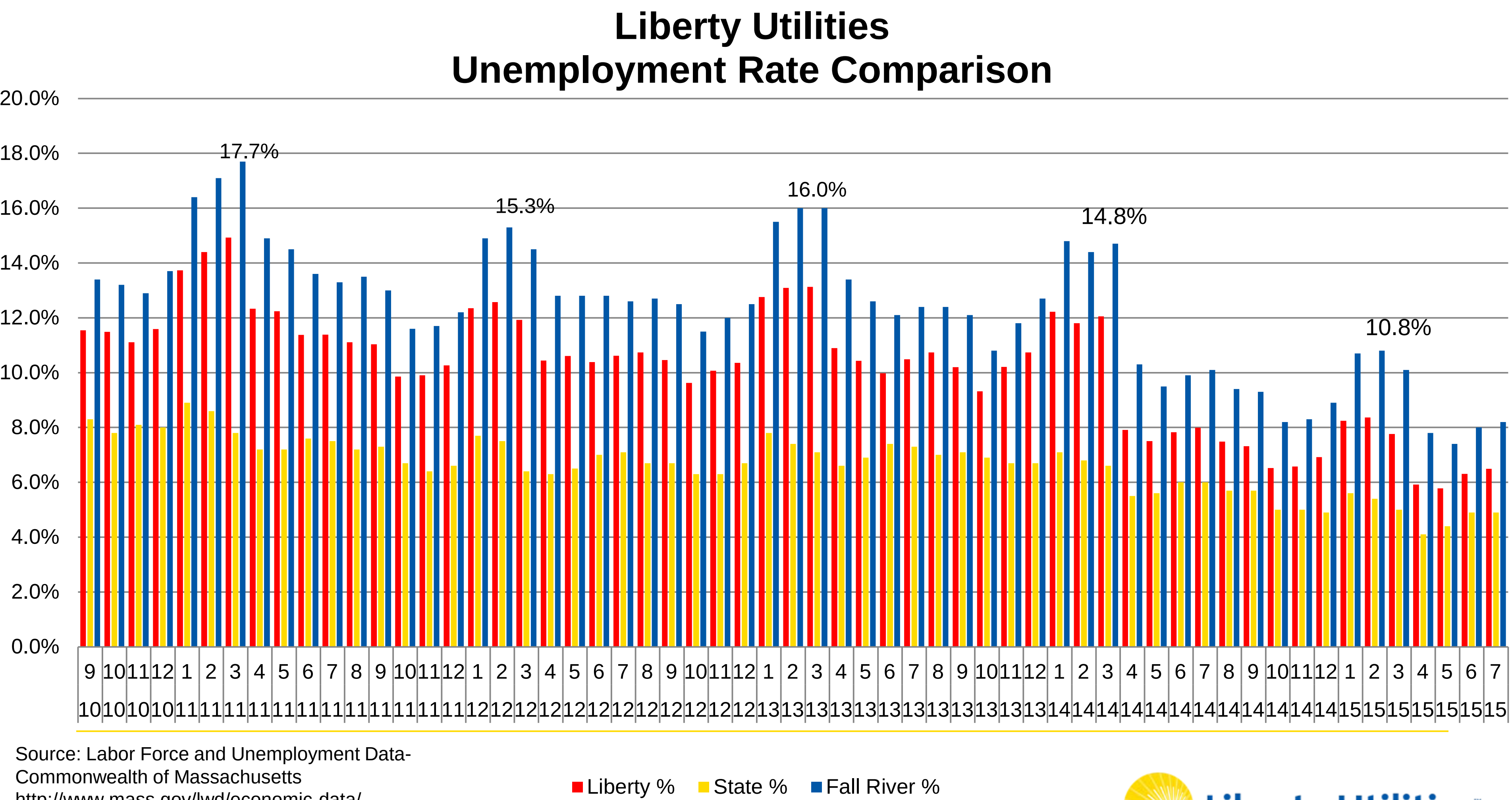
Liberty Utilities

Local Economic Climate

- Historically, Fall River consistently has had among the highest unemployment rate in the Commonwealth.
- Textile based workforce, even though the jobs in this sector are no longer in large demand.
- Motivated and eager blue collar workforce with limited opportunities.
- Fall River Median Family Household Income is $33,211 vs. Massachusetts $66,866 (2009-2013 Census data)

Liberty Utilities

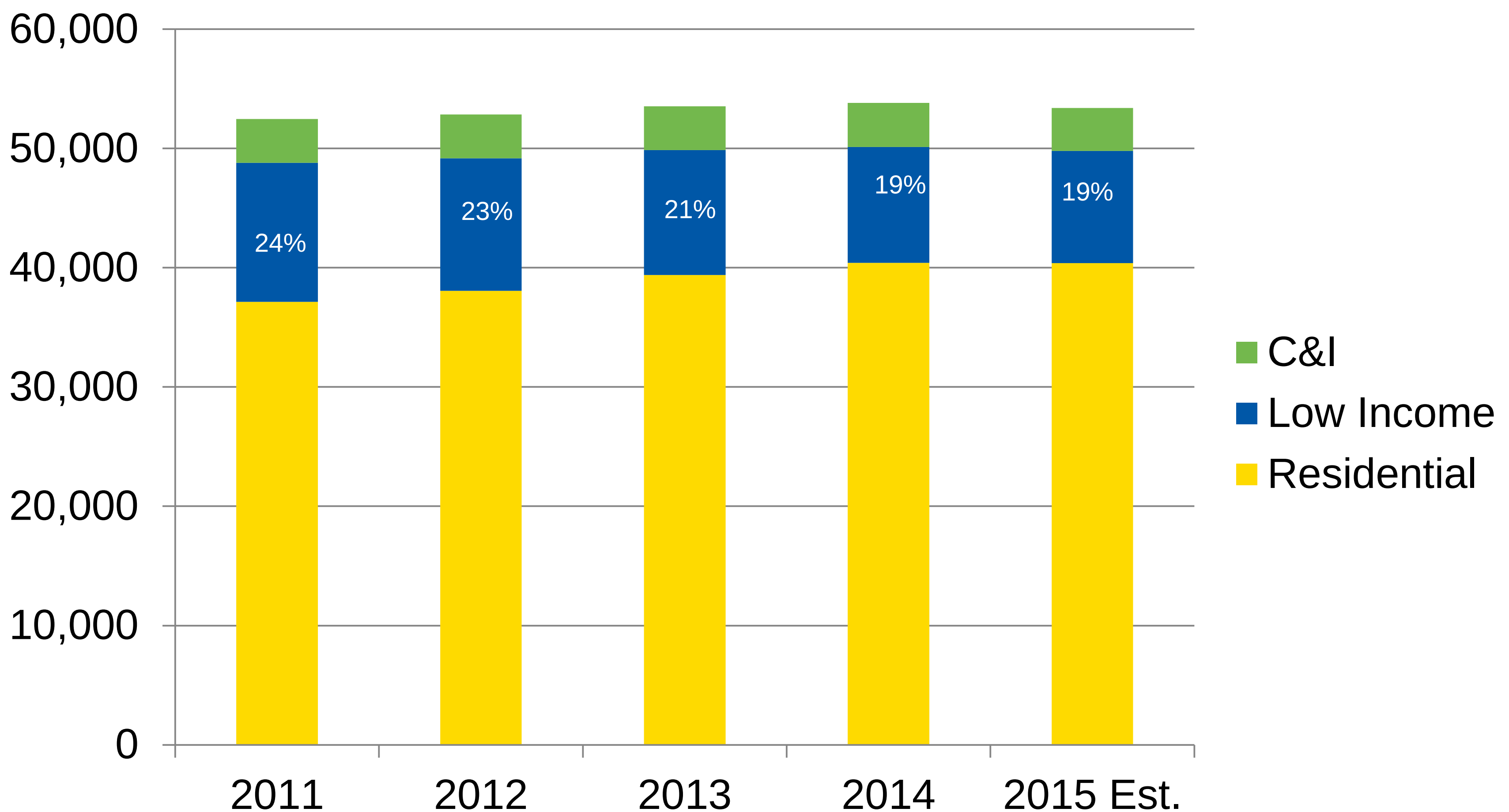
Unemployment Continues in the Service Territory



Source: Labor Force and Unemployment Data-
Commonwealth of Massachusetts
http://www.mass.gov/lwd/economic-data/

Customer Composition

Firm Sales Only



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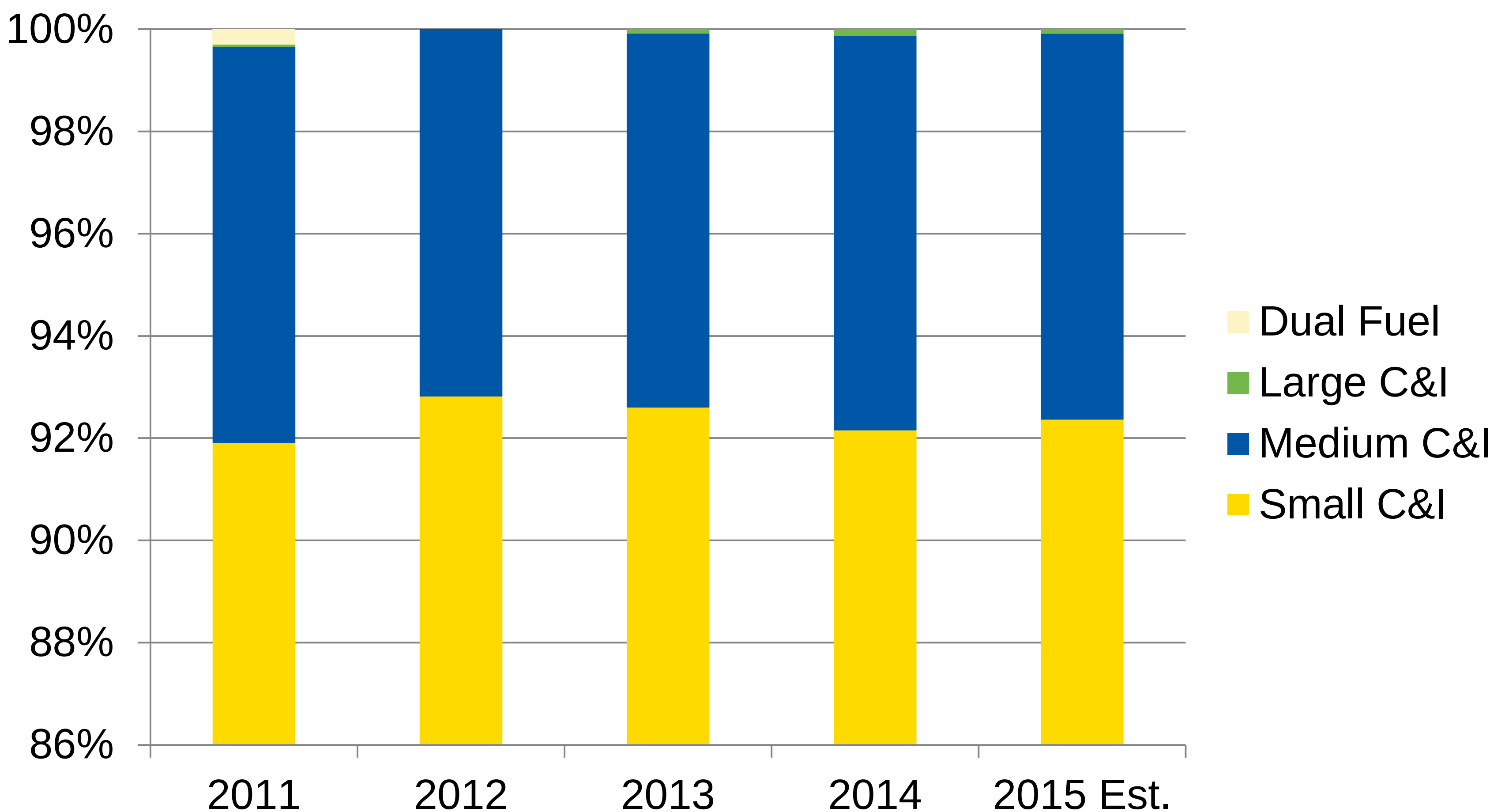
C&I Composition

Firm Sales Only



Liberty Utilities

Potential Study Background

In addition to assisting the small PAs in quantifying remaining potential within their service territories, this effort was conducted in accordance with the Massachusetts Department of Public Utilities' January 31, 2013 Order D.P.U. 12-100 through D.P.U. 12-111 (sections IV.B.2.a & 4.a – pages 18, 19 & 40) and subsequent DOER Consultant feedback. Specifically, Section IV.B.2.a states:

> "The Program Administrators with an aggregate three-year savings goal of greater than 20 percent below the statewide three-year aggregate goal will conduct a study, either jointly or individually, during the upcoming three-year term to document the penetration of energy efficiency within its service territory and the remaining cost-effective energy efficiency opportunities available.."

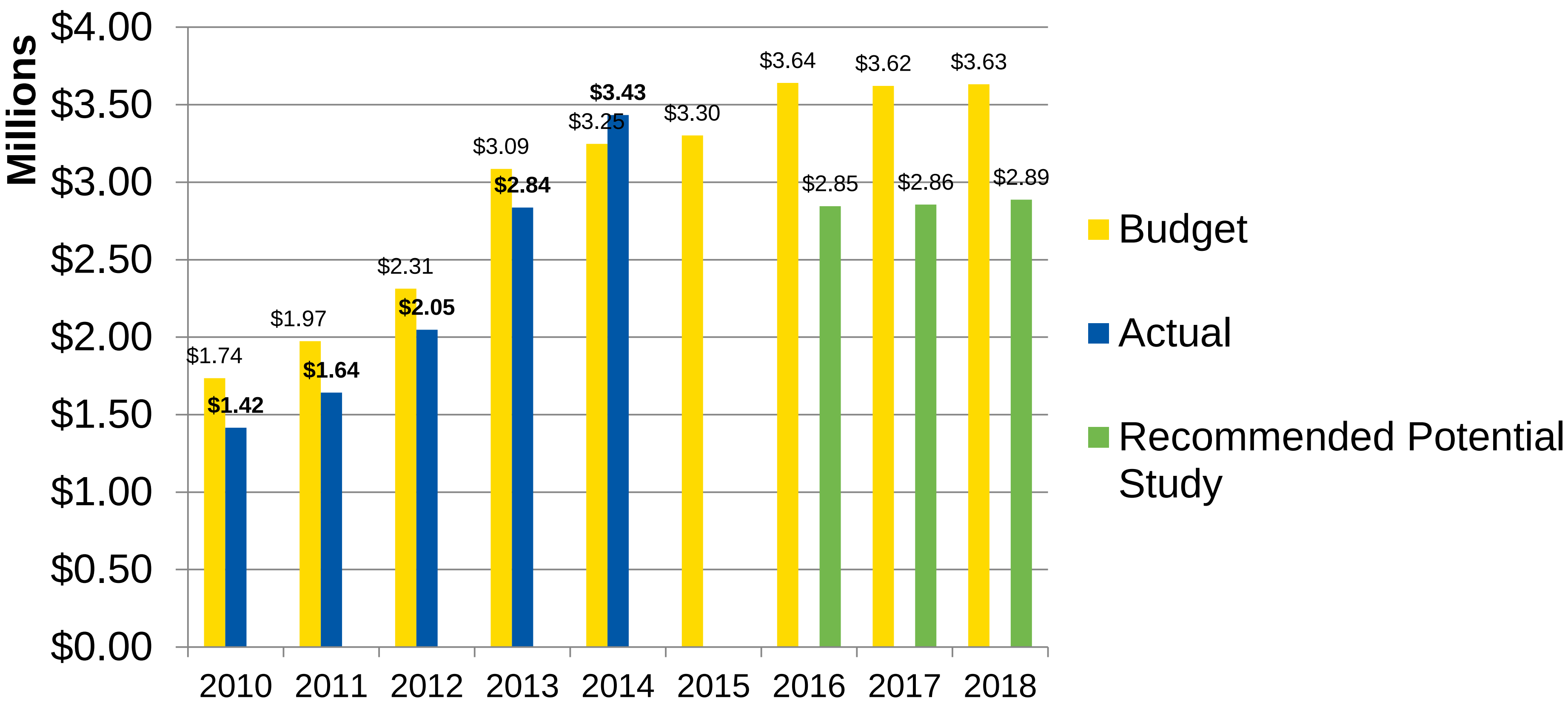
Potential Study Results

- The Likely Achievable potential across Liberty's service territory is estimated to be 0.49% of 2016 annual sales (0.48% by 2018)
  - This is much lower than Liberty's current three-year(2013-2015) territory-wide target of 0.84%
- The sector with greatest potential for savings as a % of sector sales remains with Liberty's small commercial customers (0.51% of 2016 sales, 0.60% by 2018)
- Slightly less potential remains within Liberty's residential and largest commercial customer sectors (0.48% & 0.50% respectively by 2018)

Summary Likely Achievable Scenario	2016	2017	2018
Residential			
Annual Therm Savings	185,340	185,629	187,331
Forecast Sales	38,098,740	38,506,920	38,777,850
Savings as % of sales	**0.49%**	**0.48%**	**0.48%**
PA Cost to Achieve	$ 2,429,332	$ 2,423,384	$ 2,436,638
Total Cost to Achieve	$ 3,759,344	$ 3,755,204	$ 3,782,864
Small and Med C&I			
Annual Therm Savings	75,978	83,250	90,700
Forecast Sales	14,939,619	15,141,739	15,229,403
Savings as % of sales	**0.51%**	**0.55%**	**0.60%**
PA Cost to Achieve	$ 281,690	$ 297,149	$ 315,376
Total Cost to Achieve	$ 571,173	$ 602,550	$ 639,010
Largest Customers C&I			
Annual Therm Savings	51,009	51,009	51,009
Forecast Sales	11,299,971	11,479,211	11,368,657
Savings as % of sales	**0.45%**	**0.44%**	**0.45%**
PA Cost to Achieve	$ 134,644	$ 134,644	$ 134,644
Total Cost to Achieve	$ 256,662	$ 256,662	$ 256,662
TOTAL			
Annual Therm Savings	312,326	319,887	329,040
Forecast Sales	64,338,330	65,127,870	65,375,910
Savings as % of sales	**0.49%**	**0.49%**	**0.50%**
PA Cost to Achieve	$ 2,845,665	$ 2,855,177	$ 2,886,657
Total Cost to Achieve	$ 4,587,179	$ 4,614,415	$ 4,678,536

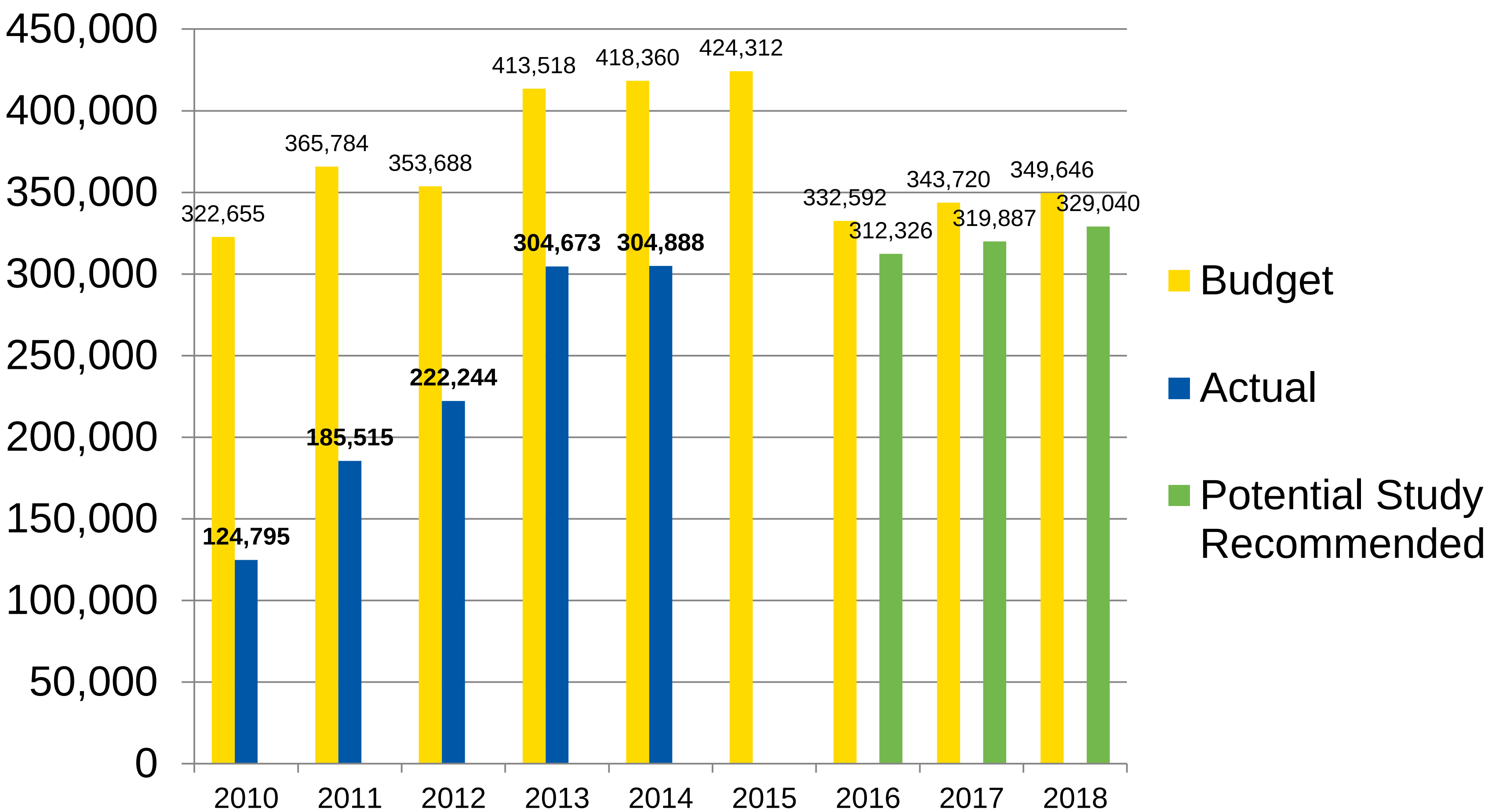
Liberty Utilities

Budget



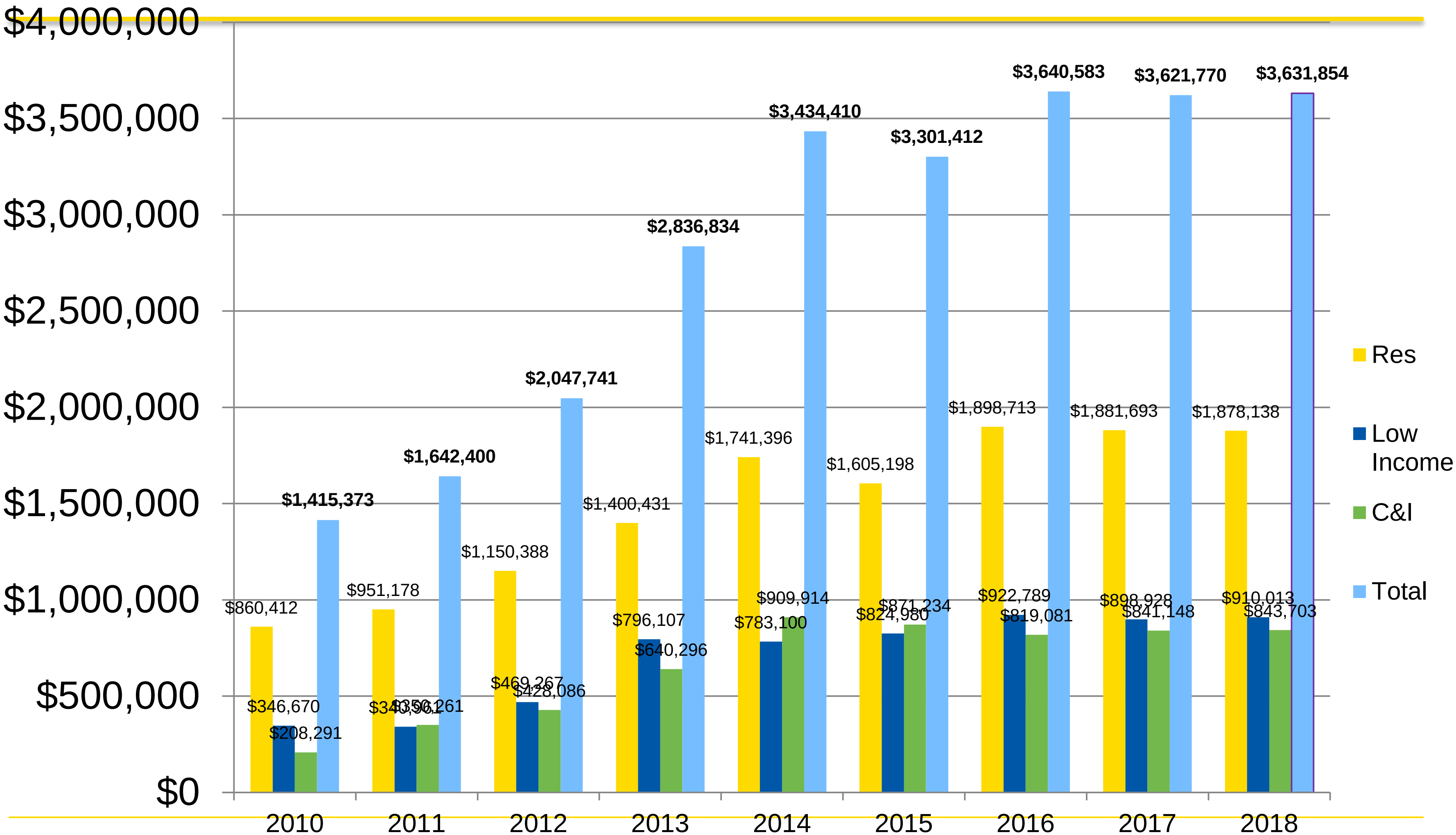
Liberty Utilities

Therm Savings



Liberty Utilities

Composition of Budgets



2010-2014 are actual dollars spent. 2015-2018 are budgeted dollars.

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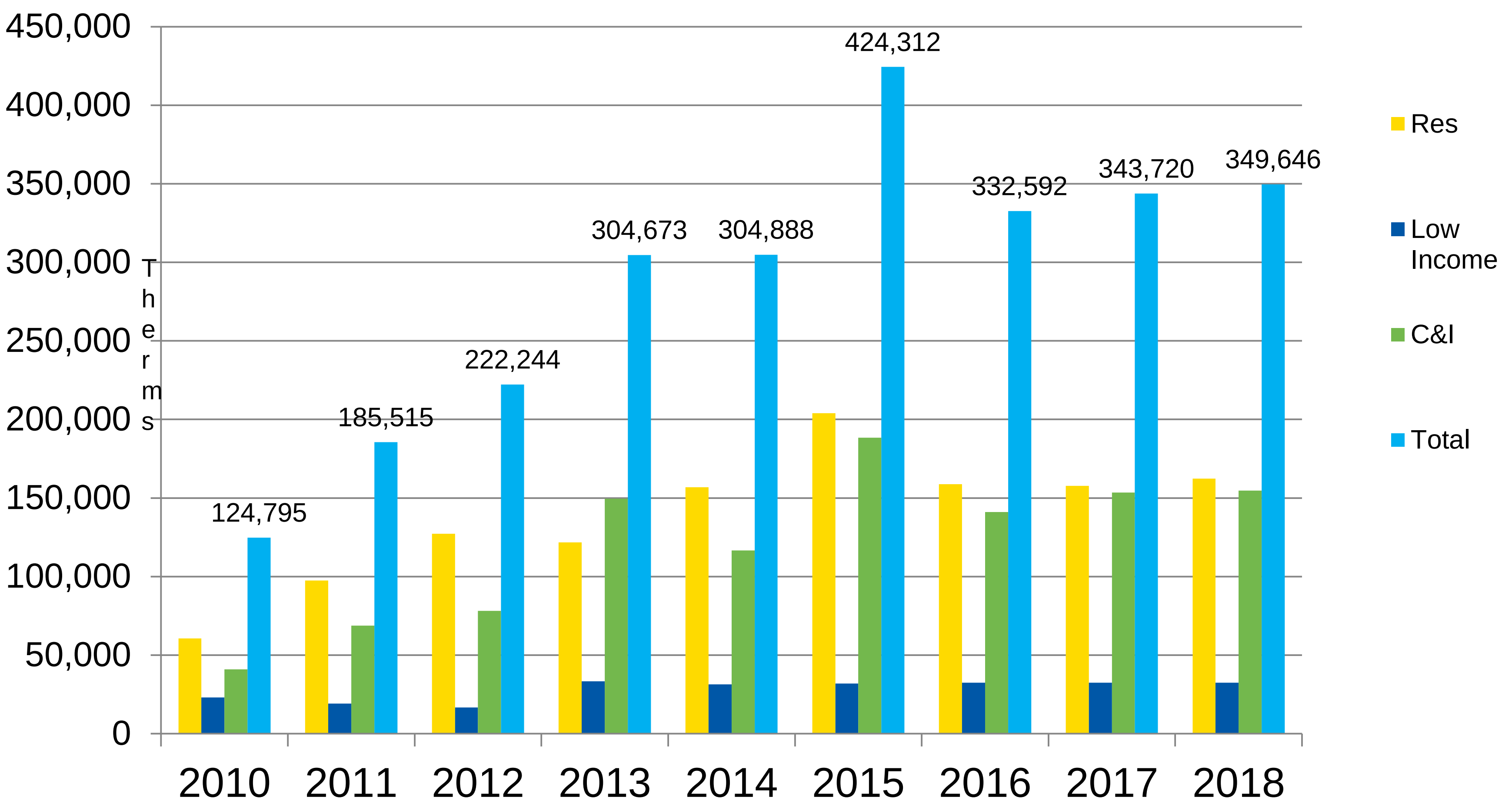
Composition of Savings



2010-2014 Actuals. 2015-2018 Budget.

Liberty Utilities

3-Year Energy Efficiency Plan (2016 – 2018)

Setting Aggressive, Sustainable Goals for the Next 3 Years

October 2015

Unitil

Basic Principles of Planning

Unitil

- In preparing our plan, we have sought to balance the need for aggressive savings goals with the need to consider:
  - rate and bill impacts
  - the challenges of continued program acceleration
  - the need for sustainable, cost-effective programs
  - service territory specific considerations
  - recent actual results
  - Unitil-specific potential studies
  - Evaluation driven impacts to savings and program design
  - Detailed knowledge of our customers and substantial experience planning and delivering programs in our service area.

Unitil Service Area… Is Unique

- **6 Communities –38,925 Residential & 5,393 C&I Customers**
  - 26 Industrial customers represent 36% of electric sales
  - 30 Industrial customers represent 41% of gas sales
    - 3 special contract customers account for 22% of sales and cannot participate in EE programs.
- **Lower economic well-being than Commonwealth as a whole**
  - High poverty rate – Lower Median household income ($45,363)
  - One of the highest proportions of households with public assistance income
  - Consistently higher unemployment and underemployment rate
- **Significant hard-to-reach / serve population**
  - High penetration of renters, 38% overall, 54% in Fitchburg
  - ~25% of households have at least one person age 65 or older in the household
  - 4.2% of households have no one >14yrs of age who speaks English a their primary language
- **Building Characteristics**
  - 90% of all buildings are "occupied" (residential housing)
  - Smaller and much older stock -median age is 65+ years
  - 55% of housing stock is 1 unit –27% is 2-4 units
  - High penetration of heating oil leads to high non-electric benefits/lower electric savings

Challenging Factors… Influence Performance

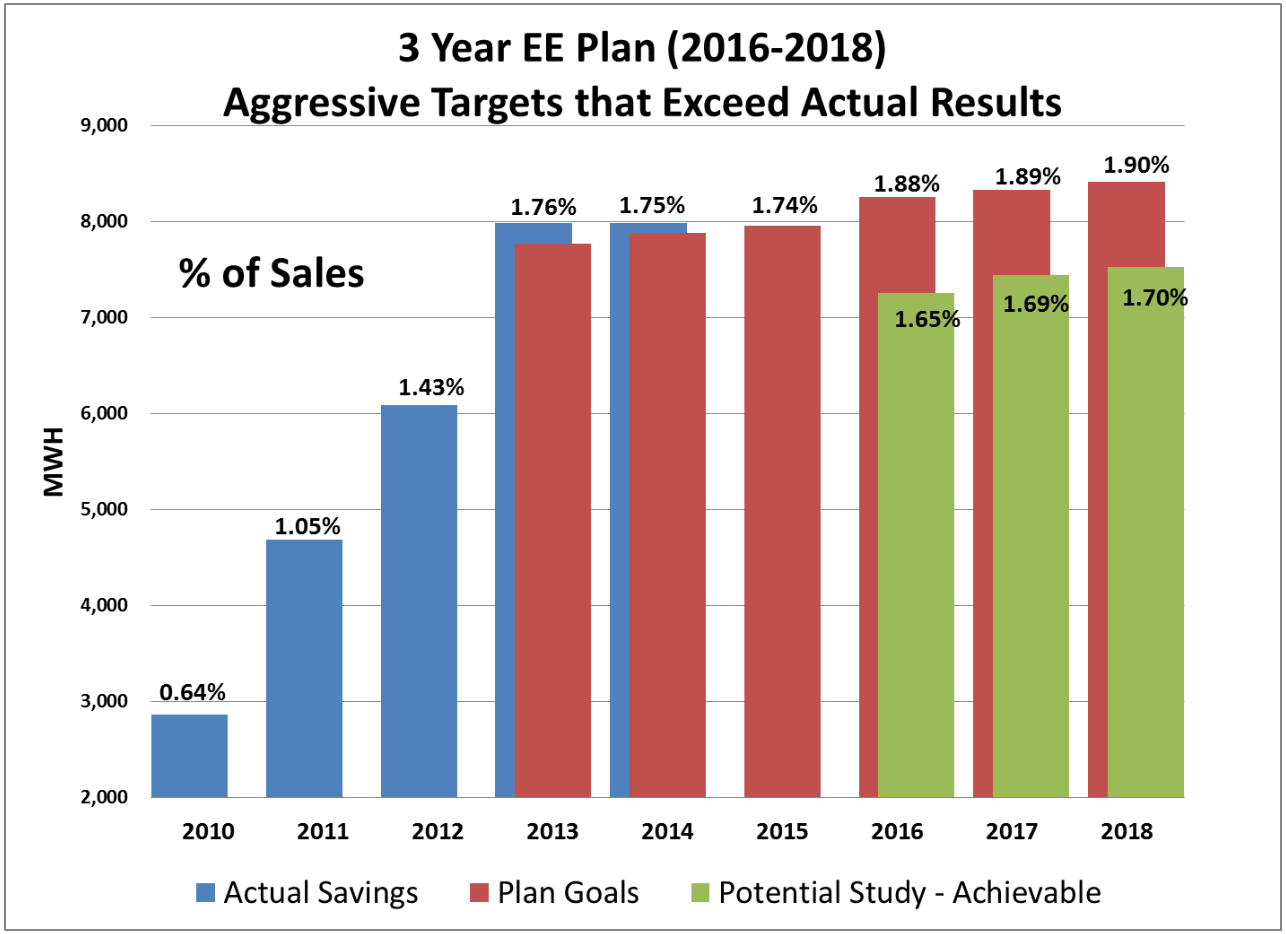
Unitil

- Our plan does not benefit from "averaging" across diverse communities:
  - ~68% of customers are in a *single community*, which is significantly different from statewide averages in all key demographic and economic factors including; income level, employment and building stock
  - Lack of diversity and size results in higher variances relative to the mean – budgets and savings are more variable and harder to predict year to year
- Variances in key parameters strongly affect relative performance:
  - HES kWh savings were 10% of total HES program savings compared to the statewide average of 35% - but Unitil's non-electric savings were 90% of the total, compared to the statewide average of 65%.
  - Much higher non-electric savings (i.e. oil, propane, etc.) for Unitil distorts the comparisons. Overall B/C ratios are consistent with Statewide ratios.

Aggressive and Sustainable Goals - Electric

Unitil

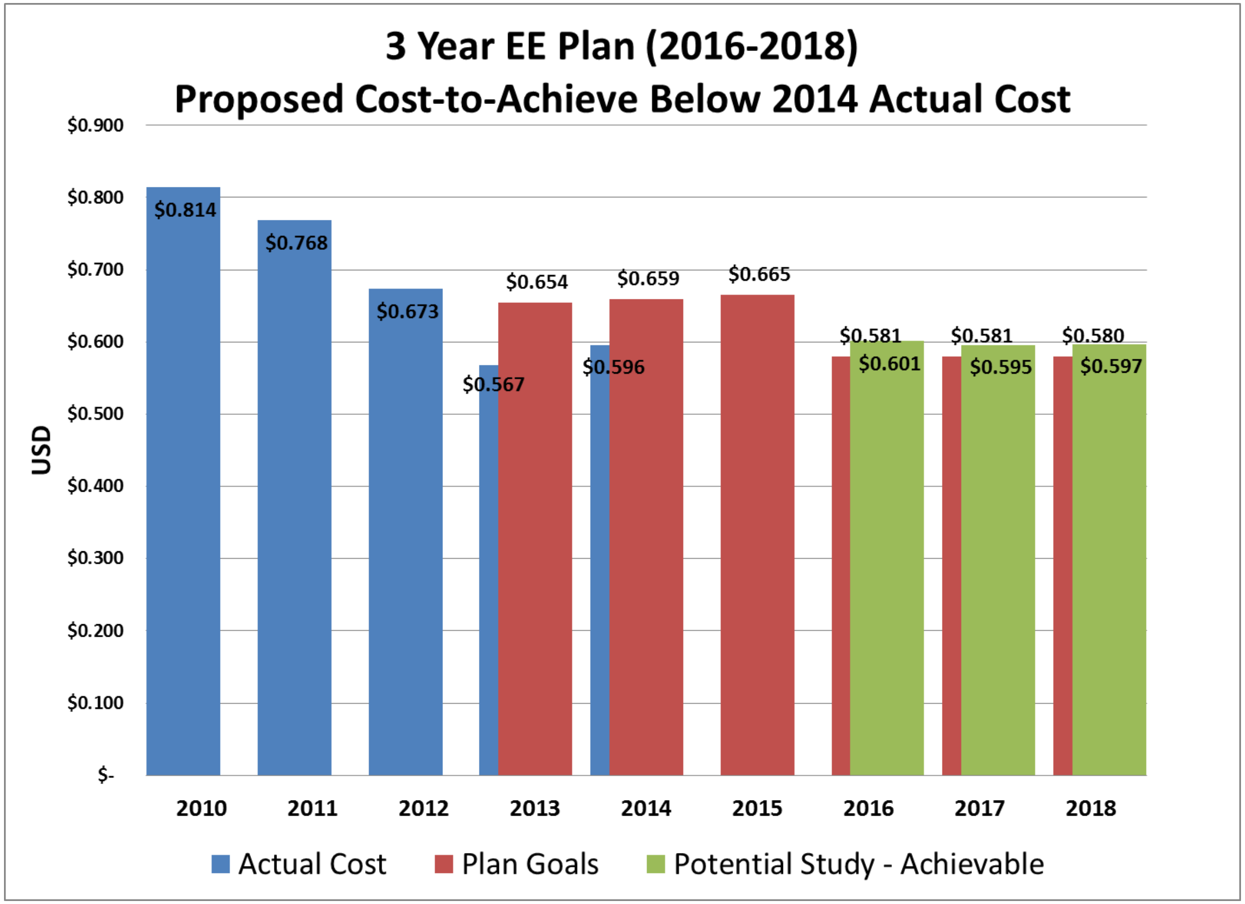
- Planned annual kWh savings exceed actual results as well as Potential Study targets
- Acceptable annual costs for participants
- Benefits per unit of spending better reflects impact than % of sales
  - Oil savings are better reflected in benefits
  - Non-energy impacts (NEIs) are more comprehensive
  - Smoothing effect for service area characteristics



… Cost & Rate Impact are Priority

Unitil

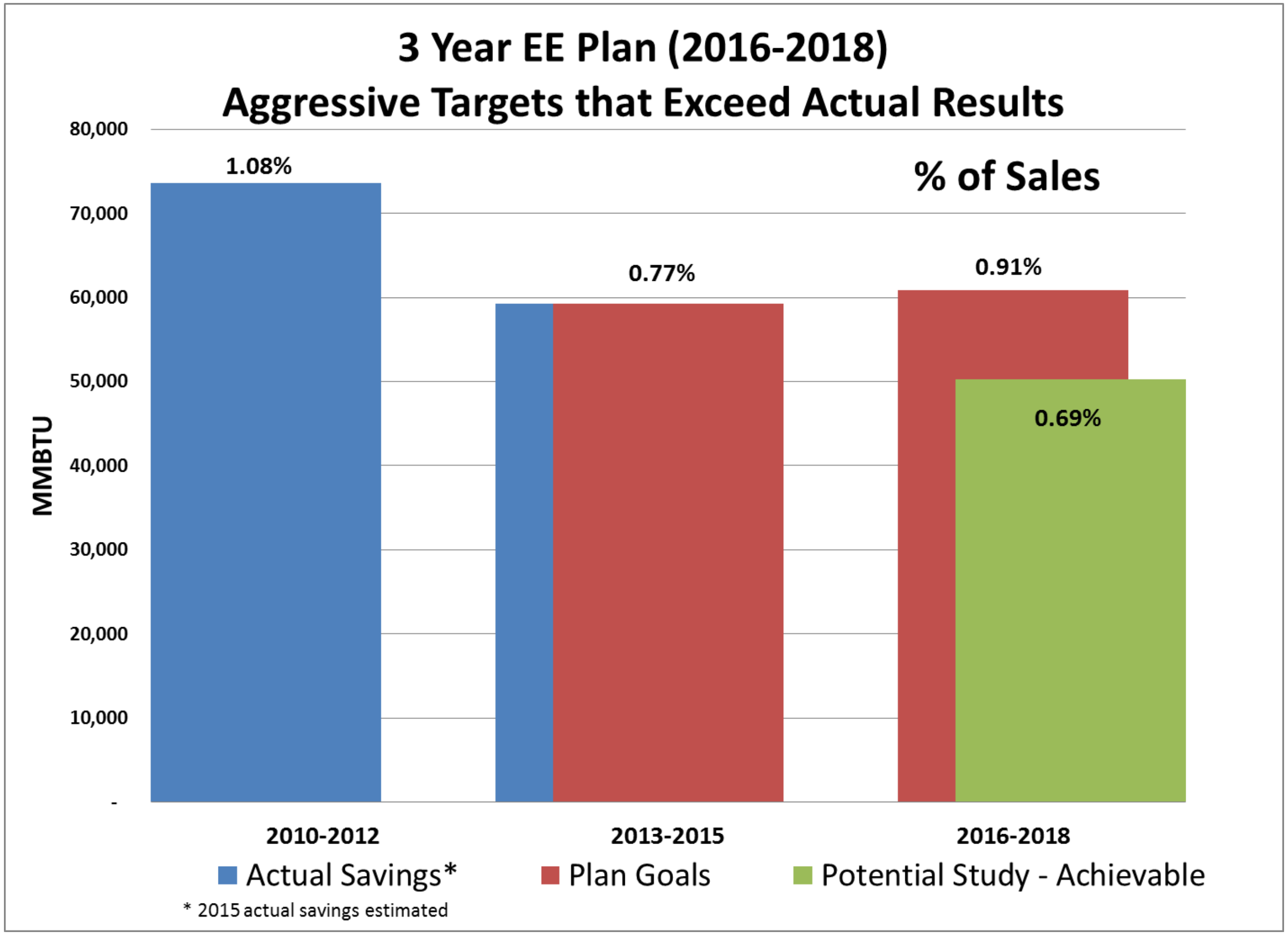
- Cost-to-Achieve kWh savings below 2014 actual costs/kWh
- 2016 proposed Cost / kWh is down 14% from 2012
- Attentive to Rate and Bill Impacts
    - Less than 1% for electric and less than 1%-3.1% for gas
    - Budgeting 2.9% of electric sales (if it were achievable) would cumulatively over 3 years increase electric bills by .1% to 5.1% depending upon rate class



Unitil

Aggressive and Sustainable Goals - Gas

- Planned MMBTU savings exceed achievable potential study estimates
- Lack of diversity & size results in greater variation in year over year results - 3 Year outlook is a better planning tool.
- Budgeting 1.24% of gas sales (if it were achievable) would increase gas bills in 2016 by 4.1% to 8.7% depending upon rate class



P. **Participant Definitions**

Participant Definitions for 2016-2018

PROGRAM/CORE INITIATIVE	PARTICIPANT DEFINITION
A - Residential	
1 - Residential Whole House	
A1a - Residential New Construction	Dwelling unit
A1b - Residential Multi-Family Retrofit	Dwelling unit with any measure installed
A1c - Residential Home Energy Services - Measures	Unique account number with at least one major measure installed
A1d - Residential Home Energy Services - RCS	[no participants; not a separate core initiative]
A1e - Residential Behavior/Feedback Program	Unique account number
2 - Residential Products	
A2a - Residential Heating & Cooling Equipment	Unique account number
A2b - Residential Consumer Products	Number of widgets; unique account number when available, assumption for upstream (2 measures per participant for Tier 1 smart strips, 1 measure per participant for all other measures).
A2c - Residential Lighting	Number of widgets, see chart below
3 - Residential Hard-to-Measure	
B - Low-Income	
4 - Low-Income Whole House	
B1a - Low-Income Single Family Retrofit	Unique account number
B1b - Low-Income Multi-Family Retrofit	Dwelling unit
5 - Low-Income Hard-to-Measure	
C - Commercial & Industrial	
6 - C&I New Construction	
C1a - C&I New Buildings & Major Renovations	Unique account number or equivalent
C1b - C&I Initial Purchase & End of Useful Life	Unique account number; for upstream, unique installation address
7 - C&I Retrofit	
C2a - C&I Existing Building Retrofit	Unique account number
C2b - C&I Small Business	Unique account number
C2c - C&I Multifamily Retrofit	Unique account number
C2d - C&I Upstream Lighting	Unique installation address
8 - C&I Hard-to-Measure	

Residential Lighting Assumptions

2016-2018 Residential Lighting	Widget per Participant
CFL Bulb	4
CFL Bulb (EISA Exempt)	2
CFL Bulb (Hard to Reach)	4
CFL Bulb (School Fundraiser)	4
Fixture	1
LED Fixture	1
LED Bulb	8
LED Bulb (EISA Exempt)	4
LED Bulb (Hard to Reach)	8
LED Bulb (School Fundraiser)	8
LED Reflectors	4

Q. **Vendor Cost Categories**

Program Administrator Vendor Cost Categories

Row Number	Cost Type	Elec/Gas/Both	Cost Category (to be applied 1/1/2016)	Additional Info/Comments
1	Statewide Database/Mass Save Data	B	Eval	Not in PP&A to enable cost tracking separately from DOER assessment
2	Builder and Equipment Incentives	B	Incentive	
3	Heating System Rebates	B	Incentive	
4	Lighting/ISMs	B	Incentive	
5	Permits	B	Incentive	
6	Pre-weatherization Incentive	B	Incentive	
7	Rater Inspection Fees	B	Incentive	
8	Rebates/ Incentives	B	Incentive	
9	Refrigerator Costs within Low-Income	E	Incentive	
10	Repairs within the Low-Income Initiatives	B	Incentive	
11	Total Interest Subsidy	B	Incentive	
12	Weatherization Costs	B	Incentive	
13	Marketing and Advertising Support	B	Marketing	
14	Cost Effectiveness Screening	B	PP&A	
15	EEAC Consultants/Regulatory Assessments/LEAN	B	PP&A	
16	Legal Services	B	PP&A	
17	Planning Support	B	PP&A	
18	Tracking System Maintenance	B	PP&A	
19	Account Management	B	STAT	
20	Audit Fees	B	STAT	
21	Call Center Activities	B	STAT	
22	Circuit Rider Activities	B	STAT	
23	Postage Associated with Rebate Processing	B	STAT	
24	Processing Fee	B	STAT	
25	Program Administration Fees	B	STAT	
26	Quality Assurance and Control activities	B	STAT	
27	Reporting	B	STAT	
28	Technical Assistance Studies	B	STAT	
29	Technical Support for Contractors	B	STAT	
30	Travel	B	STAT	
31	Contractor Fees	B	STAT (contractor services/fees); Incentive (measure costs/labor)	
32	Training	B	STAT (Workforce Development)	
33	Workforce Development/Training	B	STAT (Workforce Development)	

R. **Performance Incentive Models**

Input Sheet: Forecasted 2016 - 2018 figures
In 2016 dollars

	Electric	National Grid				Eversource			
		2016	2017	2018	3-Year Total	2016	2017	2018	3-Year Total
1	Goals (thousands of Annual MWh)	641.043	650.358	647.901	1,939.301	663.816	657.920	660.134	1,981.870
	Benefits ($)								
2	Residential	402,457,438	402,537,242	394,622,150	1,199,616,830	369,652,733	344,588,259	322,168,312	1,036,409,304
3	Low Income	56,688,814	56,714,745	57,457,336	170,860,895	47,311,025	46,211,734	44,990,193	138,512,952
4	C&I	436,953,027	457,341,602	488,136,555	1,382,431,185	613,975,065	637,986,539	669,666,510	1,921,628,115
5	Total	896,099,280	916,593,590	940,216,041	2,752,908,910	1,030,938,823	1,028,786,532	1,036,825,015	3,096,550,370
	Total Costs Excluding Proposed DR Costs								
6	Residential	174,835,089	177,544,096	174,696,533	527,075,718	143,417,272	136,894,232	132,049,158	412,360,662
7	Low Income	33,962,661	33,508,805	32,777,093	100,248,559	30,536,205	29,504,902	27,930,449	87,971,556
8	C&I	187,553,249	186,317,522	192,390,668	566,261,439	202,454,043	218,706,214	233,161,297	654,321,554
9	Total	396,350,998	397,370,423	399,864,295	1,193,585,715	376,407,520	385,105,348	393,140,904	1,154,653,772
	Performance Incentives used in preliminary Total Cost calculation								
10	Residential	6,833,921	6,919,097	7,393,864	21,146,882	-	-	-	0
11	Low Income	795,870	822,276	808,665	2,426,810	-	-	-	0
12	C&I	7,311,555	7,738,125	8,387,444	23,437,124	-	-	-	0
13	Total	14,941,345	15,479,498	16,589,972	47,010,815	0	0	0	0
	Net Benefits excluding performance incentives								
14	Residential	234,456,270	231,912,243	227,319,480	693,687,993	226,235,461	207,694,027	190,119,154	624,048,642
15	Low Income	23,522,023	24,028,216	25,488,907	73,039,147	16,774,820	16,706,832	17,059,744	50,541,396
16	C&I	256,711,334	278,762,206	304,133,330	839,606,870	411,521,022	419,280,325	436,505,213	1,267,306,561
17	Total	514,689,627	534,702,665	556,941,718	1,606,334,010	654,531,303	643,681,184	643,684,111	1,941,896,598

Input Sheet: Forecasted 2016 - 2018 figures
In 2016 dollars

	Electric	Unitil 2016	Unitil 2017	Unitil 2018	Unitil 3-Year Total	State Excluding CLC 2016	State Excluding CLC 2017	State Excluding CLC 2018	State Excluding CLC 3-Year Total	
1	Goals (thousands of Annual MWh)	8.252	8.334	8.418	25.003	1,313.111	1,316.612	1,316.452	3,946.174	
	Benefits ($)									
2	Residential	5,535,573	5,780,416	5,715,070	17,031,059	777,645,744	752,905,917	722,505,532	2,253,057,193	
3	Low Income	1,313,054	1,323,282	1,321,126	3,957,461	105,312,893	104,249,761	103,768,654	313,331,308	
4	C&I	12,067,903	11,673,452	11,792,061	35,533,416	1,062,995,995	1,107,001,594	1,169,595,126	3,339,592,715	
5	Total	18,916,529	18,777,150	18,828,257	56,521,936	1,945,954,632	1,964,157,272	1,995,869,313	5,905,981,216	Sum of Lines 2 to 4
	Total Costs Excluding Proposed DR Costs									
6	Residential	1,606,586	1,590,394	1,568,830	4,765,810	319,858,947	316,028,722	308,314,521	944,202,190	
7	Low Income	633,551	624,798	616,257	1,874,605	65,132,416	63,638,504	61,323,799	190,094,720	
8	C&I	2,887,599	2,851,467	2,812,945	8,552,011	392,894,890	407,875,203	428,364,911	1,229,135,003	
9	Total	5,127,735	5,066,659	4,998,033	15,192,426	777,886,253	787,542,429	798,003,232	2,363,431,914	Sum of Lines 6 to 8
	Performance Incentives used in preliminary Total Cost calculation									
10	Residential	102,668	108,835	109,299	320,802	6,936,589	7,027,932	7,503,162	21,467,683	
11	Low Income	20,340	20,762	21,266	62,368	816,210	843,038	829,930	2,489,178	
12	C&I	212,903	217,514	220,297	650,714	7,524,458	7,955,639	8,607,741	24,087,837	
13	Total	335,911	347,111	350,861	1,033,884	15,277,256	15,826,609	16,940,833	48,044,699	Sum of Lines 10 to 12
	Net Benefits excluding performance incentives									
14	Residential	4,031,655	4,298,857	4,255,539	12,586,050	464,723,386	443,905,127	421,694,173	1,330,322,686	Line 2 - (Line 6 - Line 10)
15	Low Income	699,844	719,247	726,134	2,145,224	40,996,687	41,454,295	43,274,785	125,725,766	Line 3 - (Line 7 - Line 11)
16	C&I	9,393,207	9,039,499	9,199,413	27,632,119	677,625,563	707,082,031	749,837,956	2,134,545,549	Line 4 - (Line 8 - Line12)
17	Total	14,124,705	14,057,602	14,181,086	42,363,394	1,183,345,635	1,192,441,452	1,214,806,915	3,590,594,002	Sum of lines 14 to 16

2016 - 2018 Energy Efficiency Performance Incentives
Derivation of Performance Metric Pool ($2016)

			2016		2017		2018		Total	Comment
	A. Total Performance Incentive Pool									
1	PA proposed goals (thousands MWh) excluding CLC		1,313		1,317		1,316		3,946	Statewide savings goals per PA plans.
2	CLC proposed goals (thousands MWh)		58		57		57		172	Savings goals proposed by CLC
3	EEAC Recommended goals (thousands MWh)								4,108	2.93% of sales projected in April 2015. See Term Sheet.
4	EEAC Recommended goals (thousands MWh) excluding CLC								3,936	Line 3 - Line 2
5	Statewide 2016 - 2018 Design Level Performance Incentives							$	100,000,000	Statewide electric PI pool
	B. Incentives Allocated by Component									
6	State Benefits excluding CLC	$	1,945,954,632	$	1,964,157,272	$	1,995,869,313	$	5,905,981,216	State benefits without CLC: Electric Input, line 5
7	Percent of Pool Allocated to Savings Component								61.5%	
8	State Performance incentives to savings	$	20,263,561	$	20,453,108	$	20,783,331	$	61,500,000	Line 5 * Line 7
9	Savings payout rate	$	0.0104132	$	0.0104132	$	0.0104132	$	0.0104132	Line 8 / Line 6
10	State Net Benefits excluding CLC	$	1,183,345,635	$	1,192,441,452	$	1,214,806,915	$	3,590,594,002	State net benefits without CLC: Electric Input, Line 17
11	Percent of Pool Allocated to Value Component								38.5%	
12	State performance incentives to value	$	12,688,376	$	12,785,906	$	13,025,718	$	38,500,000	Line 5 * Line 11
13	Value Mechanism Payout Rate	$	0.0107225	$	0.0107225	$	0.0107225	$	0.0107225	Line 12 / Line 10
14	Total Statewide 2016 - 2018 Design Level Performance Incentive	$	32,951,937	$	33,239,014	$	33,809,049	$	100,000,000	Line 8 + Line 12

2016- 2018 Energy Efficiency Performance Incentives
Derivation of Electric Targets 2016

State	Segment %	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits		777,645,744	105,312,893	1,062,995,995	1,945,954,632	Electric Input Lines 2-4
2 Savings Payout Rate 2016		0.010413172	0.010413172	0.010413172	0.010413172	Pef Met Pool, Line 10
3 Forecasted Savings Incentives		$ 8,097,759	$ 1,096,641	$ 11,069,160	$ 20,263,561	Line 1 times Line 2
4 Forecasted Net Benefits		464,723,386	40,996,687	677,625,563	1,183,345,635	Electric Input Lines 14-16
5 Value Payout Rate 2016		0.01072246	0.01072246	0.01072246	0.01072246	Pef Met Pool Line 14
6 Forecasted Value Incentives		$ 4,982,978	$ 439,585	$ 7,265,813	$ 12,688,376	Line 4 times Line 5
7 Total Performance Incentives		$ 13,080,737	$ 1,536,227	$ 18,334,973	$ 32,951,937	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total State
Savings	61.9%	71.4%	60.4%	61.5%
Value	38.1%	28.6%	39.6%	38.5%
Total	100.0%	100.0%	100.0%	100.0%

2016- 2018 Energy Efficiency Performance Incentives
Derivation of Electric Targets 2017

State	Segment %	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits		752,905,917	104,249,761	1,107,001,594	1,964,157,272	Electric Input Lines 2-4
2 Savings Payout Rate 2017		0.010413172	0.010413172	0.010413172	0.010413172	Pef Met Pool, Line 10
3 Forecasted Savings Incentives		$ 7,840,139	$ 1,085,571	$ 11,527,398	$ 20,453,108	Line 1 times Line 2
4 Forecasted Net Benefits		443,905,127	41,454,295	707,082,031	1,192,441,452	Electric Input Lines 14-16
5 Value Payout Rate 2017		0.01072246	0.01072246	0.01072246	0.01072246	Pef Met Pool Line 14
6 Forecasted Value Incentives		$ 4,759,755	$ 444,492	$ 7,581,659	$ 12,785,906	Line 4 times Line 5
7 Total Performance Incentives		$ 12,599,894	$ 1,530,063	$ 19,109,057	$ 33,239,014	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total State
Savings	62.2%	70.9%	60.3%	61.5%
Value	37.8%	29.1%	39.7%	38.5%
Total	100.0%	100.0%	100.0%	100.0%

2016- 2018 Energy Efficiency Performance Incentives
Derivation of Electric Targets 2018

State	Segment %	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits		722,505,532	103,768,654	1,169,595,126	1,995,869,313	Electric Input Lines 2-4
2 Savings Payout Rate 2018		0.010413172	0.010413172	0.010413172	0.010413172	Pef Met Pool, Line 10
3 Forecasted Savings Incentives		$ 7,523,575	$ 1,080,561	$ 12,179,196	$ 20,783,331	Line 1 times Line 2
4 Forecasted Net Benefits		421,694,173	43,274,785	749,837,956	1,214,806,915	Electric Input Lines 14-16
5 Value Payout Rate 2018		0.01072246	0.01072246	0.01072246	0.01072246	Pef Met Pool Line 14
6 Forecasted Value Incentives		$ 4,521,599	$ 464,012	$ 8,040,107	$ 13,025,718	Line 4 times Line 5
7 Total Performance Incentives		$ 12,045,173	$ 1,544,573	$ 20,219,303	$ 33,809,049	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total State
Savings	62.5%	70.0%	60.2%	61.5%
Value	37.5%	30.0%	39.8%	38.5%
Total	100.0%	100.0%	100.0%	100.0%

2016- 2018 Energy Efficiency Performance Incentives
Derivation of Electric Targets 2016 - 2018

State	Segment %	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits		$ 2,253,057,193	$ 313,331,308	$ 3,339,592,715	$ 5,905,981,216	Electric Input Lines 2-4
2 Savings Payout Rate 2016 - 2018		0.0104132	0.0104132	0.0104132	0.0104132	Pef Met Pool, Line 10
3 Forecasted Savings Incentives		$ 23,461,473	$ 3,262,773	$ 34,775,754	$ 61,500,000	Line 1 times Line 2
4 Forecasted Net Benefits		$ 1,330,322,686	$ 125,725,766	$ 2,134,545,549	$ 3,590,594,002	Electric Input Lines 14-16
5 Value Payout Rate 2016 - 2018		0.0107225	0.0107225	0.0107225	0.0107225	Pef Met Pool Line 14
6 Forecasted Value Incentives		$ 14,264,332	$ 1,348,089	$ 22,887,579	$ 38,500,000	Line 4 times Line 5
7 Total Performance Incentives		$ 37,725,804	$ 4,610,862	$ 57,663,333	$ 100,000,000	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total State
Savings	62.2%	70.8%	60.3%	61.5%
Value	37.8%	29.2%	39.7%	38.5%
Total	100.0%	100.0%	100.0%	100.0%

2016- 2018 Energy Efficiency Performance Incentives
Derivation of Electric Targets 2016

	National Grid	Segment %	Residential	Low Income	C&I	Total	Comment
1	Forecasted Benefits	$	402,457,438	$ 56,688,814	$ 436,953,027	$ 896,099,280	Electric Input Lines 2-4
2	Savings Payout Rate 2016		0.0104132	0.0104132	0.0104132	0.0104132	Pef Met Pool, Line 10
3	Forecasted Savings Incentives	$	4,190,859	$ 590,310	$ 4,550,067	$ 9,331,236	Line 1 times Line 2
4	Forecasted Net Benefits	$	234,456,270	$ 23,522,023	$ 256,711,334	$ 514,689,627	Electric Input Lines 14-16
5	Value Payout Rate 2016		0.0107225	0.0107225	0.0107225	0.0107225	Pef Met Pool Line 14
6	Forecasted Value Incentives	$	2,513,948	$ 252,214	$ 2,752,577	$ 5,518,739	Line 4 times Line 5
7	Total Performance Incentives	$	6,704,807	$ 842,524	$ 7,302,644	$ 14,849,975	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total National Grid
Savings	62.5%	70.1%	62.3%	62.8%
Value	37.5%	29.9%	37.7%	37.2%
Total	100.0%	100.0%	100.0%	100.0%

2016- 2018 Energy Efficiency Performance Incentives
Derivation of Electric Targets 2017

	National Grid	Segment %	Residential	Low Income	C&I	Total	Comment
1	Forecasted Benefits	$	402,537,242	$ 56,714,745	$ 457,341,602	$ 916,593,590	Electric Input Lines 2-4
2	Savings Payout Rate 2017		0.0104132	0.0104132	0.0104132	0.0104132	Pef Met Pool, Line 10
3	Forecasted Savings Incentives	$	4,191,690	$ 590,580	$ 4,762,377	$ 9,544,647	Line 1 times Line 2
4	Forecasted Net Benefits	$	231,912,243	$ 24,028,216	$ 278,762,206	$ 534,702,665	Electric Input Lines 14-16
5	Value Payout Rate 2017		0.0107225	0.0107225	0.0107225	0.0107225	Pef Met Pool Line 14
6	Forecasted Value Incentives	$	2,486,670	$ 257,642	$ 2,989,017	$ 5,733,328	Line 4 times Line 5
7	Total Performance Incentives	$	6,678,359	$ 848,222	$ 7,751,393	$ 15,277,975	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total National Grid
Savings	62.8%	69.6%	61.4%	62.5%
Value	37.2%	30.4%	38.6%	37.5%
Total	100.0%	100.0%	100.0%	100.0%

2016- 2018 Energy Efficiency Performance Incentives
Derivation of Electric Targets 2018

	National Grid	Segment %	Residential	Low Income	C&I	Total	Comment
1	Forecasted Benefits	$	394,622,150	$ 57,457,336	$ 488,136,555	$ 940,216,041	Electric Input Lines 2-4
2	Savings Payout Rate 2018		0.0104132	0.0104132	0.0104132	0.0104132	Pef Met Pool, Line 10
3	Forecasted Savings Incentives	$	4,109,268	$ 598,313	$ 5,083,050	$ 9,790,632	Line 1 times Line 2
4	Forecasted Net Benefits	$	227,319,480	$ 25,488,907	$ 304,133,330	$ 556,941,718	Electric Input Lines 14-16
5	Value Payout Rate 2018		0.0107225	0.0107225	0.0107225	0.0107225	Pef Met Pool Line 14
6	Forecasted Value Incentives	$	2,437,424	$ 273,304	$ 3,261,057	$ 5,971,785	Line 4 times Line 5
7	Total Performance Incentives	$	6,546,692	$ 871,617	$ 8,344,107	$ 15,762,417	Line 3 + Line 6

Ressults

Sector	Residential	Low Income	C&I	Total National Grid
Savings	62.8%	68.6%	60.9%	62.1%
Value	37.2%	31.4%	39.1%	37.9%
Total	100.0%	100.0%	100.0%	100.0%

2016- 2018 Energy Efficiency Performance Incentives
Derivation of Electric Targets 2016 - 2018

	National Grid	Segment %	Residential	Low Income	C&I	Total	Comment
1	Forecasted Benefits	$	1,199,616,830	$ 170,860,895	$ 1,382,431,185	$ 2,752,908,910	Electric Input Lines 2-4
2	Savings Payout Rate 2016 - 2018		0.0104132	0.0104132	0.0104132	0.0104132	Pef Met Pool, Line 10
3	Forecasted Savings Incentives	$	12,491,817	$ 1,779,204	$ 14,395,494	$ 28,666,515	Line 1 times Line 2
4	Forecasted Net Benefits	$	693,687,993	$ 73,039,147	$ 839,606,870	$ 1,606,334,010	Electric Input Lines 14-16
5	Value Payout Rate 2016 - 2018		0.0107225	0.0107225	0.0107225	0.0107225	Pef Met Pool Line 14
6	Forecasted Value Incentives	$	7,438,042	$ 783,159	$ 9,002,651	$ 17,223,852	Line 4 times Line 5
7	Total Performance Incentives	$	19,929,858	$ 2,562,363	$ 23,398,145	$ 45,890,367	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total National Grid
Savings	62.7%	69.4%	61.5%	62.5%
Value	37.3%	30.6%	38.5%	37.5%
Total	100.0%	100.0%	100.0%	100.0%

2016- 2018 Energy Efficiency Performance Incentives
Derivation of Electric Targets 2016

	Eversource	**Segment %**	**Residential**	**Low Income**	**C&I**	**Total**	**Comment**
1	Forecasted Benefits		$ 369,652,733	$ 47,311,025	$ 613,975,065	$ 1,030,938,823	Electric Input Lines 2-4
2	Savings Payout Rate 2016		0.0104132	0.0104132	0.0104132	0.0104132	Pef Met Pool, Line 10
3	Forecasted Savings Incentives		$ 3,849,258	$ 492,658	$ 6,393,428	$ 10,735,344	Line 1 times Line 2
4	Forecasted Net Benefits		$ 226,235,461	$ 16,774,820	$ 411,521,022	$ 654,531,303	Electric Input Lines 14-16
5	Value Payout Rate 2016		0.0107225	0.0107225	0.0107225	0.0107225	Pef Met Pool Line 14
6	Forecasted Value Incentives		$ 2,425,801	$ 179,867	$ 4,412,518	$ 7,018,186	Line 4 times Line 5
7	Total Performance Incentives		$ 6,275,058	$ 672,525	$ 10,805,946	$ 17,753,529	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Eversource
Savings	61.3%	73.3%	59.2%	60.5%
Value	38.7%	26.7%	40.8%	39.5%
Total	100.0%	100.0%	100.0%	100.0%

2016- 2018 Energy Efficiency Performance Incentives
Derivation of Electric Targets 2017

	Eversource	**Segment %**	**Residential**	**Low Income**	**C&I**	**Total**	**Comment**
1	Forecasted Benefits		$ 344,588,259	$ 46,211,734	$ 637,986,539	$ 1,028,786,532	Electric Input Lines 2-4
2	Savings Payout Rate 2017		0.0104132	0.0104132	0.0104132	0.0104132	Pef Met Pool, Line 10
3	Forecasted Savings Incentives		$ 3,588,257	$ 481,211	$ 6,643,464	$ 10,712,931	Line 1 times Line 2
4	Forecasted Net Benefits		$ 207,694,027	$ 16,706,832	$ 419,280,325	$ 643,681,184	Electric Input Lines 14-16
5	Value Payout Rate 2017		0.0107225	0.0107225	0.0107225	0.0107225	Pef Met Pool Line 14
6	Forecasted Value Incentives		$ 2,226,991	$ 179,138	$ 4,495,716	$ 6,901,846	Line 4 times Line 5
7	Total Performance Incentives		$ 5,815,248	$ 660,349	$ 11,139,180	$ 17,614,777	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Eversource
Savings	61.7%	72.9%	59.6%	60.8%
Value	38.3%	27.1%	40.4%	39.2%
Total	100.0%	100.0%	100.0%	100.0%

2016- 2018 Energy Efficiency Performance Incentives
Derivation of Electric Targets 2018

	Eversource	Segment %	Residential	Low Income	C&I	Total	Comment
1	Forecasted Benefits		$ 322,168,312	$ 44,990,193	$ 669,666,510	$ 1,036,825,015	Electric Input Lines 2-4
2	Savings Payout Rate 2018		0.0104132	0.0104132	0.0104132	0.0104132	Pef Met Pool, Line 10
3	Forecasted Savings Incentives		$ 3,354,794	$ 468,491	$ 6,973,353	$ 10,796,638	Line 1 times Line 2
4	Forecasted Net Benefits		$ 190,119,154	$ 17,059,744	$ 436,505,213	$ 643,684,111	Electric Input Lines 14-16
5	Value Payout Rate 2018		0.0107225	0.0107225	0.0107225	0.0107225	Pef Met Pool Line 14
6	Forecasted Value Incentives		$ 2,038,545	$ 182,922	$ 4,680,410	$ 6,901,877	Line 4 times Line 5
7	Total Performance Incentives		$ 5,393,339	$ 651,413	$ 11,653,762	$ 17,698,515	Line 3 + Line 6

Ressults

Sector	Residential	Low Income	C&I	Total Eversource
Savings	62.2%	71.9%	59.8%	61.0%
Value	37.8%	28.1%	40.2%	39.0%
Total	100.0%	100.0%	100.0%	100.0%

2016- 2018 Energy Efficiency Performance Incentives
Derivation of Electric Targets 2016 - 2018

	Eversource	Segment %	Residential	Low Income	C&I	Total	Comment
1	Forecasted Benefits		$ 1,036,409,304	$ 138,512,952	$ 1,921,628,115	$ 3,096,550,370	Electric Input Lines 2-4
2	Savings Payout Rate 2016 - 2018		0.0104132	0.0104132	0.0104132	0.0104132	Pef Met Pool, Line 10
3	Forecasted Savings Incentives		$ 10,792,309	$ 1,442,359	$ 20,010,245	$ 32,244,913	Line 1 times Line 2
4	Forecasted Net Benefits		$ 624,048,642	$ 50,541,396	$ 1,267,306,561	$ 1,941,896,598	Electric Input Lines 14-16
5	Value Payout Rate 2016 - 2018		0.0107225	0.0107225	0.0107225	0.0107225	Pef Met Pool Line 14
6	Forecasted Value Incentives		$ 6,691,337	$ 541,928	$ 13,588,644	$ 20,821,908	Line 4 times Line 5
7	Total Performance Incentives		$ 17,483,645	$ 1,984,287	$ 33,598,888	$ 53,066,821	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Eversource
Savings	61.7%	72.7%	59.6%	60.8%
Value	38.3%	27.3%	40.4%	39.2%
Total	100.0%	100.0%	100.0%	100.0%

2016- 2018 Energy Efficiency Performance Incentives
Derivation of Electric Targets 2016

	Unitil	Segment %	Residential	Low Income	C&I	Total	Comment
1	Forecasted Benefits		$ 5,535,573	$ 1,313,054	$ 12,067,903	$ 18,916,529	Electric Input Lines 2-4
2	Savings Payout Rate 2016		0.0104132	0.0104132	0.0104132	0.0104132	Pef Met Pool, Line 10
3	Forecasted Savings Incentives		$ 57,643	$ 13,673	$ 125,665	$ 196,981	Line 1 times Line 2
4	Forecasted Net Benefits		$ 4,031,655	$ 699,844	$ 9,393,207	$ 14,124,705	Electric Input Lines 14-16
5	Value Payout Rate 2016		0.0107225	0.0107225	0.0107225	0.0107225	Pef Met Pool Line 14
6	Forecasted Value Incentives		$ 43,229	$ 7,504	$ 100,718	$ 151,452	Line 4 times Line 5
7	Total Performance Incentives		$ 100,872	$ 21,177	$ 226,383	$ 348,433	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Unitil
Savings	57.1%	64.6%	55.5%	56.5%
Value	42.9%	35.4%	44.5%	43.5%
Total	100.0%	100.0%	100.0%	100.0%

2016- 2018 Energy Efficiency Performance Incentives
Derivation of Electric Targets 2017

	Unitil	Segment %	Residential	Low Income	C&I	Total	Comment
1	Forecasted Benefits		$ 5,780,416	$ 1,323,282	$ 11,673,452	$ 18,777,150	Electric Input Lines 2-4
2	Savings Payout Rate 2017		0.0104132	0.0104132	0.0104132	0.0104132	Pef Met Pool, Line 10
3	Forecasted Savings Incentives		$ 60,192	$ 13,780	$ 121,558	$ 195,530	Line 1 times Line 2
4	Forecasted Net Benefits		$ 4,298,857	$ 719,247	$ 9,039,499	$ 14,057,602	Electric Input Lines 14-16
5	Value Payout Rate 2017		0.0107225	0.0107225	0.0107225	0.0107225	Pef Met Pool Line 14
6	Forecasted Value Incentives		$ 46,094	$ 7,712	$ 96,926	$ 150,732	Line 4 times Line 5
7	Total Performance Incentives		$ 106,287	$ 21,492	$ 218,483	$ 346,262	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Unitil
Savings	56.6%	64.1%	55.6%	56.5%
Value	43.4%	35.9%	44.4%	43.5%
Total	100.0%	100.0%	100.0%	100.0%

2016- 2018 Energy Efficiency Performance Incentives
Derivation of Electric Targets 2018

	Unitil	Segment %	Residential	Low Income	C&I	Total	Comment
1	Forecasted Benefits		$ 5,715,070	$ 1,321,126	$ 11,792,061	$ 18,828,257	Electric Input Lines 2-4
2	Savings Payout Rate 2018		0.0104132	0.0104132	0.0104132	0.0104132	Pef Met Pool, Line 10
3	Forecasted Savings Incentives		$ 59,512	$ 13,757	$ 122,793	$ 196,062	Line 1 times Line 2
4	Forecasted Net Benefits		$ 4,255,539	$ 726,134	$ 9,199,413	$ 14,181,086	Electric Input Lines 14-16
5	Value Payout Rate 2018		0.0107225	0.0107225	0.0107225	0.0107225	Pef Met Pool Line 14
6	Forecasted Value Incentives		$ 45,630	$ 7,786	$ 98,640	$ 152,056	Line 4 times Line 5
7	Total Performance Incentives		$ 105,142	$ 21,543	$ 221,433	$ 348,118	Line 3 + Line 6

Ressults

Sector	Residential	Low Income	C&I	Total Unitil
Savings	56.6%	63.9%	55.5%	56.3%
Value	43.4%	36.1%	44.5%	43.7%
Total	100.0%	100.0%	100.0%	100.0%

2016- 2018 Energy Efficiency Performance Incentives
Derivation of Electric Targets 2016 - 2018

	Unitil	Segment %	Residential	Low Income	C&I	Total	Comment
1	Forecasted Benefits		$ 17,031,059	$ 3,957,461	$ 35,533,416	$ 56,521,936	Electric Input Lines 2-4
2	Savings Payout Rate 2016 - 2018		0.0104132	0.0104132	0.0104132	0.0104132	Pef Met Pool, Line 10
3	Forecasted Savings Incentives		$ 177,347	$ 41,210	$ 370,016	$ 588,573	Line 1 times Line 2
4	Forecasted Net Benefits		$ 12,586,050	$ 2,145,224	$ 27,632,119	$ 42,363,394	Electric Input Lines 14-16
5	Value Payout Rate 2016 - 2018		0.0107225	0.0107225	0.0107225	0.0107225	Pef Met Pool Line 14
6	Forecasted Value Incentives		$ 134,953	$ 23,002	$ 296,284	$ 454,240	Line 4 times Line 5
7	Total Performance Incentives		$ 312,301	$ 64,212	$ 666,300	$ 1,042,812	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Unitil
Savings	56.8%	64.2%	55.5%	56.4%
Value	43.2%	35.8%	44.5%	43.6%
Total	100.0%	100.0%	100.0%	100.0%

2016 Energy Efficiency Performance Incentives
Summary of Performance Incentives by Sector and Incentive Type
Assuming Design Level Performance Incentive

	In 2016 dollars					**Percent of Total Incentive**				
	State (no CLC)	Residential	Low Income	C&I	Total	**State**	Residential	Low Income	C&I	Total
1	Savings	8,097,759	1,096,641	11,069,160	20,263,561	Savings	24.6%	3.3%	33.6%	61.5%
2	Value	4,982,978	439,585	7,265,813	12,688,376	Value	15.1%	1.3%	22.0%	38.5%
3	Total	13,080,737	1,536,227	18,334,973	32,951,937	Total	39.7%	4.7%	55.6%	100.0%
	National Grid	Residential	Low Income	C&I	Total	**National Grid**	Residential	Low Income	C&I	Total
4	Savings	4,190,859	590,310	4,550,067	9,331,236	Savings	28.2%	4.0%	30.6%	62.8%
5	Value	2,513,948	252,214	2,752,577	5,518,739	Value	16.9%	1.7%	18.5%	37.2%
6	Total	6,704,807	842,524	7,302,644	14,849,975	Total	45.2%	5.7%	49.2%	100.0%
	Eversource	Residential	Low Income	C&I	Total	**Eversource**	Residential	Low Income	C&I	Total
7	Savings	3,849,258	492,658	6,393,428	10,735,344	Savings	21.7%	2.8%	36.0%	60.5%
8	Value	2,425,801	179,867	4,412,518	7,018,186	Value	13.7%	1.0%	24.9%	39.5%
9	Total	6,275,058	672,525	10,805,946	17,753,529	Total	35.3%	3.8%	60.9%	100.0%
	Unitil	Residential	Low Income	C&I	Total	**Unitil**	Residential	Low Income	C&I	Total
10	Savings	57,643	13,673	125,665	196,981	Savings	16.5%	3.9%	36.1%	56.5%
11	Value	43,229	7,504	100,718	151,452	Value	12.4%	2.2%	28.9%	43.5%
12	Total	100,872	21,177	226,383	348,433	Total	29.0%	6.1%	65.0%	100.0%

2017 Energy Efficiency Performance Incentives
Summary of Performance Incentives by Sector and Incentive Type
Assuming Design Level Performance Incentive

	In 2016 dollars					**Percent of Total Incentive**				
	State (no CLC)	Residential	Low Income	C&I	Total	**State**	Residential	Low Income	C&I	Total
1	Savings	7,840,139	1,085,571	11,527,398	20,453,108	Savings	23.6%	3.3%	34.7%	61.5%
2	Value	4,759,755	444,492	7,581,659	12,785,906	Value	14.3%	1.3%	22.8%	38.5%
3	Total	12,599,894	1,530,063	19,109,057	33,239,014	Total	37.9%	4.6%	57.5%	100.0%
	National Grid	Residential	Low Income	C&I	Total	**National Grid**	Residential	Low Income	C&I	Total
4	Savings	4,191,690	590,580	4,762,377	9,544,647	Savings	27.4%	3.9%	31.2%	62.5%
5	Value	2,486,670	257,642	2,989,017	5,733,328	Value	16.3%	1.7%	19.6%	37.5%
6	Total	6,678,359	848,222	7,751,393	15,277,975	Total	43.7%	5.6%	50.7%	100.0%
	Eversource	Residential	Low Income	C&I	Total	**Eversource**	Residential	Low Income	C&I	Total
7	Savings	3,588,257	481,211	6,643,464	10,712,931	Savings	20.4%	2.7%	37.7%	60.8%
8	Value	2,226,991	179,138	4,495,716	6,901,846	Value	12.6%	1.0%	25.5%	39.2%
9	Total	5,815,248	660,349	11,139,180	17,614,777	Total	33.0%	3.7%	63.2%	100.0%
	Unitil	Residential	Low Income	C&I	Total	**Unitil**	Residential	Low Income	C&I	Total
10	Savings	60,192	13,780	121,558	195,530	Savings	17.4%	4.0%	35.1%	56.5%
11	Value	46,094	7,712	96,926	150,732	Value	13.3%	2.2%	28.0%	43.5%
12	Total	106,287	21,492	218,483	346,262	Total	30.7%	6.2%	63.1%	100.0%

2018 Energy Efficiency Performance Incentives
Summary of Performance Incentives by Sector and Incentive Type
Assuming Design Level Performance Incentive

	In 2016 dollars					Percent of Total Incentive				
	State (no CLC)	Residential	Low Income	C&I	Total	**State**	Residential	Low Income	C&I	Total
1	Savings	7,523,575	1,080,561	12,179,196	20,783,331	Savings	22.3%	3.2%	36.0%	61.5%
2	Value	4,521,599	464,012	8,040,107	13,025,718	Value	13.4%	1.4%	23.8%	38.5%
3	Total	12,045,173	1,544,573	20,219,303	33,809,049	Total	35.6%	4.6%	59.8%	100.0%
	National Grid	Residential	Low Income	C&I	Total	**National Grid**	Residential	Low Income	C&I	Total
4	Savings	4,109,268	598,313	5,083,050	9,790,632	Savings	26.1%	3.8%	32.2%	62.1%
5	Value	2,437,424	273,304	3,261,057	5,971,785	Value	15.5%	1.7%	20.7%	37.9%
6	Total	6,546,692	871,617	8,344,107	15,762,417	Total	41.5%	5.5%	52.9%	100.0%
	Eversource	Residential	Low Income	C&I	Total	**NSTAR**	Residential	Low Income	C&I	Total
7	Savings	3,354,794	468,491	6,973,353	10,796,638	Savings	19.0%	2.6%	39.4%	61.0%
8	Value	2,038,545	182,922	4,680,410	6,901,877	Value	11.5%	1.0%	26.4%	39.0%
9	Total	5,393,339	651,413	11,653,762	17,698,515	Total	30.5%	3.7%	65.8%	100.0%
	Unitil	Residential	Low Income	C&I	Total	**Unitil**	Residential	Low Income	C&I	Total
10	Savings	59,512	13,757	122,793	196,062	Savings	17.1%	4.0%	35.3%	56.3%
11	Value	45,630	7,786	98,640	152,056	Value	13.1%	2.2%	28.3%	43.7%
12	Total	105,142	21,543	221,433	348,118	Total	30.2%	6.2%	63.6%	100.0%

2016 - 2018 Energy Efficiency Performance Incentives
Summary of Performance Incentives by Sector and Incentive Type
Assuming Design Level Performance Incentive

	In 2016 dollars					Percent of Total Incentive				
	State (no CLC)	Residential	Low Income	C&I	Total	**State**	Residential	Low Income	C&I	Total
1	Savings	23,461,473	3,262,773	34,775,754	61,500,000	Savings	23.5%	3.3%	34.8%	61.5%
2	Value	14,264,332	1,348,089	22,887,579	38,500,000	Value	14.3%	1.3%	22.9%	38.5%
3	Total	37,725,804	4,610,862	57,663,333	100,000,000	Total	37.7%	4.6%	57.7%	100.0%
	National Grid	Residential	Low Income	C&I	Total	**National Grid**	Residential	Low Income	C&I	Total
4	Savings	12,491,817	1,779,204	14,395,494	28,666,515	Savings	27.2%	3.9%	31.4%	62.5%
5	Value	7,438,042	783,159	9,002,651	17,223,852	Value	16.2%	1.7%	19.6%	37.5%
6	Total	19,929,858	2,562,363	23,398,145	45,890,367	Total	43.4%	5.6%	51.0%	100.0%
	Eversource	Residential	Low Income	C&I	Total	**Eversource**	Residential	Low Income	C&I	Total
7	Savings	10,792,309	1,442,359	20,010,245	32,244,913	Savings	20.3%	2.7%	37.7%	60.8%
8	Value	6,691,337	541,928	13,588,644	20,821,908	Value	12.6%	1.0%	25.6%	39.2%
9	Total	17,483,645	1,984,287	33,598,888	53,066,821	Total	32.9%	3.7%	63.3%	100.0%
	Unitil	Residential	Low Income	C&I	Total	**Unitil**	Residential	Low Income	C&I	Total
10	Savings	177,347	41,210	370,016	588,573	Savings	17.0%	4.0%	35.5%	56.4%
11	Value	134,953	23,002	296,284	454,240	Value	12.9%	2.2%	28.4%	43.6%
12	Total	312,301	64,212	666,300	1,042,812	Total	29.9%	6.2%	63.9%	100.0%

Discount Rate: 2.54%

2016 Energy Efficiency Performance Incentives
Summary of Performance Incentives by Sector and Incentive Type
Assuming Design Level Performance Incentive

	In 2016 dollars					**Percent of Total Incentive**				
	State (no CLC)	Residential	Low Income	C&I	Total	**State**	Residential	Low Income	C&I	Total
1	Savings	8,097,759	1,096,641	11,069,160	20,263,561	Savings	24.6%	3.3%	33.6%	61.5%
2	Value	4,982,978	439,585	7,265,813	12,688,376	Value	15.1%	1.3%	22.0%	38.5%
3	Total	13,080,737	1,536,227	18,334,973	32,951,937	Total	39.7%	4.7%	55.6%	100.0%
	National Grid	Residential	Low Income	C&I	Total	**National Grid**	Residential	Low Income	C&I	Total
4	Savings	4,190,859	590,310	4,550,067	9,331,236	Savings	28.2%	4.0%	30.6%	62.8%
5	Value	2,513,948	252,214	2,752,577	5,518,739	Value	16.9%	1.7%	18.5%	37.2%
6	Total	6,704,807	842,524	7,302,644	14,849,975	Total	45.2%	5.7%	49.2%	100.0%
	Eversource	Residential	Low Income	C&I	Total	**Eversource**	Residential	Low Income	C&I	Total
7	Savings	3,849,258	492,658	6,393,428	10,735,344	Savings	21.7%	2.8%	36.0%	60.5%
8	Value	2,425,801	179,867	4,412,518	7,018,186	Value	13.7%	1.0%	24.9%	39.5%
9	Total	6,275,058	672,525	10,805,946	17,753,529	Total	35.3%	3.8%	60.9%	100.0%
	Unitil	Residential	Low Income	C&I	Total	**Unitil**	Residential	Low Income	C&I	Total
10	Savings	57,643	13,673	125,665	196,981	Savings	16.5%	3.9%	36.1%	56.5%
11	Value	43,229	7,504	100,718	151,452	Value	12.4%	2.2%	28.9%	43.5%
12	Total	100,872	21,177	226,383	348,433	Total	29.0%	6.1%	65.0%	100.0%

2017 Energy Efficiency Performance Incentives
Summary of Performance Incentives by Sector and Incentive Type
Assuming Design Level Performance Incentive

	In 2017 Dollars					Percent of Total Incentive				
	State (no CLC)	Residential	Low Income	C&I	Total	**State**	Residential	Low Income	C&I	Total
1	Savings	8,039,279	1,113,144	11,820,194	20,972,617	Savings	23.6%	3.3%	34.7%	61.5%
2	Value	4,880,653	455,782	7,774,233	13,110,668	Value	14.3%	1.3%	22.8%	38.5%
3	Total	12,919,931	1,568,926	19,594,427	34,083,285	Total	37.9%	4.6%	57.5%	100.0%
	National Grid	Residential	Low Income	C&I	Total	**National Grid**	Residential	Low Income	C&I	Total
4	Savings	4,298,159	605,581	4,883,341	9,787,081	Savings	27.4%	3.9%	31.2%	62.5%
5	Value	2,549,831	264,186	3,064,938	5,878,954	Value	16.3%	1.7%	19.6%	37.5%
6	Total	6,847,990	869,767	7,948,279	15,666,035	Total	43.7%	5.6%	50.7%	100.0%
	Eversource	Residential	Low Income	C&I	Total	**Eversource**	Residential	Low Income	C&I	Total
7	Savings	3,679,399	493,433	6,812,208	10,985,040	Savings	20.4%	2.7%	37.7%	60.8%
8	Value	2,283,556	183,688	4,609,908	7,077,153	Value	12.6%	1.0%	25.5%	39.2%
9	Total	5,962,955	677,122	11,422,115	18,062,192	Total	33.0%	3.7%	63.2%	100.0%
	Unitil	Residential	Low Income	C&I	Total	**Unitil**	Residential	Low Income	C&I	Total
10	Savings	61,721	14,130	124,645	200,496	Savings	17.4%	4.0%	35.1%	56.5%
11	Value	47,265	7,908	99,388	154,561	Value	13.3%	2.2%	28.0%	43.5%
12	Total	108,986	22,038	224,033	355,057	Total	30.7%	6.2%	63.1%	100.0%

2018 Energy Efficiency Performance Incentives
Summary of Performance Incentives by Sector and Incentive Type
Assuming Design Level Performance Incentive

	In 2018 Dollars					**Percent of Total Incentive**				
	State (no CLC)	Residential	Low Income	C&I	Total	**State**	Residential	Low Income	C&I	Total
1	Savings	7,910,626	1,136,151	12,805,756	21,852,533	Savings	22.3%	3.2%	36.0%	61.5%
2	Value	4,754,213	487,883	8,453,732	13,695,829	Value	13.4%	1.4%	23.8%	38.5%
3	Total	12,664,839	1,624,034	21,259,488	35,548,361	Total	35.6%	4.6%	59.8%	100.0%
	National Grid	Residential	Low Income	C&I	Total	**National Grid**	Residential	Low Income	C&I	Total
4	Savings	4,320,670	629,093	5,344,548	10,294,312	Savings	26.1%	3.8%	32.2%	62.1%
5	Value	2,562,818	287,364	3,428,823	6,279,005	Value	15.5%	1.7%	20.7%	37.9%
6	Total	6,883,488	916,457	8,773,371	16,573,317	Total	41.5%	5.5%	52.9%	100.0%
	Eversource	Residential	Low Income	C&I	Total	**Eversource**	Residential	Low Income	C&I	Total
7	Savings	3,527,382	492,592	7,332,098	11,352,072	Savings	19.0%	2.6%	39.4%	61.0%
8	Value	2,143,418	192,333	4,921,194	7,256,945	Value	11.5%	1.0%	26.4%	39.0%
9	Total	5,670,800	684,925	12,253,292	18,609,017	Total	30.5%	3.7%	65.8%	100.0%
	Unitil	Residential	Low Income	C&I	Total	**Unitil**	Residential	Low Income	C&I	Total
10	Savings	62,574	14,465	129,110	206,148	Savings	17.1%	4.0%	35.3%	56.3%
11	Value	47,977	8,186	103,715	159,879	Value	13.1%	2.2%	28.3%	43.7%
12	Total	110,551	22,651	232,825	366,027	Total	30.2%	6.2%	63.6%	100.0%

2016 - 2018 Energy Efficiency Performance Incentives
Summary of Performance Incentives by Sector and Incentive Type
Assuming Design Level Performance Incentive

	In Current Year Dollars					Percent of Total Incentive				
	State (no CLC)	Residential	Low Income	C&I	Total	**State**	Residential	Low Income	C&I	Total
1	Savings	24,047,664	3,345,936	35,695,111	63,088,711	Savings	23.4%	3.3%	34.8%	61.5%
2	Value	14,617,844	1,383,251	23,493,778	39,494,872	Value	14.2%	1.3%	22.9%	38.5%
3	Total	38,665,508	4,729,187	59,188,889	102,583,583	Total	37.7%	4.6%	57.7%	100.0%
	National Grid	Residential	Low Income	C&I	Total	**National Grid**	Residential	Low Income	C&I	Total
4	Savings	12,809,688	1,824,985	14,777,957	29,412,629	Savings	27.2%	3.9%	31.4%	62.5%
5	Value	7,626,597	803,764	9,246,338	17,676,698	Value	16.2%	1.7%	19.6%	37.5%
6	Total	20,436,284	2,628,749	24,024,294	47,089,327	Total	43.4%	5.6%	51.0%	100.0%
	Eversource	Residential	Low Income	C&I	Total	**Eversource**	Residential	Low Income	C&I	Total
7	Savings	11,056,038	1,478,684	20,537,734	33,072,456	Savings	20.3%	2.7%	37.7%	60.8%
8	Value	6,852,775	555,889	13,943,619	21,352,283	Value	12.6%	1.0%	25.6%	39.2%
9	Total	17,908,814	2,034,572	34,481,353	54,424,739	Total	32.9%	3.7%	63.4%	100.0%
	Unitil	Residential	Low Income	C&I	Total	**Unitil**	Residential	Low Income	C&I	Total
10	Savings	181,938	42,267	379,420	603,626	Savings	17.0%	4.0%	35.5%	56.4%
11	Value	138,472	23,599	303,821	465,891	Value	12.9%	2.2%	28.4%	43.6%
12	Total	320,409	65,866	683,241	1,069,516	Total	30.0%	6.2%	63.9%	100.0%

Input Sheet: 2016 - 2018 figures
In 2016 dollars

	Gas	National Grid				Eversource				Columbia				Unitil			
		2016	2017	2018	Total	2016	2017	2018	Total	2016	2017	2018	Total	2016	2017	2018	Total
1	Goals (annual therms)	16,343,206	16,727,328	17,251,140	50,321,675	6,493,052	6,523,319	6,632,247	19,648,619	4,140,924	4,151,797	4,208,274	12,500,994	215,621	219,734	225,405	660,760
	Benefits																
2	Residential	165,662,129	167,151,686	171,755,208	504,569,023	57,816,651	58,010,045	59,587,313	175,414,009	66,575,024	66,704,532	67,837,626	201,117,182	2,430,533	2,480,462	2,555,995	7,466,990
3	Low Income	46,649,274	46,381,705	46,316,654	139,347,633	16,835,076	17,139,362	17,757,997	51,732,435	11,051,359	10,884,164	10,871,350	32,806,874	819,196	855,930	873,871	2,548,997
4	C&I	73,765,237	73,451,618	75,202,420	222,419,275	50,443,330	50,249,648	50,705,817	151,398,795	29,958,031	29,491,100	29,394,753	88,843,884	2,380,642	2,370,424	2,415,387	7,166,453
5	Total	286,076,641	286,985,010	293,274,281	866,335,932	125,095,058	125,399,054	128,051,127	378,545,239	107,584,414	107,079,796	108,103,729	322,767,940	5,630,371	5,706,816	5,845,253	17,182,440
	Total Costs Excluding DR Costs																
6	Residential	110,440,137	113,168,941	115,324,337	338,933,414	35,759,799	36,222,787	36,984,526	108,967,112	21,310,392	20,326,015	20,085,995	61,722,402	1,100,480	1,095,020	1,091,197	3,286,697
7	Low Income	26,413,470	25,827,757	25,201,372	77,442,598	9,279,054	9,347,941	9,555,471	28,182,466	7,274,068	7,070,611	7,063,072	21,407,751	478,985	477,722	474,942	1,431,650
8	C&I	29,975,537	30,159,616	30,837,418	90,972,572	17,323,616	17,379,795	18,105,198	52,808,609	7,941,915	7,492,273	7,429,871	22,864,058	622,674	619,603	617,918	1,860,195
9	Total	166,829,143	169,156,314	171,363,127	507,348,584	62,362,469	62,950,523	64,645,194	189,958,187	36,526,375	34,888,898	34,578,938	105,994,211	2,202,140	2,192,346	2,184,057	6,578,542
	Performance Incentives used in Preliminary Total Cost calculation																
10	Residential	1,686,475	1,694,552	1,749,344	5,130,372	-	-	-	-	818,107	817,743	832,322	2,468,172	27,102	27,602	28,470	83,174
11	Low Income	471,323	469,162	473,507	1,413,992	-	-	-	-	98,275	96,223	95,264	289,763	8,235	8,676	8,847	25,759
12	C&I	933,608	932,585	955,592	2,821,785	-	-	-	-	356,019	374,479	371,620	1,102,118	30,532	30,209	30,721	91,461
13	Total	3,091,407	3,096,299	3,178,443	9,366,149	-	-	-	-	1,272,401	1,288,445	1,299,206	3,860,052	65,869	66,487	68,038	200,394
	Net Benefits excluding performance incentives																
14	Residential	56,908,468	55,677,297	58,180,216	170,765,981	22,056,852	21,787,258	22,602,787	66,446,897	46,082,738	47,196,261	48,583,952	141,862,951	1,357,154	1,413,044	1,493,268	4,263,466
15	Low Income	20,707,128	21,023,110	21,588,789	63,319,028	7,556,022	7,791,421	8,202,526	23,549,969	3,875,566	3,909,777	3,903,543	11,688,886	348,446	386,884	407,776	1,143,106
16	C&I	44,723,308	44,224,587	45,320,593	134,268,488	33,119,714	32,869,852	32,600,619	98,590,186	22,372,135	22,373,306	22,336,503	67,081,944	1,788,500	1,781,030	1,828,189	5,397,719
17	Total	122,338,904	120,924,994	125,089,598	368,353,496	62,732,588	62,448,531	63,405,933	188,587,052	72,330,440	73,479,343	74,823,998	220,633,780	3,494,100	3,580,958	3,729,233	10,804,291

Input Sheet: 2016 - 2018 figures
In 2016 dollars

		Berkshire				Liberty				State				
	Gas	2016	2017	2018	Total	2016	2017	2018	Total	2016	2017	2018	Total	
1	Goals (annual therms)	563,940	532,868	538,150	1,634,958	338,224	349,355	355,281	1,042,860	28,094,966	28,504,401	29,210,498	85,809,866	
	Benefits													
2	Residential	6,596,210	4,755,556	4,812,779	16,164,545	4,677,290	4,622,384	4,697,753	13,997,426	303,757,837	303,724,665	311,246,673	918,729,175	
3	Low Income	1,475,886	1,469,324	1,467,793	4,413,002	1,279,006	1,270,801	1,264,648	3,814,455	78,109,798	78,001,287	78,552,313	234,663,397	
4	C&I	5,140,619	5,092,897	5,090,684	15,324,199	2,554,176	2,683,625	2,647,650	7,885,451	164,242,036	163,339,311	165,456,710	493,038,056	
5	Total	13,212,714	11,317,777	11,371,255	35,901,746	8,510,473	8,576,810	8,610,050	25,697,332	546,109,670	545,065,263	555,255,695	1,646,430,628	Sum of Lines 2 to 4
	Total Costs Excluding DR Costs													
6	Residential	4,550,768	3,480,521	3,470,903	11,502,191	2,723,017	2,634,337	2,585,191	7,942,546	175,884,593	176,927,621	179,542,149	532,354,363	
7	Low Income	963,560	943,624	923,284	2,830,468	923,448	887,697	870,437	2,681,581	45,332,585	44,555,352	44,088,578	133,976,514	
8	C&I	2,027,335	1,984,030	1,941,859	5,953,224	1,231,670	1,227,042	1,326,390	3,785,102	59,122,747	58,862,360	60,258,654	178,243,761	
9	Total	7,541,662	6,408,175	6,336,047	20,285,884	4,878,135	4,749,077	4,782,018	14,409,229	280,339,925	280,345,333	283,889,380	844,574,638	Sum of Lines 6 to 8
	Performance Incentives used in Preliminary Total Co													
10	Residential	57,694	40,890	41,498	140,083	45,930	45,962	47,373	139,264	2,635,308	2,626,750	2,699,007	7,961,064	
11	Low Income	12,808	12,909	12,888	38,605	10,765	11,036	10,875	32,675	601,407	598,006	601,381	1,800,793	
12	C&I	58,385	57,722	57,831	173,938	26,528	29,161	26,989	82,678	1,405,071	1,424,156	1,442,753	4,271,980	
13	Total	128,887	111,521	112,217	352,625	83,223	86,159	85,236	254,618	4,641,786	4,648,911	4,743,140	14,033,838	Sum of Lines 10 to 12
	Net Benefits excluding performance incentives													
14	Residential	2,103,136	1,315,926	1,383,374	4,802,436	2,000,203	2,034,008	2,159,935	6,194,145	130,508,552	129,423,794	134,403,531	394,335,876	Line 2 - (Line 6 - Line 10)
15	Low Income	525,134	538,609	557,396	1,621,138	366,323	394,140	405,086	1,165,549	33,378,620	34,043,941	35,065,116	102,487,676	Line 3 - (Line 7 - Line 11)
16	C&I	3,171,668	3,166,589	3,206,656	9,544,913	1,349,035	1,485,743	1,348,248	4,183,026	106,524,359	105,901,107	106,640,808	319,066,275	Line 4 - (Line 8 - Line12)
17	Total	5,799,939	5,021,123	5,147,426	15,968,488	3,715,561	3,913,892	3,913,268	11,542,720	270,411,531	269,368,842	276,109,455	815,889,828	Sum of lines 14 to 16

2016 - 2018 Energy Efficiency Performance Incentives
Derivation of Payout Rates

			2016		2017		2018		Total		Comment
	A. Total Performance Incentive Pool										
1	PA Proposed Goals (Annual Therms)		28,094,966		28,504,401		29,210,498		85,809,866	therms	Statewide goals per PA Plans
2	EEAC Recommended Goals (Annual Therms)								85,777,384	therms	1.24% of sales projected in April 2015. See Term Sheet.
3	Statewide 2016 - 2018 Design Level Performance Incentives							$	18,000,000		Proposed Statewide PI pool for gas.
	B. Incentives Allocated by Component										
4	State Benefits	$	546,109,670	$	545,065,263	$	555,255,695	$	1,646,430,628		Gas Input, line 5
5	Percent of Pool Allocated to Savings Component								61.5%		
6	State peformance incentives to savings	$	3,671,843	$	3,664,820	$	3,733,337	$	11,070,000		Line 3 * Line 5
7	Savings payout rate		0.0067236		0.0067236		0.0067236		0.0067236		Line 6 / Line 4
8	State Net Benefits	$	270,411,531	$	269,368,842	$	276,109,455	$	815,889,828		Gas Input, line 17
9	Percent of Pool Allocated to Value Component								38.5%		
10	State performance incentives to value	$	2,296,820	$	2,287,963	$	2,345,217	$	6,930,000.00		Line 3 * Line 9
11	Value payout rate	$	0.0084938	$	0.0084938	$	0.0084938	$	0.0084938		Line 10 / Line 8
12	Total Statewide 2016 - 2018 Design Level Performance Incentive	$	5,968,662	$	5,952,784	$	6,078,554	$	18,000,000		Line 6 + Line 10

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2016

State		Residential		Low Income		C&I		Total	Comment
1 Forecasted Benefits	$	303,757,837	$	78,109,798	$	164,242,036	$	546,109,670	Gas Input, Lines 2-4
2 Savings Payout Rate 2016		0.0067236		0.0067236		0.0067236		0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$	2,042,357	$	525,182	$	1,104,304	$	3,671,843	Line 1 times Line 2
4 Forecasted Net Benefits	$	130,508,552	$	33,378,620	$	106,524,359	$	270,411,531	Gas Input, Lines 14-16
5 Value Payout Rate 2016		0.0084938		0.0084938		0.0084938		0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$	1,108,513	$	283,511	$	904,796	$	2,296,820	Line 4 times Line 5
7 Total Peformance Incentives at target	$	3,150,870	$	808,693	$	2,009,100	$	5,968,662	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total State
Savings	64.8%	64.9%	55.0%	61.5%
Value	35.2%	35.1%	45.0%	38.5%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2017

State		Residential		Low Income		C&I		Total	Comment
1 Forecasted Benefits	$	303,724,665	$	78,001,287	$	163,339,311	$	545,065,263	Gas Input, Lines 2-4
2 Savings Payout Rate 2017		0.0067236		0.0067236		0.0067236		0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$	2,042,134	$	524,452	$	1,098,234	$	3,664,820	Line 1 times Line 2
4 Forecasted Net Benefits	$	129,423,794	$	34,043,941	$	105,901,107	$	269,368,842	Gas Input, Lines 14-16
5 Value Payout Rate 2017		0.0084938		0.0084938		0.0084938		0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$	1,099,299	$	289,162	$	899,502	$	2,287,963	Line 4 times Line 5
7 Total Peformance Incentives at target	$	3,141,433	$	813,614	$	1,997,736	$	5,952,784	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total State
Savings	65.0%	64.5%	55.0%	61.6%
Value	35.0%	35.5%	45.0%	38.4%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2018

	State		Residential		Low Income		C&I		Total	Comment
1	Forecasted Benefits	$	311,246,673	$	78,552,313	$	165,456,710	$	555,255,695	Gas Input, Lines 2-4
2	Savings Payout Rate 2018		0.0067236		0.0067236		0.0067236		0.0067236	Pef Met Pool, Line 8
3	Forecasted Savings Incentives	$	2,092,709	$	528,157	$	1,112,471	$	3,733,337	Line 1 times Line 2
4	Forecasted Net Benefits	$	134,403,531	$	35,065,116	$	106,640,808	$	276,109,455	Gas Input, Lines 14-16
5	Value Payout Rate 2018		0.0084938		0.0084938		0.0084938		0.0084938	Pef Met Pool, Line 12
6	Forecasted Value Incentives	$	1,141,596	$	297,836	$	905,785	$	2,345,217	Line 4 times Line 5
7	Total Peformance Incentives at target	$	3,234,305	$	825,993	$	2,018,256	$	6,078,554	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total State
Savings	64.7%	63.9%	55.1%	61.4%
Value	35.3%	36.1%	44.9%	38.6%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2016 - 2018

	State		Residential		Low Income		C&I		Total	Comment
1	Forecasted Benefits	$	918,729,175	$	234,663,397	$	493,038,056	$	1,646,430,628	Gas Input, Lines 2-4
2	Savings Payout Rate 2016 - 2018		0.0067236		0.0067236		0.0067236		0.0067236	Pef Met Pool, Line 8
3	Forecasted Savings Incentives	$	6,177,200	$	1,577,791	$	3,315,008	$	11,070,000	Line 1 times Line 2
4	Forecasted Net Benefits	$	394,335,876	$	102,487,676	$	319,066,275	$	815,889,828	Gas Input, Lines 14-16
5	Value Payout Rate 2016 - 2018		0.0084938		0.0084938		0.0084938		0.0084938	Pef Met Pool, Line 12
6	Forecasted Value Incentives	$	3,349,408	$	870,509	$	2,710,083	$	6,930,000	Line 4 times Line 5
7	Total Peformance Incentives at target	$	9,526,608	$	2,448,300	$	6,025,092	$	18,000,000	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total State
Savings	64.8%	64.4%	55.0%	61.5%
Value	35.2%	35.6%	45.0%	38.5%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2016

National Grid	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits	$ 165,662,129	$ 46,649,274	$ 73,765,237	$ 286,076,641	Gas Input, Lines 2-4
2 Savings Payout Rate 2016	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$ 1,113,852	$ 313,653	$ 495,971	$ 1,923,475	Line 1 times Line 2
4 Forecasted Net Benefits	$ 56,908,468	$ 20,707,128	$ 44,723,308	$ 122,338,904	Gas Input, Lines 14-16
5 Value Payout Rate 2016	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$ 483,369	$ 175,882	$ 379,871	$ 1,039,121	Line 4 times Line 5
7 Total Peformance Incentives at target	$ 1,597,221	$ 489,535	$ 875,841	$ 2,962,597	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total National Grid
Savings	69.7%	64.1%	56.6%	64.9%
Value	30.3%	35.9%	43.4%	35.1%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2017

National Grid	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits	$ 167,151,686	$ 46,381,705	$ 73,451,618	$ 286,985,010	Gas Input, Lines 2-4
2 Savings Payout Rate 2017	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$ 1,123,867	$ 311,854	$ 493,862	$ 1,929,583	Line 1 times Line 2
4 Forecasted Net Benefits	$ 55,677,297	$ 21,023,110	$ 44,224,587	$ 120,924,994	Gas Input, Lines 14-16
5 Value Payout Rate 2017	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$ 472,911	$ 178,566	$ 375,635	$ 1,027,112	Line 4 times Line 5
7 Total Peformance Incentives at target	$ 1,596,779	$ 490,420	$ 869,496	$ 2,956,695	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total National Grid
Savings	70.4%	63.6%	56.8%	65.3%
Value	29.6%	36.4%	43.2%	34.7%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2018

	National Grid	Residential	Low Income	C&I	Total	Comment
1	Forecasted Benefits	$ 171,755,208	$ 46,316,654	$ 75,202,420	$ 293,274,281	Gas Input, Lines 2-4
2	Savings Payout Rate 2018	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3	Forecasted Savings Incentives	$ 1,154,819	$ 311,416	$ 505,634	$ 1,971,869	Line 1 times Line 2
4	Forecasted Net Benefits	$ 58,180,216	$ 21,588,789	$ 45,320,593	$ 125,089,598	Gas Input, Lines 14-16
5	Value Payout Rate 2018	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6	Forecasted Value Incentives	$ 494,171	$ 183,371	$ 384,944	$ 1,062,485	Line 4 times Line 5
7	Total Peformance Incentives at target	$ 1,648,990	$ 494,787	$ 890,577	$ 3,034,355	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total National Grid
Savings	70.0%	62.9%	56.8%	65.0%
Value	30.0%	37.1%	43.2%	35.0%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2016 - 2018

	National Grid	Residential	Low Income	C&I	Total	Comment
1	Forecasted Benefits	$ 504,569,023	$ 139,347,633	$ 222,419,275	$ 866,335,932	Gas Input, Lines 2-4
2	Savings Payout Rate 2016 - 2018	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3	Forecasted Savings Incentives	$ 3,392,538	$ 936,923	$ 1,495,466	$ 5,824,927	Line 1 times Line 2
4	Forecasted Net Benefits	$ 170,765,981	$ 63,319,028	$ 134,268,488	$ 368,353,496	Gas Input, Lines 14-16
5	Value Payout Rate 2016 - 2018	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6	Forecasted Value Incentives	$ 1,450,451	$ 537,819	$ 1,140,449	$ 3,128,719	Line 4 times Line 5
7	Total Peformance Incentives at target	$ 4,842,989	$ 1,474,742	$ 2,635,915	$ 8,953,646	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total National Grid
Savings	70.1%	63.5%	56.7%	65.1%
Value	29.9%	36.5%	43.3%	34.9%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2016

Eversource	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits	$ 57,816,651	$ 16,835,076	$ 50,443,330	$ 125,095,058	Gas Input, Lines 2-4
2 Savings Payout Rate 2016	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$ 388,738	$ 113,193	$ 339,163	$ 841,094	Line 1 times Line 2
4 Forecasted Net Benefits	$ 22,056,852	$ 7,556,022	$ 33,119,714	$ 62,732,588	Gas Input, Lines 14-16
5 Value Payout Rate 2016	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$ 187,346	$ 64,179	$ 281,312	$ 532,838	Line 4 times Line 5
7 Total Peformance Incentives at target	$ 576,084	$ 177,372	$ 620,475	$ 1,373,931	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Eversource
Savings	67.5%	63.8%	54.7%	61.2%
Value	32.5%	36.2%	45.3%	38.8%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2017

Eversource	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits	$ 58,010,045	$ 17,139,362	$ 50,249,648	$ 125,399,054	Gas Input, Lines 2-4
2 Savings Payout Rate 2017	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$ 390,038	$ 115,239	$ 337,860	$ 843,138	Line 1 times Line 2
4 Forecasted Net Benefits	$ 21,787,258	$ 7,791,421	$ 32,869,852	$ 62,448,531	Gas Input, Lines 14-16
5 Value Payout Rate 2017	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$ 185,056	$ 66,179	$ 279,190	$ 530,425	Line 4 times Line 5
7 Total Peformance Incentives at target	$ 575,095	$ 181,418	$ 617,050	$ 1,373,563	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Eversource
Savings	67.8%	63.5%	54.8%	61.4%
Value	32.2%	36.5%	45.2%	38.6%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2018

Eversource	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits	$ 59,587,313	$ 17,757,997	$ 50,705,817	$ 128,051,127	Gas Input, Lines 2-4
2 Savings Payout Rate 2018	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$ 400,643	$ 119,398	$ 340,927	$ 860,969	Line 1 times Line 2
4 Forecasted Net Benefits	$ 22,602,787	$ 8,202,526	$ 32,600,619	$ 63,405,933	Gas Input, Lines 14-16
5 Value Payout Rate 2018	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$ 191,983	$ 69,671	$ 276,903	$ 538,557	Line 4 times Line 5
7 Total Peformance Incentives at target	$ 592,627	$ 189,069	$ 617,830	$ 1,399,526	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Eversource
Savings	67.6%	63.2%	55.2%	61.5%
Value	32.4%	36.8%	44.8%	38.5%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2016 - 2018

Eversource	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits	$ 175,414,009	$ 51,732,435	$ 151,398,795	$ 378,545,239	Gas Input, Lines 2-4
2 Savings Payout Rate 2016 - 2018	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$ 1,179,420	$ 347,830	$ 1,017,950	$ 2,545,200	Line 1 times Line 2
4 Forecasted Net Benefits	$ 66,446,897	$ 23,549,969	$ 98,590,186	$ 188,587,052	Gas Input, Lines 14-16
5 Value Payout Rate 2016 - 2018	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$ 564,386	$ 200,029	$ 837,405	$ 1,601,820	Line 4 times Line 5
7 Total Peformance Incentives at target	$ 1,743,806	$ 547,859	$ 1,855,355	$ 4,147,020	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Eversource
Savings	67.6%	63.5%	54.9%	61.4%
Value	32.4%	36.5%	45.1%	38.6%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2016

Columbia	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits	$ 66,575,024	$ 11,051,359	$ 29,958,031	$ 107,584,414	Gas Input, Lines 2-4
2 Savings Payout Rate 2016	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$ 447,626	$ 74,305	$ 201,427	$ 723,358	Line 1 times Line 2
4 Forecasted Net Benefits	$ 46,082,738	$ 3,875,566	$ 22,372,135	$ 72,330,440	Gas Input, Lines 14-16
5 Value Payout Rate 2016	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$ 391,417	$ 32,918	$ 190,024	$ 614,360	Line 4 times Line 5
7 Total Peformance Incentives at target	$ 839,043	$ 107,224	$ 391,451	$ 1,337,718	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Columbia
Savings	53.3%	69.3%	51.5%	54.1%
Value	46.7%	30.7%	48.5%	45.9%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2017

Columbia	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits	$ 66,704,532	$ 10,884,164	$ 29,491,100	$ 107,079,796	Gas Input, Lines 2-4
2 Savings Payout Rate 2017	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$ 448,497	$ 73,181	$ 198,287	$ 719,966	Line 1 times Line 2
4 Forecasted Net Benefits	$ 47,196,261	$ 3,909,777	$ 22,373,306	$ 73,479,343	Gas Input, Lines 14-16
5 Value Payout Rate 2017	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$ 400,875	$ 33,209	$ 190,034	$ 624,118	Line 4 times Line 5
7 Total Peformance Incentives at target	$ 849,372	$ 106,390	$ 388,322	$ 1,344,084	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Columbia
Savings	52.8%	68.8%	51.1%	53.6%
Value	47.2%	31.2%	48.9%	46.4%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2018

Columbia	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits	$ 67,837,626	$ 10,871,350	$ 29,394,753	$ 108,103,729	Gas Input, Lines 2-4
2 Savings Payout Rate 2018	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$ 456,115	$ 73,095	$ 197,640	$ 726,850	Line 1 times Line 2
4 Forecasted Net Benefits	$ 48,583,952	$ 3,903,543	$ 22,336,503	$ 74,823,998	Gas Input, Lines 14-16
5 Value Payout Rate 2018	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$ 412,662	$ 33,156	$ 189,722	$ 635,540	Line 4 times Line 5
7 Total Peformance Incentives at target	$ 868,778	$ 106,251	$ 387,361	$ 1,362,390	Line 3 + Line 6

<u>Results</u>

Sector	Residential	Low Income	C&I	Total Columbia
Savings	52.5%	68.8%	51.0%	53.4%
Value	47.5%	31.2%	49.0%	46.6%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2016 - 2018

Columbia	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits	$ 201,117,182	$ 32,806,874	$ 88,843,884	$ 322,767,940	Gas Input, Lines 2-4
2 Savings Payout Rate 2016 - 2018	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$ 1,352,239	$ 220,581	$ 597,354	$ 2,170,174	Line 1 times Line 2
4 Forecasted Net Benefits	$ 141,862,951	$ 11,688,886	$ 67,081,944	$ 220,633,780	Gas Input, Lines 14-16
5 Value Payout Rate 2016 - 2018	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$ 1,204,955	$ 99,283	$ 569,780	$ 1,874,018	Line 4 times Line 5
7 Total Peformance Incentives at target	$ 2,557,193	$ 319,864	$ 1,167,134	$ 4,044,192	Line 3 + Line 6

<u>Results</u>

Sector	Residential	Low Income	C&I	Total Columbia
Savings	52.9%	69.0%	51.2%	53.7%
Value	47.1%	31.0%	48.8%	46.3%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2016

Unitil	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits	$ 2,430,533	$ 819,196	$ 2,380,642	$ 5,630,371	Gas Input, Lines 2-4
2 Savings Payout Rate 2016	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$ 16,342	$ 5,508	$ 16,007	$ 37,857	Line 1 times Line 2
4 Forecasted Net Benefits	$ 1,357,154	$ 348,446	$ 1,788,500	$ 3,494,100	Gas Input, Lines 14-16
5 Value Payout Rate 2016	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$ 11,527	$ 2,960	$ 15,191	$ 29,678	Line 4 times Line 5
7 Total Peformance Incentives at target	$ 27,869	$ 8,468	$ 31,198	$ 67,535	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Unitil
Savings	58.6%	65.0%	51.3%	56.1%
Value	41.4%	35.0%	48.7%	43.9%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2017

Unitil	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits	$ 2,480,462	$ 855,930	$ 2,370,424	$ 5,706,816	Gas Input, Lines 2-4
2 Savings Payout Rate 2017	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$ 16,678	$ 5,755	$ 15,938	$ 38,371	Line 1 times Line 2
4 Forecasted Net Benefits	$ 1,413,044	$ 386,884	$ 1,781,030	$ 3,580,958	Gas Input, Lines 14-16
5 Value Payout Rate 2017	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$ 12,002	$ 3,286	$ 15,128	$ 30,416	Line 4 times Line 5
7 Total Peformance Incentives at target	$ 28,680	$ 9,041	$ 31,066	$ 68,786	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Unitil
Savings	58.2%	63.7%	51.3%	55.8%
Value	41.8%	36.3%	48.7%	44.2%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2018

Unitil	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits	$ 2,555,995	$ 873,871	$ 2,415,387	$ 5,845,253	Gas Input, Lines 2-4
2 Savings Payout Rate 2018	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$ 17,186	$ 5,876	$ 16,240	$ 39,301	Line 1 times Line 2
4 Forecasted Net Benefits	$ 1,493,268	$ 407,776	$ 1,828,189	$ 3,729,233	Gas Input, Lines 14-16
5 Value Payout Rate 2018	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$ 12,684	$ 3,464	$ 15,528	$ 31,675	Line 4 times Line 5
7 Total Peformance Incentives at target	$ 29,869	$ 9,339	$ 31,768	$ 70,977	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Unitil
Savings	57.5%	62.9%	51.1%	55.4%
Value	42.5%	37.1%	48.9%	44.6%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2016 - 2018

Unitil	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits	$ 7,466,990	$ 2,548,997	$ 7,166,453	$ 17,182,440	Gas Input, Lines 2-4
2 Savings Payout Rate 2016 - 2018	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$ 50,205	$ 17,139	$ 48,185	$ 115,528	Line 1 times Line 2
4 Forecasted Net Benefits	$ 4,263,466	$ 1,143,106	$ 5,397,719	$ 10,804,291	Gas Input, Lines 14-16
5 Value Payout Rate 2016 - 2018	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$ 36,213	$ 9,709	$ 45,847	$ 91,769	Line 4 times Line 5
7 Total Peformance Incentives at target	$ 86,418	$ 26,848	$ 94,032	$ 207,298	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Unitil
Savings	58.1%	63.8%	51.2%	55.7%
Value	41.9%	36.2%	48.8%	44.3%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2016

Berkshire		Residential		Low Income		C&I		Total	Comment
1 Forecasted Benefits	$	6,596,210	$	1,475,886	$	5,140,619	$	13,212,714	Gas Input, Lines 2-4
2 Savings Payout Rate 2016		0.0067236		0.0067236		0.0067236		0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$	44,351	$	9,923	$	34,564	$	88,837	Line 1 times Line 2
4 Forecasted Net Benefits	$	2,103,136	$	525,134	$	3,171,668	$	5,799,939	Gas Input, Lines 14-16
5 Value Payout Rate 2016		0.0084938		0.0084938		0.0084938		0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$	17,864	$	4,460	$	26,939	$	49,263	Line 4 times Line 5
7 Total Peformance Incentives at target	$	62,214	$	14,384	$	61,503	$	138,101	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Berkshire
Savings	71.3%	69.0%	56.2%	64.3%
Value	28.7%	31.0%	43.8%	35.7%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2017

Berkshire		Residential		Low Income		C&I		Total	Comment
1 Forecasted Benefits	$	4,755,556	$	1,469,324	$	5,092,897	$	11,317,777	Gas Input, Lines 2-4
2 Savings Payout Rate 2017		0.0067236		0.0067236		0.0067236		0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$	31,975	$	9,879	$	34,243	$	76,097	Line 1 times Line 2
4 Forecasted Net Benefits	$	1,315,926	$	538,609	$	3,166,589	$	5,021,123	Gas Input, Lines 14-16
5 Value Payout Rate 2017		0.0084938		0.0084938		0.0084938		0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$	11,177	$	4,575	$	26,896	$	42,648	Line 4 times Line 5
7 Total Peformance Incentives at target	$	43,152	$	14,454	$	61,139	$	118,745	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Berkshire
Savings	74.1%	68.3%	56.0%	64.1%
Value	25.9%	31.7%	44.0%	35.9%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2018

Berkshire	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits	$ 4,812,779	$ 1,467,793	$ 5,090,684	$ 11,371,255	Gas Input, Lines 2-4
2 Savings Payout Rate 2018	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$ 32,359	$ 9,869	$ 34,228	$ 76,456	Line 1 times Line 2
4 Forecasted Net Benefits	$ 1,383,374	$ 557,396	$ 3,206,656	$ 5,147,426	Gas Input, Lines 14-16
5 Value Payout Rate 2018	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$ 11,750	$ 4,734	$ 27,237	$ 43,721	Line 4 times Line 5
7 Total Peformance Incentives at target	$ 44,109	$ 14,603	$ 61,465	$ 120,177	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Berkshire
Savings	73.4%	67.6%	55.7%	63.6%
Value	26.6%	32.4%	44.3%	36.4%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2016 - 2018

Berkshire	Residential	Low Income	C&I	Total	Comment
1 Forecasted Benefits	$ 16,164,545	$ 4,413,002	$ 15,324,199	$ 35,901,746	Gas Input, Lines 2-4
2 Savings Payout Rate 2016 - 2018	0.0067236	0.0067236	0.0067236	0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$ 108,685	$ 29,671	$ 103,034	$ 241,390	Line 1 times Line 2
4 Forecasted Net Benefits	$ 4,802,436	$ 1,621,138	$ 9,544,913	$ 15,968,488	Gas Input, Lines 14-16
5 Value Payout Rate 2016 - 2018	0.0084938	0.0084938	0.0084938	0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$ 40,791	$ 13,770	$ 81,073	$ 135,633	Line 4 times Line 5
7 Total Peformance Incentives at target	$ 149,475	$ 43,441	$ 184,107	$ 377,023	Line 3 + Line 6

Results

Sector	Residential	Low Income	C&I	Total Berkshire
Savings	72.7%	68.3%	56.0%	64.0%
Value	27.3%	31.7%	44.0%	36.0%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2016

Liberty		Residential		Low Income		C&I		Total	Comment
1 Forecasted Benefits	$	4,677,290	$	1,279,006	$	2,554,176	$	8,510,473	Gas Input, Lines 2-4
2 Savings Payout Rate 2016		0.0067236		0.0067236		0.0067236		0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$	31,448	$	8,600	$	17,173	$	57,221	Line 1 times Line 2
4 Forecasted Net Benefits	$	2,000,203	$	366,323	$	1,349,035	$	3,715,561	Gas Input, Lines 14-16
5 Value Payout Rate 2016		0.0084938		0.0084938		0.0084938		0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$	16,989	$	3,111	$	11,458	$	31,559	Line 4 times Line 5
7 Total Peformance Incentives at target	$	48,438	$	11,711	$	28,632	$	88,781	Line 3 + Line 6

<u>Results</u>

Sector	Residential	Low Income	C&I	Total Liberty
Savings	64.9%	73.4%	60.0%	64.5%
Value	35.1%	26.6%	40.0%	35.5%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2017

Liberty		Residential		Low Income		C&I		Total	Comment
1 Forecasted Benefits	$	4,622,384	$	1,270,801	$	2,683,625	$	8,576,810	Gas Input, Lines 2-4
2 Savings Payout Rate 2017		0.0067236		0.0067236		0.0067236		0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$	31,079	$	8,544	$	18,044	$	57,667	Line 1 times Line 2
4 Forecasted Net Benefits	$	2,034,008	$	394,140	$	1,485,743	$	3,913,892	Gas Input, Lines 14-16
5 Value Payout Rate 2017		0.0084938		0.0084938		0.0084938		0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$	17,276	$	3,348	$	12,620	$	33,244	Line 4 times Line 5
7 Total Peformance Incentives at target	$	48,356	$	11,892	$	30,663	$	90,911	Line 3 + Line 6

<u>Results</u>

Sector	Residential	Low Income	C&I	Total Liberty
Savings	64.3%	71.8%	58.8%	63.4%
Value	35.7%	28.2%	41.2%	36.6%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2018

Liberty		Residential		Low Income		C&I		Total	Comment
1 Forecasted Benefits	$	4,697,753	$	1,264,648	$	2,647,650	$	8,610,050	Gas Input, Lines 2-4
2 Savings Payout Rate 2018		0.0067236		0.0067236		0.0067236		0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$	31,586	$	8,503	$	17,802	$	57,891	Line 1 times Line 2
4 Forecasted Net Benefits	$	2,159,935	$	405,086	$	1,348,248	$	3,913,268	Gas Input, Lines 14-16
5 Value Payout Rate 2018		0.0084938		0.0084938		0.0084938		0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$	18,346	$	3,441	$	11,452	$	33,238	Line 4 times Line 5
7 Total Peformance Incentives at target	$	49,932	$	11,944	$	29,254	$	91,129	Line 3 + Line 6

<u>Results</u>

Sector	Residential	Low Income	C&I	Total Liberty
Savings	63.3%	71.2%	60.9%	63.5%
Value	36.7%	28.8%	39.1%	36.5%
Total	100.0%	100.0%	100.0%	100.0%

2016 - 2018 Energy Effiency Performance Incentives
Derivation of Gas Targets 2016 - 2018

Liberty		Residential		Low Income		C&I		Total	Comment
1 Forecasted Benefits	$	13,997,426	$	3,814,455	$	7,885,451	$	25,697,332	Gas Input, Lines 2-4
2 Savings Payout Rate 2016 - 2018		0.0067236		0.0067236		0.0067236		0.0067236	Pef Met Pool, Line 8
3 Forecasted Savings Incentives	$	94,114	$	25,647	$	53,019	$	172,780	Line 1 times Line 2
4 Forecasted Net Benefits	$	6,194,145	$	1,165,549	$	4,183,026	$	11,542,720	Gas Input, Lines 14-16
5 Value Payout Rate 2016 - 2018		0.0084938		0.0084938		0.0084938		0.0084938	Pef Met Pool, Line 12
6 Forecasted Value Incentives	$	52,612	$	9,900	$	35,530	$	98,041	Line 4 times Line 5
7 Total Peformance Incentives at target	$	146,725	$	35,547	$	88,549	$	270,821	Line 3 + Line 6

<u>Results</u>

Sector	Residential	Low Income	C&I	Total Liberty
Savings	64.1%	72.1%	59.9%	63.8%
Value	35.9%	27.9%	40.1%	36.2%
Total	100.0%	100.0%	100.0%	100.0%

2016 Energy Efficiency Performance Incentives
Summary of Performance Incentives by Sector and Incentive Type
Assuming Design Level Performance Incentive

In 2016 dollars

		Residential	Low Income	C&I	Total
	State	Residential	Low Income	C&I	Total
1	Savings	2,042,357	525,182	1,104,304	3,671,843
2	Value	1,108,513	283,511	904,796	2,296,820
3	Total	3,150,870	808,693	2,009,100	5,968,662
	National Grid	Residential	Low Income	C&I	Total
4	Savings	1,113,852	313,653	495,971	1,923,475
5	Value	483,369	175,882	379,871	1,039,121
6	Total	1,597,221	489,535	875,841	2,962,597
	Eversource	Residential	Low Income	C&I	Total
7	Savings	388,738	113,193	339,163	841,094
8	Value	187,346	64,179	281,312	532,838
9	Total	576,084	177,372	620,475	1,373,931
	Columbia	Residential	Low Income	C&I	Total
10	Savings	447,626	74,305	201,427	723,358
11	Value	391,417	32,918	190,024	614,360
12	Total	839,043	107,224	391,451	1,337,718
	Unitil	Residential	Low Income	C&I	Total
13	Savings	16,342	5,508	16,007	37,857
14	Value	11,527	2,960	15,191	29,678
15	Total	27,869	8,468	31,198	67,535
	Berkshire	Residential	Low Income	C&I	Total
16	Savings	44,351	9,923	34,564	88,837
17	Value	17,864	4,460	26,939	49,263
18	Total	62,214	14,384	61,503	138,101
	Liberty	Residential	Low Income	C&I	Total
19	Savings	31,448	8,600	17,173	57,221
20	Value	16,989	3,111	11,458	31,559
21	Total	48,438	11,711	28,632	88,781

Percent of Total Incentive

	Residential	Low Income	C&I	Total
State	Residential	Low Income	C&I	Total
Savings	34.2%	8.8%	18.5%	61.5%
Value	18.6%	4.7%	15.2%	38.5%
Total	52.8%	13.5%	33.7%	100.0%
National Grid	Residential	Low Income	C&I	Total
Savings	37.6%	10.6%	16.7%	64.9%
Value	16.3%	5.9%	12.8%	35.1%
Total	53.9%	16.5%	29.6%	100.0%
EverSource	Residential	Low Income	C&I	Total
Savings	28.3%	8.2%	24.7%	61.2%
Value	13.6%	4.7%	20.5%	38.8%
Total	41.9%	12.9%	45.2%	100.0%
Columbia	Residential	Low Income	C&I	Total
Savings	33.5%	5.6%	15.1%	54.1%
Value	29.3%	2.5%	14.2%	45.9%
Total	62.7%	8.0%	29.3%	100.0%
Unitil	Residential	Low Income	C&I	Total
Savings	24.2%	8.2%	23.7%	56.1%
Value	17.1%	4.4%	22.5%	43.9%
Total	41.3%	12.5%	46.2%	100.0%
Berkshire	Residential	Low Income	C&I	Total
Savings	32.1%	7.2%	25.0%	64.3%
Value	12.9%	3.2%	19.5%	35.7%
Total	45.0%	10.4%	44.5%	100.0%
Liberty	Residential	Low Income	C&I	Total
Savings	35.4%	9.7%	19.3%	64.5%
Value	19.1%	3.5%	12.9%	35.5%
Total	54.6%	13.2%	32.3%	100.0%

2017 Energy Efficiency Performance Incentives
Summary of Performance Incentives by Sector and Incentive Type
Assuming Design Level Performance Incentive

	In 2016 dollars					Percent of Total Incentive				
	State	Residential	Low Income	C&I	Total	**State**	Residential	Low Income	C&I	Total
1	Savings	2,042,134	524,452	1,098,234	3,664,820	Savings	34.3%	8.8%	18.4%	61.6%
2	Value	1,099,299	289,162	899,502	2,287,963	Value	18.5%	4.9%	15.1%	38.4%
3	Total	3,141,433	813,614	1,997,736	5,952,784	Total	52.8%	13.7%	33.6%	100.0%
	National Grid	Residential	Low Income	C&I	Total	**National Grid**	Residential	Low Income	C&I	Total
4	Savings	1,123,867	311,854	493,862	1,929,583	Savings	38.0%	10.5%	16.7%	65.3%
5	Value	472,911	178,566	375,635	1,027,112	Value	16.0%	6.0%	12.7%	34.7%
6	Total	1,596,779	490,420	869,496	2,956,695	Total	54.0%	16.6%	29.4%	100.0%
	Eversource	Residential	Low Income	C&I	Total	**EverSource**	Residential	Low Income	C&I	Total
7	Savings	390,038	115,239	337,860	843,138	Savings	28.4%	8.4%	24.6%	61.4%
8	Value	185,056	66,179	279,190	530,425	Value	13.5%	4.8%	20.3%	38.6%
9	Total	575,095	181,418	617,050	1,373,563	Total	41.9%	13.2%	44.9%	100.0%
	Columbia	Residential	Low Income	C&I	Total	**Columbia**	Residential	Low Income	C&I	Total
10	Savings	448,497	73,181	198,287	719,966	Savings	33.4%	5.4%	14.8%	53.6%
11	Value	400,875	33,209	190,034	624,118	Value	29.8%	2.5%	14.1%	46.4%
12	Total	849,372	106,390	388,322	1,344,084	Total	63.2%	7.9%	28.9%	100.0%
	Unitil	Residential	Low Income	C&I	Total	**Unitil**	Residential	Low Income	C&I	Total
13	Savings	16,678	5,755	15,938	38,371	Savings	24.2%	8.4%	23.2%	55.8%
14	Value	12,002	3,286	15,128	30,416	Value	17.4%	4.8%	22.0%	44.2%
15	Total	28,680	9,041	31,066	68,786	Total	41.7%	13.1%	45.2%	100.0%
	Berkshire	Residential	Low Income	C&I	Total	**Berkshire**	Residential	Low Income	C&I	Total
16	Savings	31,975	9,879	34,243	76,097	Savings	26.9%	8.3%	28.8%	64.1%
17	Value	11,177	4,575	26,896	42,648	Value	9.4%	3.9%	22.7%	35.9%
18	Total	43,152	14,454	61,139	118,745	Total	36.3%	12.2%	51.5%	100.0%
	Liberty	Residential	Low Income	C&I	Total	**Liberty**	Residential	Low Income	C&I	Total
19	Savings	31,079	8,544	18,044	57,667	Savings	34.2%	9.4%	19.8%	63.4%
20	Value	17,276	3,348	12,620	33,244	Value	19.0%	3.7%	13.9%	36.6%
21	Total	48,356	11,892	30,663	90,911	Total	53.2%	13.1%	33.7%	100.0%

2018 Energy Efficiency Performance Incentives
Summary of Performance Incentives by Sector and Incentive Type
Assuming Design Level Performance Incentive

	In 2016 dollars					Percent of Total Incentive				
	State	Residential	Low Income	C&I	Total	**State**	Residential	Low Income	C&I	Total
1	Savings	2,092,709	528,157	1,112,471	3,733,337	Savings	34.4%	8.7%	18.3%	61.4%
2	Value	1,141,596	297,836	905,785	2,345,217	Value	18.8%	4.9%	14.9%	38.6%
3	Total	3,234,305	825,993	2,018,256	6,078,554	Total	53.2%	13.6%	33.2%	100.0%
	National Grid	Residential	Low Income	C&I	Total	**National Grid**	Residential	Low Income	C&I	Total
4	Savings	1,154,819	311,416	505,634	1,971,869	Savings	38.1%	10.3%	16.7%	65.0%
5	Value	494,171	183,371	384,944	1,062,485	Value	16.3%	6.0%	12.7%	35.0%
6	Total	1,648,990	494,787	890,577	3,034,355	Total	54.3%	16.3%	29.3%	100.0%
	Eversource	Residential	Low Income	C&I	Total	**EverSource**	Residential	Low Income	C&I	Total
7	Savings	400,643	119,398	340,927	860,969	Savings	28.6%	8.5%	24.4%	61.5%
8	Value	191,983	69,671	276,903	538,557	Value	13.7%	5.0%	19.8%	38.5%
9	Total	592,627	189,069	617,830	1,399,526	Total	42.3%	13.5%	44.1%	100.0%
	Columbia	Residential	Low Income	C&I	Total	**Columbia**	Residential	Low Income	C&I	Total
10	Savings	456,115	73,095	197,640	726,850	Savings	33.5%	5.4%	14.5%	53.4%
11	Value	412,662	33,156	189,722	635,540	Value	30.3%	2.4%	13.9%	46.6%
12	Total	868,778	106,251	387,361	1,362,390	Total	63.8%	7.8%	28.4%	100.0%
	Unitil	Residential	Low Income	C&I	Total	**Unitil**	Residential	Low Income	C&I	Total
13	Savings	17,186	5,876	16,240	39,301	Savings	24.2%	8.3%	22.9%	55.4%
14	Value	12,684	3,464	15,528	31,675	Value	17.9%	4.9%	21.9%	44.6%
15	Total	29,869	9,339	31,768	70,977	Total	42.1%	13.2%	44.8%	100.0%
	Berkshire	Residential	Low Income	C&I	Total	**Berkshire**	Residential	Low Income	C&I	Total
16	Savings	32,359	9,869	34,228	76,456	Savings	26.9%	8.2%	28.5%	63.6%
17	Value	11,750	4,734	27,237	43,721	Value	9.8%	3.9%	22.7%	36.4%
18	Total	44,109	14,603	61,465	120,177	Total	36.7%	12.2%	51.1%	100.0%
	Liberty	Residential	Low Income	C&I	Total	**Liberty**	Residential	Low Income	C&I	Total
19	Savings	31,586	8,503	17,802	57,891	Savings	34.7%	9.3%	19.5%	63.5%
20	Value	18,346	3,441	11,452	33,238	Value	20.1%	3.8%	12.6%	36.5%
21	Total	49,932	11,944	29,254	91,129	Total	54.8%	13.1%	32.1%	100.0%

2016 - 2018 Energy Efficiency Performance Incentives
Summary of Performance Incentives by Sector and Incentive Type
Assuming Design Level Performance Incentive

	In 2016 dollars					**Percent of Total Incentive**				
	State	Residential	Low Income	C&I	Total	**State**	Residential	Low Income	C&I	Total
1	Savings	6,177,200	1,577,791	3,315,008	11,070,000	Savings	34.3%	8.8%	18.4%	61.5%
2	Value	3,349,408	870,509	2,710,083	6,930,000	Value	18.6%	4.8%	15.1%	38.5%
3	Total	9,526,608	2,448,300	6,025,092	18,000,000	Total	52.9%	13.6%	33.5%	100.0%
	National Grid	Residential	Low Income	C&I	Total	**National Grid**	Residential	Low Income	C&I	Total
4	Savings	3,392,538	936,923	1,495,466	5,824,927	Savings	37.9%	10.5%	16.7%	65.1%
5	Value	1,450,451	537,819	1,140,449	3,128,719	Value	16.2%	6.0%	12.7%	34.9%
6	Total	4,842,989	1,474,742	2,635,915	8,953,646	Total	54.1%	16.5%	29.4%	100.0%
	Eversource	Residential	Low Income	C&I	Total	**EverSource**	Residential	Low Income	C&I	Total
7	Savings	1,179,420	347,830	1,017,950	2,545,200	Savings	28.4%	8.4%	24.5%	61.4%
8	Value	564,386	200,029	837,405	1,601,820	Value	13.6%	4.8%	20.2%	38.6%
9	Total	1,743,806	547,859	1,855,355	4,147,020	Total	42.0%	13.2%	44.7%	100.0%
	Columbia	Residential	Low Income	C&I	Total	**Columbia**	Residential	Low Income	C&I	Total
10	Savings	1,352,239	220,581	597,354	2,170,174	Savings	33.4%	5.5%	14.8%	53.7%
11	Value	1,204,955	99,283	569,780	1,874,018	Value	29.8%	2.5%	14.1%	46.3%
12	Total	2,557,193	319,864	1,167,134	4,044,192	Total	63.2%	7.9%	28.9%	100.0%
	Unitil	Residential	Low Income	C&I	Total	**Unitil**	Residential	Low Income	C&I	Total
13	Savings	50,205	17,139	48,185	115,528	Savings	24.2%	8.3%	23.2%	55.7%
14	Value	36,213	9,709	45,847	91,769	Value	17.5%	4.7%	22.1%	44.3%
15	Total	86,418	26,848	94,032	207,298	Total	41.7%	13.0%	45.4%	100.0%
	Berkshire	Residential	Low Income	C&I	Total	**Berkshire**	Residential	Low Income	C&I	Total
16	Savings	108,685	29,671	103,034	241,390	Savings	28.8%	7.9%	27.3%	64.0%
17	Value	40,791	13,770	81,073	135,633	Value	10.8%	3.7%	21.5%	36.0%
18	Total	149,475	43,441	184,107	377,023	Total	39.6%	11.5%	48.8%	100.0%
	Liberty	Residential	Low Income	C&I	Total	**Liberty**	Residential	Low Income	C&I	Total
19	Savings	94,114	25,647	53,019	172,780	Savings	34.8%	9.5%	19.6%	63.8%
20	Value	52,612	9,900	35,530	98,041	Value	19.4%	3.7%	13.1%	36.2%
21	Total	146,725	35,547	88,549	270,821	Total	54.2%	13.1%	32.7%	100.0%

Discount Rate: 2.54%

2016 Energy Efficiency Performance Incentives
Summary of Performance Incentives by Sector and Incentive Type
Assuming Design Level Performance Incentive

	In 2016 dollars					**Percent of Total Incentive**				
	State	Residential	Low Income	C&I	Total	**State**	Residential	Low Income	C&I	Total
1	Savings	2,042,357	525,182	1,104,304	3,671,843	Savings	34.2%	8.8%	18.5%	61.5%
2	Value	1,108,513	283,511	904,796	2,296,820	Value	18.6%	4.7%	15.2%	38.5%
3	Total	3,150,870	808,693	2,009,100	5,968,662	Total	52.8%	13.5%	33.7%	100.0%
	National Grid	Residential	Low Income	C&I	Total	**National Grid**	Residential	Low Income	C&I	Total
4	Savings	1,113,852	313,653	495,971	1,923,475	Savings	37.6%	10.6%	16.7%	64.9%
5	Value	483,369	175,882	379,871	1,039,121	Value	16.3%	5.9%	12.8%	35.1%
6	Total	1,597,221	489,535	875,841	2,962,597	Total	53.9%	16.5%	29.6%	100.0%
	Eversource	Residential	Low Income	C&I	Total	**EverSource**	Residential	Low Income	C&I	Total
7	Savings	388,738	113,193	339,163	841,094	Savings	28.3%	8.2%	24.7%	61.2%
8	Value	187,346	64,179	281,312	532,838	Value	13.6%	4.7%	20.5%	38.8%
9	Total	576,084	177,372	620,475	1,373,931	Total	41.9%	12.9%	45.2%	100.0%
	Columbia	Residential	Low Income	C&I	Total	**Columbia**	Residential	Low Income	C&I	Total
10	Savings	447,626	74,305	201,427	723,358	Savings	33.5%	5.6%	15.1%	54.1%
11	Value	391,417	32,918	190,024	614,360	Value	29.3%	2.5%	14.2%	45.9%
12	Total	839,043	107,224	391,451	1,337,718	Total	62.7%	8.0%	29.3%	100.0%
	Unitil	Residential	Low Income	C&I	Total	**Unitil**	Residential	Low Income	C&I	Total
13	Savings	16,342	5,508	16,007	37,857	Savings	24.2%	8.2%	23.7%	56.1%
14	Value	11,527	2,960	15,191	29,678	Value	17.1%	4.4%	22.5%	43.9%
15	Total	27,869	8,468	31,198	67,535	Total	41.3%	12.5%	46.2%	100.0%
	Berkshire	Residential	Low Income	C&I	Total	**Berkshire**	Residential	Low Income	C&I	Total
16	Savings	44,351	9,923	34,564	88,837	Savings	32.1%	7.2%	25.0%	64.3%
17	Value	17,864	4,460	26,939	49,263	Value	12.9%	3.2%	19.5%	35.7%
18	Total	62,214	14,384	61,503	138,101	Total	45.0%	10.4%	44.5%	100.0%
	Liberty	Residential	Low Income	C&I	Total	**Liberty**	Residential	Low Income	C&I	Total
19	Savings	31,448	8,600	17,173	57,221	Savings	35.4%	9.7%	19.3%	64.5%
20	Value	16,989	3,111	11,458	31,559	Value	19.1%	3.5%	12.9%	35.5%
21	Total	48,438	11,711	28,632	88,781	Total	54.6%	13.2%	32.3%	100.0%

2017 Energy Efficiency Performance Incentives
Summary of Performance Incentives by Sector and Incentive Type
Assuming Design Level Performance Incentive

In 2017 Dollars

		Residential	Low Income	C&I	Total
	State	Residential	Low Income	C&I	Total
1	Savings	2,094,004	537,773	1,126,129	3,757,907
2	Value	1,127,221	296,507	922,350	2,346,078
3	Total	3,221,225	834,280	2,048,479	6,103,984
	National Grid	Residential	Low Income	C&I	Total
4	Savings	1,152,413	319,775	506,406	1,978,594
5	Value	484,923	183,102	385,176	1,053,201
6	Total	1,637,337	502,876	891,582	3,031,795
	Eversource	Residential	Low Income	C&I	Total
7	Savings	399,945	118,166	346,442	864,553
8	Value	189,757	67,860	286,281	543,898
9	Total	589,702	186,026	632,723	1,408,451
	Columbia	Residential	Low Income	C&I	Total
10	Savings	459,889	75,040	203,324	738,253
11	Value	411,058	34,052	194,861	639,971
12	Total	870,946	109,092	398,185	1,378,224
	Unitil	Residential	Low Income	C&I	Total
13	Savings	17,101	5,901	16,343	39,345
14	Value	12,307	3,370	15,512	31,188
15	Total	29,408	9,271	31,855	70,534
	Berkshire	Residential	Low Income	C&I	Total
16	Savings	32,787	10,130	35,113	78,029
17	Value	11,461	4,691	27,580	43,732
18	Total	44,248	14,821	62,692	121,761
	Liberty	Residential	Low Income	C&I	Total
19	Savings	31,869	8,761	18,502	59,132
20	Value	17,715	3,433	12,940	34,088
21	Total	49,584	12,194	31,442	93,220

Percent of Total Incentive

	Residential	Low Income	C&I	Total
State	Residential	Low Income	C&I	Total
Savings	34.3%	8.8%	18.4%	61.6%
Value	18.5%	4.9%	15.1%	38.4%
Total	52.8%	13.7%	33.6%	100.0%
National Grid	Residential	Low Income	C&I	Total
Savings	38.0%	10.5%	16.7%	65.3%
Value	16.0%	6.0%	12.7%	34.7%
Total	54.0%	16.6%	29.4%	100.0%
EverSource	Residential	Low Income	C&I	Total
Savings	28.4%	8.4%	24.6%	61.4%
Value	13.5%	4.8%	20.3%	38.6%
Total	41.9%	13.2%	44.9%	100.0%
Columbia	Residential	Low Income	C&I	Total
Savings	33.4%	5.4%	14.8%	53.6%
Value	29.8%	2.5%	14.1%	46.4%
Total	63.2%	7.9%	28.9%	100.0%
Unitil	Residential	Low Income	C&I	Total
Savings	24.2%	8.4%	23.2%	55.8%
Value	17.4%	4.8%	22.0%	44.2%
Total	41.7%	13.1%	45.2%	100.0%
Berkshire	Residential	Low Income	C&I	Total
Savings	26.9%	8.3%	28.8%	64.1%
Value	9.4%	3.9%	22.7%	35.9%
Total	36.3%	12.2%	51.5%	100.0%
Liberty	Residential	Low Income	C&I	Total
Savings	34.2%	9.4%	19.8%	63.4%
Value	19.0%	3.7%	13.9%	36.6%
Total	53.2%	13.1%	33.7%	100.0%

2018 Energy Efficiency Performance Incentives
Summary of Performance Incentives by Sector and Incentive Type
Assuming Design Level Performance Incentive

	In 2018 Dollars					**Percent of Total Incentive**				
	State	Residential	Low Income	C&I	Total	**State**	Residential	Low Income	C&I	Total
1	Savings	2,200,369	555,328	1,169,702	3,925,399	Savings	34.4%	8.7%	18.3%	61.4%
2	Value	1,200,325	313,158	952,383	2,465,867	Value	18.8%	4.9%	14.9%	38.6%
3	Total	3,400,695	868,486	2,122,085	6,391,266	Total	53.2%	13.6%	33.2%	100.0%
	National Grid	Residential	Low Income	C&I	Total	**National Grid**	Residential	Low Income	C&I	Total
4	Savings	1,214,229	327,437	531,646	2,073,313	Savings	38.1%	10.3%	16.7%	65.0%
5	Value	519,593	192,804	404,747	1,117,145	Value	16.3%	6.0%	12.7%	35.0%
6	Total	1,733,823	520,241	936,393	3,190,458	Total	54.3%	16.3%	29.3%	100.0%
	Eversource	Residential	Low Income	C&I	Total	**EverSource**	Residential	Low Income	C&I	Total
7	Savings	421,255	125,541	358,467	905,262	Savings	28.6%	8.5%	24.4%	61.5%
8	Value	201,860	73,255	291,148	566,263	Value	13.7%	5.0%	19.8%	38.5%
9	Total	623,115	198,796	649,615	1,471,525	Total	42.3%	13.5%	44.1%	100.0%
	Columbia	Residential	Low Income	C&I	Total	**Columbia**	Residential	Low Income	C&I	Total
10	Savings	479,580	76,855	207,807	764,243	Savings	33.5%	5.4%	14.5%	53.4%
11	Value	433,892	34,862	199,482	668,235	Value	30.3%	2.4%	13.9%	46.6%
12	Total	913,472	111,717	407,289	1,432,478	Total	63.8%	7.8%	28.4%	100.0%
	Unitil	Residential	Low Income	C&I	Total	**Unitil**	Residential	Low Income	C&I	Total
13	Savings	18,070	6,178	17,076	41,323	Savings	24.2%	8.3%	22.9%	55.4%
14	Value	13,336	3,642	16,327	33,305	Value	17.9%	4.9%	21.9%	44.6%
15	Total	31,406	9,820	33,403	74,628	Total	42.1%	13.2%	44.8%	100.0%
	Berkshire	Residential	Low Income	C&I	Total	**Berkshire**	Residential	Low Income	C&I	Total
16	Savings	34,024	10,377	35,989	80,389	Savings	26.9%	8.2%	28.5%	63.6%
17	Value	12,355	4,978	28,638	45,970	Value	9.8%	3.9%	22.7%	36.4%
18	Total	46,379	15,355	64,627	126,360	Total	36.7%	12.2%	51.1%	100.0%
	Liberty	Residential	Low Income	C&I	Total	**Liberty**	Residential	Low Income	C&I	Total
19	Savings	33,211	8,940	18,718	60,869	Savings	34.7%	9.3%	19.5%	63.5%
20	Value	19,290	3,618	12,041	34,948	Value	20.1%	3.8%	12.6%	36.5%
21	Total	52,501	12,558	30,759	95,817	Total	54.8%	13.1%	32.1%	100.0%

2016 - 2018 Energy Efficiency Performance Incentives
Summary of Performance Incentives by Sector and Incentive Type
Assuming Design Level Performance Incentive

	In Current Year Dollars					**Percent of Total Incentive**				
	State	Residential	Low Income	C&I	Total	**State**	Residential	Low Income	C&I	Total
1	Savings	6,336,730	1,618,283	3,400,135	11,355,149	Savings	34.3%	8.8%	18.4%	61.5%
2	Value	3,436,059	893,176	2,779,529	7,108,764	Value	18.6%	4.8%	15.1%	38.5%
3	Total	9,772,790	2,511,460	6,179,664	18,463,913	Total	52.9%	13.6%	33.5%	100.0%
	National Grid	Residential	Low Income	C&I	Total	**National Grid**	Residential	Low Income	C&I	Total
4	Savings	3,480,494	960,865	1,534,023	5,975,382	Savings	37.9%	10.5%	16.7%	65.1%
5	Value	1,487,886	551,788	1,169,793	3,209,467	Value	16.2%	6.0%	12.7%	34.9%
6	Total	4,968,380	1,512,653	2,703,816	9,184,849	Total	54.1%	16.5%	29.4%	100.0%
	Eversource	Residential	Low Income	C&I	Total	**EverSource**	Residential	Low Income	C&I	Total
7	Savings	1,209,938	356,900	1,044,071	2,610,909	Savings	28.4%	8.4%	24.5%	61.4%
8	Value	578,963	205,294	858,741	1,642,998	Value	13.6%	4.8%	20.2%	38.6%
9	Total	1,788,901	562,193	1,902,813	4,253,907	Total	42.1%	13.2%	44.7%	100.0%
	Columbia	Residential	Low Income	C&I	Total	**Columbia**	Residential	Low Income	C&I	Total
10	Savings	1,387,095	226,201	612,558	2,225,854	Savings	33.4%	5.5%	14.8%	53.7%
11	Value	1,236,366	101,832	584,367	1,922,566	Value	29.8%	2.5%	14.1%	46.3%
12	Total	2,623,462	328,033	1,196,925	4,148,420	Total	63.2%	7.9%	28.9%	100.0%
	Unitil	Residential	Low Income	C&I	Total	**Unitil**	Residential	Low Income	C&I	Total
13	Savings	51,513	17,587	49,425	118,525	Savings	24.2%	8.3%	23.2%	55.7%
14	Value	37,170	9,971	47,030	94,172	Value	17.5%	4.7%	22.1%	44.3%
15	Total	88,683	27,558	96,455	212,696	Total	41.7%	13.0%	45.3%	100.0%
	Berkshire	Residential	Low Income	C&I	Total	**Berkshire**	Residential	Low Income	C&I	Total
16	Savings	111,161	30,430	105,665	247,256	Savings	28.8%	7.9%	27.4%	64.0%
17	Value	41,679	14,129	83,157	138,966	Value	10.8%	3.7%	21.5%	36.0%
18	Total	152,841	44,559	188,822	386,222	Total	39.6%	11.5%	48.9%	100.0%
	Liberty	Residential	Low Income	C&I	Total	**Liberty**	Residential	Low Income	C&I	Total
19	Savings	96,528	26,301	54,393	177,222	Savings	34.7%	9.5%	19.6%	63.8%
20	Value	53,994	10,162	36,439	100,596	Value	19.4%	3.7%	13.1%	36.2%
21	Total	150,522	36,463	90,832	277,818	Total	54.2%	13.1%	32.7%	100.0%

S. **Strategic Evaluation Plan**

2016-2018

Massachusetts Statewide Energy Efficiency
STRATEGIC EVALUATION PLAN

October 2015

Table of Contents

1. BACKGROUND

1.1 INTRODUCTION

Evaluation, Measurement and Verification (EM&V) has been an integral component of the efficiency programs in Massachusetts since their inception. Over time, the EM&V process has become more rigorous and strategic, and in 2013-2014 the Program Administrators (PAs), the Energy Efficiency Advisory Council (EEAC) Consultants, and evaluation contractors first introduced a long-term evaluation planning document. The planning document provided the structure that was used to guide evaluation activities during the 2013-2015 Three Year Plan. Due to its success, the same planning framework is repeated here for the 2016-2018 Three Year Plan.

1.2 EM&V FRAMEWORK

Consistent with past three-year plans and the Council's September 8, 2009 EM&V Resolution, the PAs propose to continue the evaluation framework that has successfully allowed the PAs to engage in high quality third-party EM&V efforts. The Council and the PAs find that it is critical that the programs be evaluated, measured, and verified in a way that provides confidence to the public at large that the savings are real and in a way that enables the PAs to report those savings to the Department of Public Utilities (DPU) with full confidence. Additionally, the Council stated that there is a need to ensure both the reality and the perception of the independence and objectivity of EM&V activities, as well as the need to help ensure consistency, timeliness, and credibility of the results. Accordingly, the Council will continue to have an oversight role over the EM&V activities of the Program Administrators to ensure the objectivity and independence of those activities, and the perception of such, and to help ensure consistency, timeliness, and credibility. The Council's oversight role will be accomplished through the Council's EM&V consultant ("EM&V Consultant"), a third-party expert consultant who has primary responsibility for working with the PAs to plan and implement high-quality EM&V activities in Massachusetts.

While PAs and the EM&V Consultant will continue to work diligently to reach a consensus on evaluation issues, where there are areas of difference that may arise that cannot be resolved through consensus during the on-going interactive process between the EM&V Consultant and the PA evaluation staff, authority for decision-making will reside with the EM&V Consultant and the Council.[1]

To enable the Program Administrators to fulfill their responsibility to report program savings to the Department with full confidence, an appeals process has been established, through which the PAs may bring decisions made by the EM&V Consultant or the Council for review and resolution. This process will be implemented through the formation of an evaluation appeals committee ("Appeals Committee") of the Council, whose responsibility in this area will be to hear the matter under dispute and rule so that the study may proceed in a timely way. In general, it is expected that this review process will be completed within 72 hours once an issue is elevated to the Appeals Committee. This Appeals Committee will consist of three voting members of the Council, including DOER. Consistent with general Council proceedings, the Appeals Committee will include and consult with, in both deliberations and decision-making, a representative of both the PAs and the Council's consultant team, neither of whom shall have a vote in the standing committee. The Appeals Committee will review the issues related to the disputed matter, hear from the PA evaluation staff and EM&V Consultant (the "principals"), and make a determination on the outcome of the matter. The decision will be recorded, along with a description of the applicable issues. The participants in the appeal will sign the record of the decision, indicating their acceptance of,

[1] To date the EM&V Consultant and PA Evaluation staff have been able to resolve all areas of differences without proceeding to the Appeals Committee.

the representation of the issues and of the decision. In exceptional cases, where the PAs perceive there to be significant risk to their ability to manage the energy efficiency programs in the near term, the PAs will note their disagreement with the decision of the Appeals Committee on the record of the decision and reserve the right to immediately petition the DPU on the Appeal's Committee's decision. The PAs shall be able to submit any such documents to the DPU in conjunction with the filing of the three-year plans, mid-term modifications, and term reports. The DPU will be able to review the record of this decision in its review of three-year plans, mid-term modifications, plan-year reports, and term reports.

As discussed below, the Evaluation Management Committee has been a key component to keeping communication channels open. To date, all major disagreements have been resolved through a data driven consensus process. It is a testament to the hard work and collaborative engagement of the PAs and the EM&V Consultant that there has not been an occasion where it has been necessary to invoke this appeals process.

The PAs will maintain a statewide focus to the maximum extent possible, will review EM&V budgets with the EM&V Consultant, and will integrate electric and gas evaluation efforts to the maximum extent possible. The Program Administrators will be the main mechanism for contracting with the independent evaluation contractors, and will work with evaluation contractors to maintain privacy of customer data.

1.3 EVALUATION MANAGEMENT COMMITTEE

The PAs and the EM&V Consultant established the Evaluation Management Committee (EMC) to be similar to other management committees. The EMC serves as a steering committee for statewide evaluation issues, providing guidance and direction to each of the evaluation research areas. The EMC works to plan, prioritize and delineate the research studies to be undertaken over the three-year plan period.

The Program Administrators and the EM&V consultant have worked to consistently improve the EM&V process over time. As issues arise, the EMC has established working groups to review and address new topics, areas of concern, or disagreement. For example, in 2014, the PAs and the EM&V Consultant determined that there was no clear path forward to determine an appropriate baseline for a particular program. In response to that issue, the EMC formed a Baseline Working Group, and established guidelines to handle such concerns in the future. An initial summary of the report of this working group is attached at Appendix B. The EMC will continue to establish appropriate working groups to address issues as they arise and keep the EM&V process running smoothly.

1.4 EVALUATION FUNCTIONS

EM&V refers to the systematic collection and analysis of information to document the impacts of energy efficiency programs and recommend improvements in program design and delivery. EM&V includes the following types of studies:

- *Impact Evaluation* refers to the measurement of net or gross savings achieved within overall program populations.
- *Market Effects Evaluation* refers to the measurement of the effects that programs have on the structure and functioning of their target markets.
- *Process Evaluation* refers to the systematic assessment of programs for the purpose of documenting their operations and developing recommendations to improve their effectiveness.
- *Market Characterization or Assessment* refers to the systematic assessment of energy efficiency markets for the purpose of improving the effectiveness of programs targeting those markets.
- *Evaluation of Pilots* refers to EM&V activities intended to assess the effectiveness of pilot programs, determine their potential for full-scale implementation, and develop recommendations for any changes in program approach.

As discussed in Section 1.6, the PAs and EEAC Consultants have utilized evaluation planning principles to assess potential evaluation activities, identify priorities, and determine the appropriate timing of all evaluation efforts since 2010. Research priorities to date have been driven by the need to support Massachusetts' rapid increase in program activity, which has required a commensurate rapid gearing up of the scale of EM&V activity. The rapid increase in EM&V activity required that limited administrative resources be allocated strategically to: (1) impact evaluations intended to ensure that as the savings ramp up the results remain reliable; (2) market assessments intended to help support reaching new markets and penetrating existing ones more effectively; and (3) process evaluations, to help make existing programs more effective.

1.5 SCOPE OF RESEARCH AREAS

1.5.1 RESIDENTIAL

Originally this research area consisted of three separate categories: Residential Retrofit and Low Income, Residential Retail Products, and Residential New Construction. The residential evaluation research area as currently defined includes the following initiatives:

- Residential New Construction
- Home Energy Services
- Multi-Family Retrofit
- Residential Lighting
- Consumer Products
- Residential Heating & Cooling Equipment
- Low Income Single Family Retrofit
- Low Income Multi-Family Retrofit

1.5.2 NON-RESIDENTIAL

The Non-Residential (or Commercial & Industrial, C&I) research area combines two separate categories: C&I New Construction and C&I Retrofit. As of the 2016-2018 Three Year Plan, the C&I initiatives within this research area include:

- New Buildings & Major Renovations
- Initial Purchase & End of Useful Life
- Existing Building Retrofit
- Small Business
- Multifamily Retrofit
- Upstream[2] Lighting

1.5.3 CROSS-CUTTING

This research area covers topics that do not fit cleanly into either the Residential or Non- Residential research areas, as well as additional specialized topics in which it is particularly important to ensure consistency across research areas and markets. Topics within this research area include, but are not limited to:

- Behavioral Programs
- Codes & Standards

[2] Upstream refers to the buy down of products at the distributor-level rather than the end-user-level (incentives are provided further up the supply chain). Typically, monetary savings that the distributors experience are passed on to contractors and eventually the end-user but the end-user is often unaware that they participated in an energy efficiency program.

- Community Mobilization Initiatives
- Education & Training
- Market Effects
- Net-to-Gross (NTG)
- Non-Energy Impacts (NEI)
- Program & Portfolio Marketing
- Top-Down Modeling[3]

1.6 PLANNING PRINCIPLES

Collaboratively, the PAs and EEAC Consultants have developed the following set of four primary evaluation planning principles and four additional considerations, which collectively are utilized to assess potential evaluation activities, identify priorities, and determine the appropriate timing of all evaluation efforts.

There are four primary principles that establish the priority of the evaluation research:

1. Importance. Allocate evaluation resources to research questions that have a significant impact on demand-side management (DSM) investments or that directly inform significant policy questions and stakeholder interests. Not all programs and measures contribute equally to the PA's DSM portfolio. Therefore, the PAs and EEAC Consultants will focus available evaluation resources on the programs and measures that generate the greatest savings and require more recent and accurate evaluation findings.

2. History. Make the most of existing research before investing in additional research. This includes previous evaluation research conducted in Massachusetts and other relevant research, such as that conducted by the Northeast Energy Efficiency Partnerships or other relevant secondary sources of information. As the PAs have been conducting evaluations for over 20 years, the PAs will leverage, build-on, and complement the wealth of historical information available when prioritizing and planning evaluations. However, the PAs and EEAC consultants recognize that some of this information becomes dated and that updated information might be valuable, even for smaller contributors to portfolio level savings. The PAs and EEAC consultants attempt to assess the likely shelf-life of different types of data, based on an assessment of how rapidly the programs, technologies, economy and markets are likely to be changing.

3. Uncertainty. Allocate evaluation resources to research questions with the greatest uncertainty. Uncertainty may be due to dependence on dated research, introduction of new measures or evaluation methodologies, and/or variability in programs operating in quickly evolving markets. To ensure savings estimates and program designs reflect current market conditions, the PAs and EEAC Consultants will assess programs and measures in more dynamic markets with greater frequency. Similarly, evaluation practices also evolve over time and new best practices are established. Consequently, the PAs and EEAC Consultants prioritize evaluations that will apply improved methodologies or that will take advantage of data not previously available.

4. Timing. Ensure the timing of the research is appropriate for the research questions being asked. Is the program mature enough to allow the research to produce viable results? Is there a significant program change underway

[3] Top-down modeling can be used to estimate program net impacts and can capture effects of multiple programs jointly contributing to aggregate savings. Top-down modeling is an economic approach to measure program impacts using cross-sectional and time series data. These models measure changes to aggregate energy consumption relative to changes in energy efficiency programmatic activity, prices and other economic factors with a goal of isolating the effect of program activity from other natural changes and policy variables. A top-down modeling methods study was produced as part of the work completed in the cross-cutting research area.

that may affect the results or affect the usefulness of the results? Typically, it is not necessary to evaluate a mature program annually, though it may make sense with a new program. The PAs and EEAC Consultants will evaluate the major elements (impact, process, NTG, other) of each significant PA program as part of a multi-year evaluation cycle.

Once the priority is established, there are four additional principles considered when establishing the evaluation research portfolio. These include:

- Balance -- The PAs and EEAC Consultants undertake a mix of studies each year, in terms of the evaluation elements assessed (impact, process, NTG, other) and which programs are evaluated.
- Depth -- Greater resources always allow for more in-depth study, and typically more reliable evaluation findings. The PAs and EEAC Consultants consider each evaluation option as an investment and determine the level of study needed to cost-effectively estimate savings.
- Flexibility -- Unanticipated but not yet known or identified evaluation may arise over time. To ensure that these issues may be addressed, the PAs will allocate sufficient resources for unidentified ad hoc evaluation efforts. The PAs and EEAC Consultants develop evaluation plans with flexibility to add evaluation activities (such as pilot evaluations or assessments of the effectiveness of mid-year program design changes) without compromising the timing and quality of concurrent evaluation work.
- Differences – The PAs and EEAC Consultants recognize that there can be legitimate reasons for variations in findings of statewide studies within small vs. large PAs, gas vs. electric PAs, or within definable economic/demographic areas of the state. When appropriate, evaluation research activities may be implemented in a manner that ensures consideration, identification, and documentation of any such legitimate differences.

While planning strategies vary depending on the particulars of each specific study, the following outlines the principles that apply to each type of evaluation.

- Impact Evaluation – The core principles driving impact evaluation planning are Importance and Timing. When determining which end-use(s) to study, the evaluation team considers both the vintage of the most recent study as well as the percent of savings an end-use represents within a program and portfolio. Uncertainty is also an important principle as the availability of higher quality data or improved evaluation methodologies offer opportunities to more reliably estimate energy savings. Secondary principles considered in this planning process are Balance and Depth.
- Market Effects Evaluation – The two core principles for determining if a market effects study is warranted are Timing and Importance. A successful Market Effects study requires both a baseline market measurement prior to program intervention and a follow-up market measurement to assess the program's impact on the market, ideally 2 or 3 years after the program is introduced. Secondary principles that are also considered are Balance and Differences.
- Process Evaluation – The core principles driving process evaluation planning are Uncertainty and Timing. When determining the appropriateness of conducting a process evaluation of a specific program or initiative, the evaluation team looks at the maturity of the program as well as whether any changes to program delivery or market conditions have recently occurred. In the event changes have occurred or if a program or initiative is new, a process evaluation is typically warranted. However, prioritizing early feedback on program or market changes must be balanced with appropriate consideration, such as a program or initiative that is still undergoing significant changes and therefore should not be evaluated as the findings may be premature and therefore not likely to be useful. Secondary principles considered in the planning process are Importance, Balance and Depth.
- Market Characterization or Assessment – Similar to process evaluation, Uncertainty and Timing are the core principles considered in planning market assessments. In addition, History plays a key role as the evaluation team must consider the information already available about a given market prior to commencing new research. When considering the relevance of historical data, the evaluation team will

also assess the volatility or changes occurring in the market in question. Secondary principles that are also considered are Differences and Balance.

- Evaluation of Pilots – The core principles driving the planning of evaluation of pilots are Timing and History. In general, the evaluation team considers if other sources are available that provide credible estimates of savings. In addition, the evaluation team considers the timing of the pilot effort and conduct evaluations of any kind only when the timing is appropriate.

1.6.1 RESIDENTIAL

For Residential, the specific strategy for planning impact evaluations is dependent on three things: the size of each core initiative or end-use, when each core initiative or end-use was last evaluated, and whether or not the program has undergone recent and significant changes. Particularly large programs, or major end-uses within programs, are evaluated on a more frequent basis to ensure the largest contributors to savings in the statewide portfolio are accurate. In addition, the PAs and EEAC Consultants consider evaluating smaller programs, even if the program represents only a small portion of our portfolio savings. Finally, if a program undergoes significant changes, or is newly developed, the PAs and EEAC Consultants consider an evaluation to understand how well the program is performing and identify any issues with the delivery as early as possible.

1.6.2 NON-RESIDENTIAL

In regards to Non-Residential impact evaluation studies, these have traditionally followed a rotating strategy as described in the 2013-2015 Strategic Evaluation Plan[4]. However, there is a hypothesis among PA evaluation staff and the EEAC consultants that impact evaluation results have shown stability, so the evaluation consultants have been asked to investigate whether results are in fact showing consistency. If the stability of Non-Residential impact evaluations is confirmed, the PA evaluation staff and EEAC consultants may revise the current rotation evaluation strategy so that key methodological issues, such as baseline investigation, can receive increased attention. Impact evaluations, however, will always remain an important and necessary component of Non-Residential EM&V efforts, especially as new initiatives are introduced and mature programs need to be periodically evaluated for over/under performance.

1.6.3 CROSS-CUTTING

For each cross-cutting topic area, specific planning strategies may vary. A brief overview of the current strategy for each topic area follows.

- Behavioral Programs – Multiple impact evaluations have been performed for each distinct behavioral effort in the state. As programs mature and stabilize, this research area will update realization rates periodically, in line with the governing principles discussed above. As new behavioral programs and strategies are implemented, it is anticipated that there would be repeated early evaluation until results stabilize and a reliable realization rate can be developed.

- Codes & Standards – A detailed evaluation plan for the Code Compliance Support Initiative (CCSI) was developed in August 2014 and amended in April 2015. Evaluation plans for other components of the Codes and Standards Initiative will be proposed shortly after the implementation plans are developed. The evaluation work for the CCSI and the work to be proposed for other components provide overall coordination with implementation to ensure that the necessary data are collected to (1) provide early feedback on the implementation of the Initiative; (2) evaluate the impact of Codes and Standards efforts; and (3) determine the appropriate attribution of energy savings to the PAs. Overall work

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The 2013-2015 Strategic Evaluation Plan can be found on the Massachusetts EEAC website:

performed will include surveys of participants, assessment of baselines at the beginning and end of code cycles, and careful documentation of the PAs' specific efforts. In addition to laying the groundwork for evaluating Codes and Standards impacts, the evaluations will support the future development of the Codes and Standards Initiative -- for example, by clarifying where the greatest opportunities lie.

- Community Mobilization Initiatives; Education & Training – For these two topic areas, process and impact evaluations are performed as appropriate based on the defined goals of each delivery model and the planning principles discussed above. Each new in-the-field effort is reviewed to determine whether a specific evaluation of the effort should occur. Evaluation efforts will focus on new or changing delivery models rather than established models, but all efforts will be periodically reviewed.

- Market Effects – Planning will focus on (1) quantifying market effects where the necessary data are available for programs previously identified as being likely to induce measurable market effects; (2) attempting to acquire market penetration data to use in quantification; (3) providing program planning, implementation, and evaluation staff with the market information they need to maximize market effects from program activities; 4) coordinating work among the evaluation teams to track appropriate market progress indicators to support market effects evaluation in the future without duplicating efforts or overburdening limited market actor groups; and 5) developing recommended market effects approaches for any additional programs identified as being likely to induce measurable market effects. This is expected to include undertaking studies to track market effects indicators and quantify market effects, developing market actor panels to supply critical market-level data, and carrying out market characterization studies, such as those for multifamily retrofit and commercial refrigeration.

- Top-Down – Top-Down Methods employ aggregate consumption and macro-economic data to measure reductions in energy use resulting from energy efficiency efforts. Over the past year and a half, activity in this topic area has resulted in an abbreviated top-down modeling literature review, as well as an Expanded Methods review to better understand the strengths and weaknesses of the approaches that have been used, and the necessary data requirements. The team also completed the two pilot studies—the PA-Municipal Utility pilot study (residential and C&I) and the PA-Data pilot study (C&I only). In the 2016-2018 Three Year Plan, work in this topic area will result in (1) recommendations for using the results of top-down methods in conjunction with market effects and NTG results to claim savings, (2) identification of additional top-down modeling that should be conducted and when, and (3) deeper examination of the key econometric concerns that should be addressed with models going forward in order to make the results more reliable.

- Net-to-Gross (NTG) – After initial work in the 2010-2012 Three Year Plan to identify, standardize, and document research methods in this area, evaluation efforts in the past three years focused on quantifying NTG ratios for the PA's downstream C&I programs—two studies were completed for electric measures and two for gas measures. In the 2016-2018 Plan, this topic area will research how NTG results should be integrated with market effects and top-down modeling results in planning, program design, and claiming savings; re-examine the most appropriate approaches for estimating NTG under different circumstances and with different types of customers/program models; research what is driving the differences in NTG ratios by end-use and over time; and repeat NTG studies as needed.

- Non-Energy Impacts (NEI) – Similar to NTG, initial work in this area focused on developing methods for quantifying NEIs attributable to the PA programs. Research in this area continues to quantify appropriate NEIs for the C&I new construction programs. This topic area also examines additional NEIs that may be appropriate to either study for the first time, or further update or refine.

- Program & Portfolio Marketing – Currently, this area focuses on determining the effectiveness of each statewide marketing campaign. Each year, a pre- and post-survey is done to measure the impact of the campaign in raising brand and program awareness. Additional work will measure brand effectiveness as well as support marketing efforts with specific smaller scale evaluations as necessary.

- Additional Work – Work in this area may cross multiple topics in order to identify overarching market trends and consumer behavior. Some additional cross-cutting work is typically developed on a short turnaround, ad-hoc basis. This work may include literature reviews or surveys of programs in other jurisdictions and other smaller scale work designed to inform implementation efforts or program strategy.

In addition to the topics and strategies discussed above, another priority of this research area is to retain the flexibility to respond to new efforts in the field to provide appropriate and timely evaluation support.

1.7 AVAILABLE BUDGET

The EM&V budget available to the research areas for the 2016-2018 Plan is projected to be in line with historical program budget levels. Twenty percent of each sector's available evaluation budget is allocated to the Cross-Cutting research area. The remaining evaluation budget in the residential and low-income sector is allocated to the Residential research area; the remaining evaluation budget in the C&I sector is allocated to the Non-Residential research area.

Total evaluation budgets for the 2016-2018 Three Year Plan term are expected to be $18.7 million for gas programs and $41.3 million for electric programs.

1.8 ASSIGNED STAFF

There are approximately 14 PA full time equivalent (FTE) employees assigned to MA evaluations as a portion of their job responsibilities, with over 20 PA employees actively engaged in study oversight. The PAs currently contract with several external evaluation experts to supplement staff. External evaluation experts are employed in addition to the evaluation contractors that are responsible for completing the evaluations in each research area.

1.9 STAGES OF EVALUATION

The stages through which a project moves from an initial idea to being completed are as follows:

Stages of Evaluation

Stage	**Document Under Review**	**Description**
Stage 1: Conceptual Framework	1 Page Summary	Provides conceptual framework for the project including a very high-level budget and timing, as well as the objective or goal.
Stage 2: Preliminary (High Level) Work Plan	2 - 3 Page Summary	Provides strategies to meet objective including more detail on the potential research design, level of effort (number of surveys, site visits) including additional detail on budget/timing.

Stage	Document Under Review	Description
Stage 3: Detailed Work Plan	3 – 25 Page Work Plan	Provides detailed sampling and analysis plans; specific staffing and milestone deliverables.
Stage 4: In Progress	Status Report	Work is conducted consistently with plan – there may be detailed planning occurring simultaneously with execution on early tasks.
Stage 5: Reporting	Draft Report	Period from draft report through final report and any review/communications/meetings in-between, includes paperwork for submittal.
Stage 6: Complete	Final Report	Report is finalized and either filed or ready to be filed with the DPU.

There are multiple planning stages since there is a need for projects to proceed incrementally from concept to preliminary work plan to detailed work plan. By proceeding incrementally, the PAs and EEAC Consultants are not only able to better manage the stakeholder review process but effectively stage studies across the three research areas.

The methods in which stakeholders are engaged can vary based on the stage of evaluation. The PAs have hosted strategic evaluation planning meetings to encourage participation in the early stage of the evaluation planning process and solicit input from a wide variety of program stakeholders. Additionally, there is active engagement with both program implementers and policymakers to identify additional key research needs and to further refine project recommendations developed at the strategic evaluation planning meetings.

Much of the stakeholder engagement happens through the Residential Management Committee and C&I Management Committee. Since both PAs and EEAC Consultants are members of the management committees, stakeholder engagement at the committee meetings by the research area leads has been successful. For projects in stage 1, one page summaries are developed and shared with the management committees. Progress on projects in stages 2, 3 and 4 (preliminary and detailed work plans and in progress) is also provided to the management committees and for projects in stage 5, draft reports are shared with the management committees.

Input from non-utility stakeholders represented on the Council generally flows through the EEAC consultants. A representative from the EMC attends RMC and CIMC meetings as frequently as possible in order to facilitate coordination and solicit feedback from the various management councils and working groups.

1.10 RESEARCH COMPLETED DURING 2013-2015 PLAN TERM

1.10.1 RESIDENTIAL

Since 2010, the PAs and EEAC consultants have supported over 65 residential evaluation studies grouped into three subject areas: lighting and products, heating and cooling, and whole house. Highlights of recent residential evaluation studies are summarized below.

1. **Lighting and Products.** A primary point of focus was continuing to track the residential lighting market and its reaction to PA activity and the Energy Independence Security Act of 2007. Research has included:
    - On-site lighting inventories of homes in Massachusetts, New York, Georgia, and Kansas;
    - Interviews with lighting manufacturers and lighting retailers;
    - Assessment of store shelf stocking practices;
    - Customer surveys; and
    - Metering household lighting to assess hours of use.

For the first time, point-of-sale data was obtained from most channels for lighting sales. This provided a source for definitive data on market share of efficient lighting. Use of tools such as web-scraping also provided insights into the pricing of efficient lighting. Trends in prices provided a basis for projecting what prices might be for the next three years, which in turn can be used to inform program planning efforts and support projections of prospective NTG values. Households participating in on-site inventories and panel studies yielded insights into bulb replacement behavior.

Key Evaluation Findings To Date: (a) Massachusetts households exhibited higher CFL and LED socket saturation (percent of sockets filled with a bulb type) and penetration (percentage of households using at least one bulb of a type) than all three comparison areas. (b) The delta watts for program-supported bulbs have decreased, which affects program planning for 2016 to 2018. (c) The recommended NTG retrospective ratios for CFLs ranged from 53% to 95% while those for LEDs hovered at around 100%. (d) Prices for LED incremental costs are expected to decrease as CFL and halogen prices stabilize but LED prices continue to fall. (e) The overall hours of use stood at 2.7 regionally, but were higher for efficient bulbs (3.0 hours) versus inefficient ones (2.3 hours).

2. **Heating and Cooling**. Several studies focused on HVAC and water heating measures were conducted during the 2013-2015 period, including:
    - ***Impact evaluation of high-efficiency furnaces and boilers*** - On-site metering and billing analyses were conducted to update heating equipment savings values for gas furnaces and gas boilers.
    - ***Impact evaluation and baseline assessment of DMSHPs*** - A comprehensive on-site metering effort was conducted to explore appropriate baseline technologies, energy savings, interaction with existing heating systems, and more information around cold-climate DMSHPs.
    - ***Assessment of energy-efficiency related incremental cost associated with central cooling and heat pump equipmen***t - This study evaluated and estimated how equipment costs and prices change as equipment efficiency increases, supporting the design of cost-effective rebates.
    - ***Assessment of Net-to-Gross values applicable to heating measures*** - This study included research with manufacturers, distributors and contractors and is serving as a platform to build from for the HVAC market effects research.

Key Evaluation Findings To Date: (a) both standard and high-efficiency boilers are less efficient than their ratings, often not being controlled to maximize potential savings, while standard efficiency furnaces perform slightly higher than ratings and high-efficiency furnaces perform at their ratings; (b) participants with combined boilers (combined heating and small hot water tanks) consume less gas than other homes; (c) Net-to-gross is 77% for boilers and 81% for furnaces (AFUE≥95%), (d) customers that purchased DMSHPs with the intent of heating used their units primarily for heating, while users whose stated purchase intent was cooling often used their units for heating as well; (e) while approximately 31% of participants stated cooling-only intentions regarding their DMSHP purchases, approximately 40% of them used it for both heating and cooling.

2. **Whole-House**. Several whole house studies were completed focusing on retrofits and both single and multifamily buildings, including the following:
   - ***Home Energy Services Program Delivery Assessment*** – A data-driven assessment of HES core initiative effectiveness which detailed a number of key performance indicators, compared performance between service providers (i.e., Lead Vendors and Home Performance Contractors), and explored cross-program participation.
   - ***HEAT Loan Assessment –*** Explored extent to which no-interest loans for energy-efficiency influence customer decision making in the HES program.
   - ***Low-Income Multifamily Impact Evaluation –*** This study assessed electric and gas savings associated with low-income multifamily retrofits. Methods used included gas billing analysis, common area light metering, and engineering algorithm review.
   - ***Multifamily Process and Impact Evaluations*** – This study aimed to monitor the Multifamily initiative's current state as a standalone or integrated offering; and provide an ongoing examination of barriers, program operations, and customer experience. A billing analysis was performed to attempt to assess energy saving.
   - ***Residential Customer Profile Study (RCPS)*** – Through integration of a wide array of data sources (e.g., billing data, program participation/tracking data, U.S. Census data, Residential Energy Consumption Survey (RECS)), this research assessed levels and patterns of participation for programs across different PAs. The study also conducted a regional assessment of upstream lighting program impacts that are distributed geographically based on income-driven purchase behavior patterns and GIS analysis of driving time and distance to retailers.
   - ***New Construction Baseline studies of Single Family and Multifamily High-Rise Buildings*** – These market assessments are aimed at exploring baseline research in new construction, with a focus around building practices, code compliance, and building characterizes for these markets.

   Key Evaluation Findings To Date: (a) Each unique HES delivery channel offers complimentary approaches (each with their own benefits and limitations) for delivering the program and help expand the reach of the HES initiative, (b) the HEAT Loan has been successful in promoting deeper/broader savings, acting as a motivating factor for a select group of customers (who choose to use the loan) and a business tool for contractors, though opportunities remain for increasing awareness among HES participants; (c) the RCPS found, in 2013, over 15,000 customer premises (not including behavioral) across the state participated in two or more core initiatives (representing 7.7% of total program participation across fuels); (d) through a billing analysis, the Low-Income Multifamily initiative achieved approximately 21% savings relative to pre-retrofit natural gas consumption.

1.10.2 NON-RESIDENTIAL

Since 2010, the PAs and EEAC consultants have supported 55 non-residential evaluation studies in four major research areas: impact evaluations, process evaluations, net-to-gross evaluations, and market assessments (see figure below). These studies seek to quantify program impacts and provide focused, actionable recommendations to improve the performance and efficiency of non-residential programs.[5]

During the 2010 to 2015 contract period, the non-residential evaluation team also developed a C&I Evaluation Database—complete with four years of PA billing and tracking data, GIS libraries, and tax assessor data—to provide a consistent, efficient underpinning for all current and future non-residential evaluation activities.[6] This database allows the team to identify and analyze differences in PA customer usage and program participation over time. For example, we can examine whether participation in a certain sector, region, service territory, or program (or any combination thereof) has increased or decreased from 2011 to 2014, providing insight into trends and areas of opportunity for program activity.

Highlights of recent non-residential evaluation studies are summarized below.

Impact Evaluations
Impact evaluations provide an independent assessment of the energy and/or demand savings achieved by a specific population of energy efficiency measures, and provide recommendations focused on improving the program and the accuracy of its savings estimates.

Thirteen non-residential impact evaluations were recently completed (see list below). This work included an investigation to determine the impact of upstream C&I lighting programs, several high-rigor evaluations of electric custom and prescriptive programs, and several gas measure evaluations.

Impact Evaluations:

1. Custom Electric Impact – Refrigeration, Motor, Other
2. Upstream Lighting Impact
3. Custom Electric Impact – CHP
4. Prescriptive Gas Impact – Boiler, Furnace, Infrared Heating, Indirect Water Heater
5. Custom Gas Impact – Desk Review
6. Custom Gas Impact – NSTAR Onsites
7. Custom Electric Impact – HVAC
8. Prescriptive Electric Impact – Chillers, Compressed Air
9. Prescriptive Gas Impact – Spray Valves
10. Custom Gas Impact – Desk Review & Site Visits
11. Prescriptive Gas Impact – Thermostat, Steam Trap
12. Custom Electric Impact – Process
13. Upstream Lighting Program – In Storage Lamps Follow-Up Study

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[5] To further ensure actionable results, the non-residential evaluation contractor team now submits a one-page summary with each draft report to communicate the study's purpose, results, and recommendations to key stakeholders who may not have time to read detailed research reports.

[6] The fourth year of data was added to the Evaluation Database in 2015 as part of the ongoing Customer Profile study.

Process Evaluations
Process evaluations analyze information on a program's operations and—on the basis of that analysis—identify practical approaches to improve that program in relation to program goals.

Six non-residential process evaluations were undertaken in the last contract period (see list below). This work included an expansion of a comprehensive process evaluation conducted in 2011, and studies that focused on upstream lighting programs, small business engagement, differences among PAs that affect performance, and the participation of mid-size C&I customers.

Process Evaluations:

1. Upstream Lighting Process Evaluation
2. Mid-Sized Customer Needs Assessment
3. Whole System Approach Assessment
4. How PA Differences Affect C&I Outcomes
5. Learning from Successful Projects
6. Direct Install Process Evaluation

Net-to-Gross Evaluations
Net-to-gross (NTG) evaluations estimate energy savings that are specifically attributable to the program under study. This research area also includes market effects research and baseline studies.

Three non-residential NTG evaluations were undertaken in the last contract period (see list below).[7] Market effects[8] remained a priority for the PAs and EEAC. Given the rapidly evolving Light Emitting Diode (LED) market, the team investigated the baseline for LEDs in Massachusetts to lay the groundwork for future assessments of market effects within the C&I lighting market. The PAs and EEAC also investigated LED spillover[9] to understand the extent it's contributing to program net savings, and the team began an effort to better understand HVAC supply-side market actors and differences by HVAC equipment types. Our team's work on the LED studies, in particular, is at the forefront of market effects research nationally. We will be building on this body of work with a retrospective market effects study on C&I lighting and a prospective baseline study on lighting controls in the new contract period.

NTG Evaluations:

1. Commercial New Construction Energy Code Compliance Follow-Up Study
2. LED Market Effects: Baseline Characterization
3. Characterization of (HVAC) Supply-Side Market Actors

Market Assessments
Market assessments characterize and assess changes in market conditions for energy efficiency products, and provide information to help PAs influence those markets to increase energy savings.

Eleven non-residential market assessments were undertaken in the last contract period (see list below). This work included the 2011, 2012, and 2013 C&I Customer Profile studies—which analyzed PA customer usage and tracking

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[7] Five NTG projects were initiated in the last contract period ; however, one was a coordination project, and one was cancelled before completion. Thus we only list three studies in this section.
[8] See Section 1.4 for "market effects" definition.
[9] "Spillover" refers to program influence beyond the program's design. For example, PA programs to support efficient lighting, not necessarily LED lighting, may be influencing the LED market. The LED spillover study mentioned here was initiated in April 2015. A final report will be filed with the 2016-2018 Three Year Plan.

data in order to identify where C&I energy efficiency savings and participation are occurring, and what segments remain to be served—and a multi-year research effort to better understand existing building stock and technology saturations (i.e., the prevalence of each technology in the existing building stock) of C&I customers in Massachusetts. This market characterization effort divided the general population into building and customer segments, examined the level of energy efficiency activity and awareness of energy efficiency opportunities among existing customers, and collected data to support other evaluation studies. The project has included a general population survey and a large-scale on-site data collection effort (anticipated 800 completes).

Market Assessments (2012/2013 – 2014/2015):

1. Existing Buildings Market Characterization – Phone Survey
2. Existing Buildings Market Characterization – Site Visits
3. Lighting Controls Assessment
4. 2011 C&I Customer Profile
5. 2012 C&I Customer Profile
6. 2013 C&I Customer Profile
7. Commercial Real Estate Survey Analysis
8. Boiler Market Characterization
9. Boiler Market Characterization Phase II
10. T-12 Phase Out Market Assessment
11. Market Share Assessment

1.10.3 CROSS-CUTTING

Top-Down, Net to Gross, Market Effects, Code Compliance, and Non-Energy Impacts (NEIs)

There are a variety of methods that can be used to estimate net savings attributable to the PAs' programs and they all have pluses and minuses. The first four topics below examined different methods that can be used to provide estimates of net savings.

1. **Top-Down Modeling** is an econometric approach to measuring program impacts across all programs in a geographic region. It models energy consumption as a function of variables such as programmatic activity, price, weather, and other economic factors. The objectives of this research were to:
    - Review existing top-down modeling studies and techniques
    - Recommend specific approaches to be piloted in MA during the first year of the study
    - Obtain the necessary data for employing one or more agreed approaches
    - Implement the agreed upon pilot approaches
    - Establish next steps for model specifications and data requirements for the top-down modeling efforts to be employed in the second year and beyond

    To accomplish these objectives, the team prepared an abbreviated top-down modeling literature review and an Expanded Methods review to better understand the strengths and weaknesses of the approaches that have been used as well as the necessary data requirements. The team also completed the PA-Municipal Utility pilot study (residential and C&I) and the PA-Data pilot study (C&I only). The PA Municipal Utility pilot used publicly available aggregate data to contrast changes in consumption in the C&I and residential sectors relative to programmatic activity by the PAs and Municipal Utilities. The PA-Data model used PA tracking and consumption data.

    Key Evaluation Findings to Date: (a)The literature and methods review conclude that top-down modeling may provide an additional tool in the set of tools used to evaluate the portfolio of programs; (b) The pilot studies confirmed that there are many challenges to collecting the necessary data over a sufficiently long time period; (c) the PA-Muni model showed significant results, although the error bands are wide; (d) the

PA-Data model, though not significant, demonstrated that with sufficient data top-down models may be able to address many policy questions; and (e) The pilot modeling effort provides preliminary evidence that the combined impact of programs may be responsible for substantial spillover effects.

2. **Self-Report C&I Net-to-gross (NTG) studies**. Since 2011, the team has conducted 4 NTG surveys with participants in the MA C&I downstream programs (2 electric and 2 gas). Prior to implementing these studies, the team conducted an extensive literature review in 2011 of the various methodologies used to assess free-ridership and spillover for C&I and residential downstream programs across the country and made recommendations for consistent approaches to apply in MA. The C&I electric NTG studies were conducted in 2011 and 2014, and the C&I gas NTG studies were conducted in 2012 and 2014-2015 (on-going).

   Key Evaluation Findings to Date: (a) Overall, statewide NTG ratios were relatively stable between studies conducted in 2011 and 2014; (b) Electric NTG ratios are higher for electric measures than they are for gas measures; (c) NTG ratios can vary dramatically between end-uses; (d) Electric NTG results are similar between municipal buildings in Green Communities and non-Green Communities; and (e) for some electric end-uses and many gas end-uses, the small number of participating customers makes the estimates more volatile and it is difficult to utilize end-use specific results.

3. **Market Effects**. Market Effects studies seek to find evidence of and measure spillover savings from program-induced changes in the structure of the market. The objectives of this research were to:
   - Understand and agree to working definitions of what market effects are and what conditions could lead to them
   - Identify and prioritize specific markets that may be sufficiently influenced by existing or planned programs
   - Develop methodologically consistent approaches for assessing market effects within these markets
   - Identify how the PAs can improve the evaluability of market effects for the programs or parts of programs targeting these markets.

   To accomplish these objectives, the team held workshops with PA evaluation and program staff and the EEAC to agree on the definition of market effects and identify and prioritize specific markets for expedited and future market effects studies. These markets included four HVAC markets, the Commercial Lighting market, and the non-residential New Construction market. For each of these markets, the team prepared a methods document which provided an overview of the market and contained recommendations for conducting market effects research.

   Key Evaluation Findings to Date: (a) For the HVAC market effects study, there is a need to establish panel(s) of HVAC manufacturers, distributors and contractors to meet the research needs; (b) Other panels may be needed for other markets; (c) The HARDI data warrants re-negotiation and re-purchase; (d) The commercial refrigeration and multifamily retrofit markets need further market characterization prior to undertaking a market effects study; (e) It is possible to account for overlapping estimates of net savings from different studies in the non-residential new construction market; and (f) Market effects research needs to be closely coordinated with other research to avoid duplication of efforts, overburdening trade allies, and ensuring consistency.

4. **Code Compliance Support Initiative (CCSI)**. The CCSI seeks to improve code compliance in MA through various avenues over the long term. Current activities include formal trainings for builders, subcontractors and code officials, and one-on-one technical assistance on codes, building practices and design. The objectives of the CCSI evaluation, which began in late 2014, are to:
   - Develop and implement methodologies for evaluating the CCSI and tracking key indicators of impacts

- Ensure that the information necessary to fairly assess the CCSI effects will be available
- Gather interim data on the effectiveness of the trainings and one-on-one technical assistance on a regular basis to adjust and improve CCSI offerings
- Develop a methodology for estimating savings attributable to the CCSI efforts

Prior to the CCSI kicking off, the team conducted a 2014 Code Compliance Study for single-family non-program homes built at the end of 2006 and the beginning of the 2099 IECC code cycles. Beginning in the fall of 2014, the team began analyzing and reporting on surveys conducted with CCSI training participants and those who called for one-on-one technical assistance.

Key Evaluation Findings to Date: (a) Homes built at the end of the 2006 IECC cycle have significantly higher overall compliances scores than those built at the beginning of the 2009 IECC; (b)The code compliance study also found that the Pacific Northwest National Laboratory (PNNL) checklist does not adequately account for energy efficiency in its code compliance estimates; (c) The trainings and one-on-one technical assistances are viewed positively and the information is being used; and (d) The overlap in savings from different programs and savings estimates from different studies is considerable.

5. **C&I Non-Energy Impacts (NEIs).** NEIs include any positive or negative effects beyond energy savings that are attributable to energy efficiency programs. Examples of positive NEIs include reduced labor or non-labor O&M costs, and increased sales. Negative NEIs include increased labor or O&M costs, or reduced productivity or sales. The goal of this study is to provide guidance to the PAs and the EEAC by quantifying participant non-energy impacts (NEIs) associated with commercial and industrial new construction (NC) projects. The Stage 1 research was designed to determine whether NEIs from NC measures were best estimated from self-reports from participants and/or other market actors, engineering review, Delphi-panel, or other techniques and to recommend an approach for this Stage 2 analysis.

   Key Evaluation Findings to Date: (a) The Stage 1 study recommended that the analysis of NEIs associated with new construction measures should focus on true new construction only; (b) Self-reports by end users would not provide an effective means for estimating NEIs associated with most new construction measures; and (c) Instead, it recommended that an engineering-based approach is warranted to estimate NEIs.

   The objectives of the current Stage 2 analysis, which has just begun, are to:
   - Establish baseline conditions for NEIs
   - Quantify gross NEIs per unit of energy savings (both gas and electric) resulting from commercial and industrial new construction projects completed in 2013[10].

Behavior and Education

Behavior

The statewide research and evaluation activities in behavior and education has primarily focused on the evaluation of the residential behavior program, the Home Energy Report (HER) Program, implemented by Opower and first launched in MA in 2009. Three other behavioral initiatives implemented by the MA Program Administrators (PAs) have also been evaluated. In total, the statewide evaluation teams have measured the net impacts of over 31

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10 NEIs include any positive or negative effects beyond energy savings that are attributable to energy efficiency programs.

unique behavioral program participant groups across multiple PAs, program years, and fuel-types (gas and electric) using experimental and quasi-experimental billing-based regression impact evaluations.

The evaluation findings demonstrate that behavioral program savings range from 0.82% to 1.87% per household for gas programs and 0.50% and 2.51% per household for electric households. The program savings associated with behavioral program efforts, in particular the HER programs, have produced reliable savings. In response to reliable and replicable savings impact values, the PAs have established realization rates for their HER programs.

The MA PA's have also funded multiple rounds of process evaluation research, including survey research among program participant and control customers, in-home and in-depth interviews with program participants, and experimental research to determine the marginal savings impacts of varying engagement strategies.

Finally, in 2014/2015 the MA PAs funded a research project in which a comprehensive review of residential and small/medium commercial behavioral programs across the United States and Canada was conducted. This research also explored behavioral programs implemented in small markets.

Education

The statewide research in education has primarily been targeted at the Building Operator Certification (BOC) program and around K-12 energy education programs. Most recently, a process evaluation was completed for the BOC which included a literature review of savings estimates resulting in recommended savings values. The MA PAs have also funded research projects in which a comprehensive review of K-12 energy education programs was conducted. The most recent review (completed in 2015) included K-12 programs with behavioral interventions.

Community-Based Initiatives and Statewide Marketing

Community-Based Initiatives

Opinion Dynamics has conducted several major studies since 2011 to evaluate community-based initiatives across Massachusetts. These studies assessed initiative processes, impacts, and incremental costs. The specific evaluation efforts included:

1. Process and limited cost evaluation of Renew Boston and New Bedford Community Mobilization Initiative
2. Process, impact, and all-in cost assessment of the Powering Pittsfield and Leading the Way Northampton Initiatives (under EE2020 umbrella)
3. Process, impact, and incremental cost assessment of the Efficient Neighborhoods+ Initiative

The evaluation studies answered a range of important questions including identifying best practices to planning, designing, and implementing community-based initiatives and assessing incremental costs associated with administration of such initiatives.

The research efforts to date focused on the evaluation of one-off distinct community-based initiatives and did not attempt to take a cross-cutting view or answer some key overarching questions about these initiatives. Several of these questions emerged during the 2015 Program Administrator Planning Summit and ongoing evaluation planning discussions. A particular topic of interest was defining the roles and objectives that PAs envision community-based initiatives will serve. A related question is what defines a "community" in the context of a community-based initiative. Communities could be defined by demographics, geography, common interests, or the work of a specific community organization.

The success of future community-based initiatives will greatly benefit from additional research into the comparative effectiveness of the various community-based design elements, as well as messaging and marketing strategies in driving participation and depth of savings among different customer segments.

Through the past research, we have learned that community-based initiatives often result in considerable incremental costs that could prevent implementing them on a broader scale. Understanding which community-based initiative designs are scalable and lend themselves to broader implementation, collecting incremental cost data, as well as assessing the reduction in incremental costs associated with scaling the initiatives will provide PAs with powerful insights into planning and designing future initiatives.

Statewide Marketing

Between 2010 and 2015, Opinion Dynamics conducted a number of research activities to evaluate the statewide marketing of energy efficiency programs. Massachusetts-based energy efficiency Program Administrators collectively implemented the marketing campaign under the trademark of Mass Save®. The primary evaluation activity was a series of tracking surveys with residential and commercial customers. The surveys measured customer awareness, knowledge, and associations with the Mass Save brand and the effectiveness of marketing activities. Opinion Dynamics also conducted surveys with trade allies to assess their knowledge of Mass Save, Gas Networks, and Cool Smart brands.

Just over half of residential customers (54%) and two-thirds of commercial customers (66%) were aware of Mass Save at the beginning of 2015. Among residential customers, the early 2016 survey documented the first statistically significant increase in Mass Save awareness since the first tracking survey was conducted in early 2012 when awareness was 39%. During this same time, awareness among commercial customers doubled (33% to 66%). Customers who were aware of the brand said that they felt the campaign messages were clear and communicated that the brand could help them lower their energy bills (69% of commercial customers and 77% of residential customers in January 2015).

Past research efforts have focused on brand awareness as a metric of program success. Future research could explore whether additional metrics are useful, what target levels are appropriate, and how much time and effort is needed to hit targets. Additional metrics could move beyond brand awareness to assessing the impact of statewide marketing on program participation and energy savings.

Past statewide marketing has been broad-based. Future research could explore whether more targeted marketing would be a better strategy. Targets could be defined by demographics, customer attitudes, potential energy savings, or communities, to name a few. Likewise, most marketing has targeted end-users, but future research could explore whether targeting trade allies would be a more effective marketing strategy.

2. NEAR-TERM PRIORITIES

February 2015 Planning Summit

To encourage early participation in the evaluation planning process, the PAs hosted a strategic evaluation Planning Summit in February 2015. The Planning Summit provided a forum for the PAs, EEAC Consultants, and evaluation contractor teams to identify emerging evaluation topics and activities. As a group, these stakeholders then developed a preliminary assessment of each research area's relative priorities.

It became clear during the Planning Summit that as programs have matured, they have been studied in a commensurate manner. In many areas, results have started to stabilize. While previously studied factors remain important and will continue to be studied, it may not be necessary to study them at the same frequency as was previously done. This does not mean that impact or similar evaluation methodologies will no longer be employed, as they are essential to the proper functioning of EM&V, but this does present an opportunity to research new topics and areas that can help PAs optimize program performance and program delivery.

One of the recurring themes throughout the Planning Summit was that evaluations need to better identify implications for program design moving forward. In order to ensure that evaluation dollars are being spent wisely, studies must have a practical application to current or future programs. Another goal that was identified was to shorten the timeframe between when research is done and when it is presented to implementation teams so that implementation teams can more quickly and better leverage evaluation results. These themes will help guide future evaluation development.

The Near-Term Priorities listed in the sections below were generated through collaborative discussions at the February Planning Summit and subsequent discussions with stakeholders. As this Strategic Plan evolves going forward, it is anticipated that the individual points outlined in Sections 2.1, 2.2, and 2.3 will be refined and expanded upon.

In order to maintain alignment with the three year planning cycles, it is anticipated that Evaluation Planning Summits will continue to be held prior to the beginning of new three year cycles in order to support subsequent planning activities.

2.1 RESIDENTIAL

The work in this research area is currently led by The Cadmus Group, Inc. The Cadmus evaluation contractor team also includes Navigant, NMR Group, Inc., DNV GL, Tetra Tech and Dorothy Conant Consulting as subcontractors. This evaluation team was selected through a competitively procured joint RFP process conducted in the spring of 2013. The current Cadmus team has been awarded the contract through June of 2016. Each research area and study has an assigned PA staff member and EEAC Consultant covering it.

This research area is currently led by an Eversource employee with seven employees representing two PA organizations currently leading studies in this area.

2016-2018 Residential Priorities

The identified priorities for the Residential research area are outlined below. In addition to the priorities outlined below that were developed during the evaluation planning process, issues surrounding equipment baseline have also been identified as a priority and are described in greater detail in Appendix B.

Residential Lighting:

- Better understand to what extent different types of light bulbs are going into sockets
    - How will these trends impact lighting as a percentage of overall home energy use?
- Determine the optimal strategy and timeline for supporting or discontinuing support for CFLs
- Determine whether the MA programs are bringing about long term changes in the structure and functioning of the lighting market
- Understand how manufacturers', retailers', and customers' decisions affect the lighting market
    - Bulb replacement strategy, bulb storage, perceptions, knowledge, response to lighting options, pricing, adoption of LEDs

Residential Products:

- Identify which products PAs should support going forward and how the PAs should support them
    - Technology assessment, program design, product recycling
    - E.g. incentives, marketing, standards advocacy, upstream
    - E.g. gas fireplaces, power strips, set-top boxes
- Determine the opportunities for home automation
    - Wi-Fi & lighting, interconnectivity, DR, NEIs, peak load
- Continue to support the development of new sources of savings by evaluating new pilots and initiatives

Residential Heating Equipment

- Boiler Installations (Lost Opportunity)
    - How can these be improved to capture lost opportunities identified through evaluation of installed condensing boilers?
    - Can smart thermostats improve the performance of high efficiency (i.e.., condensing) gas boilers?
- Oil retrofits
    - Establish accurate baselines for early replacement, etc.
    - Identify opportunities for efficiency gains
    - Identify opportunities for savings associated with Maintenance/quality installation savings
    - Program delivery issues – can we make sure people get offered fuel switching opportunities at key times (LI, new pipeline, equipment failure, targeting at non-gas areas)
- Hot Water-- Contractor knowledge/stocking practices
    - Do contractors regularly stock high efficiency equipment?
    - What would it take to change their behavior?
- Heat Pump Water Heaters
    - Establish the proper baseline/energy code
    - Interaction with heating/cooling system
    - Savings by unit type/efficiency
    - Market channels/Upstream opportunities
- How knowledgeable are DMSHP installation contractors?
    - Are they selling cold climate units when appropriate?
    - Are the contractors sizing the units correctly?
    - How are they educating homeowners on optimal operation?
    - Is the incentive structure appropriate?
- What is the potential for Smart Devices/Controls/Thermostats?
- Have we identified all relevant non-energy impacts from equipment?

Home Energy Services (HES)

- How can the program optimize limited time in the customers' homes?
    - How much is too much information? When do we lose customer's attention? Contractors?
- How have the insulation/air sealing savings changed (including realization rates)?
- What opportunities exist for home automation savings?
- Does program participation increase home resale value?
- How can evaluation leverage/utilize the inspection and quality control data already being collected?
- Improve our understanding of patterns of equipment adoption and how customers interact with other programs in addition to HES
    - Understand if patterns of equipment adoption and interaction with additional programs vary by delivery channel results (lead vendors, home performance contractors, and independent installation contractors)
    - Inform the evolving program design

Residential Multifamily

- What are the relevant indicators to assess the program's performance, particularly regarding residential/commercial cross-participation?

    - Are the data available to support this? If not, what do we need?
- Are there opportunities to provide customers with cost information and/or building labeling to overcome landlord/tenant issues?
- Should the program serve condo customers differently?
- Would structural changes to the different res/C&I claimed benefits increase cross-sector participation?

2.2 NON-RESIDENTIAL

The EM&V work in this research area is currently conducted by an EM&V contractor team led by DNV GL's Energy and Sustainability group with Apprise, DMI, ERS, Illume Advising, Itron, NMR Group, Inc., SBW and TetraTech, as subcontractors. This evaluation team was selected through a competitively procured joint RFP process conducted in 2014-2015. It is anticipated that the term for this contract will end mid-2018. Each research area and study has an assigned PA staff member and EEAC Consultant covering it.

This research area is currently led by a National Grid employee with six employees representing two PA organizations currently leading studies in this area.

2016-2018 Non-Residential Priorities

The identified priorities for the Non-Residential research area are outlined below. In addition to the priorities outlined below that were developed during the evaluation planning process, other global priorities have been identified and include:

- Support the efforts of program implementers to broaden and deepen the savings achieved, and to meet savings goals
- Better understand the drivers of differences in outcomes across PAs
- Conduct studies to inform the development of segment-focused efforts

Impact Evaluations:

- Systematic impact planning
    - Do we want to look into continuous measurement evaluation approach?
    - Are we properly accounting for the inter-relationship between net to gross studies and changing baselines (upstream lighting)?
- Specific studies
    - Upstream lighting (and HVAC)
    - Comprehensive Design Approach (CDA)
    - Measure life

Market Assessments:

- How can we effectively target mid-size customers to increase participation and savings?
- Emerging Technologies-- What is missing from programs' current mix of measures? What's in the pipeline for manufacturers, PA programs, other programs?
    - Example measures: lighting controls, heat pumps, plug loads, retrocommissioning, others?

Process Evaluations:

- How can the PAs expand program activity in the microbusiness sector?

  - Looking at non-MA external best practices, Main Street pilots, online portals, OPower-type benchmarking, trade associations, language barriers.
- How can we develop long-term engagements with customers, especially mid-sized customers, to increase lifetime value?
- How can the PAs coordinate with vendors to achieve deeper savings within various fuel types?
- What types of coordinated data collection (e.g., baseline info, data tracking info) is needed to facilitate the evaluation of upstream programs?
- How can the PAs better integrate the C&I and residential multifamily programs?
- Are there electric and gas integration best practices that can be learned from either external (outside MA) or internal (e.g. MA program implementation contractors and PA sales staff) sources?

2.3 CROSS-CUTTING

Currently, Cross-Cutting research is divided into three broad areas and each area is served by a different EM&V contracting team. The evaluation teams were selected through a competitively procured joint RFP process conducted in 2013-2014. The term for this contract will end mid-2017. The research areas and contracting teams are outlined below.

- Net-to-Gross, Market Effects, Top-Down Modeling, Codes & Standards, and NEIs
  - Prime Contractor: Tetra Tech
  - Subcontractor: NMR Group, Inc., DNV GL, and the Cadmus Group
- Behavior and Education
  - Prime Contractor: Navigant Consulting
  - Subcontractor: Research into Action, Illume Advising, and Bellomy Research
- Community-Based Initiatives and Umbrella/Statewide Marketing
  - Prime Contractor: Opinion Dynamics Corporation
  - Subcontractor: Evergreen Economics

A representative of Eversource is currently the statewide research area manager, with seven employees from four different PA organizations leading individual study efforts.

2016-2018 Cross-Cutting Priorities

As the savings goals have ramped up, the program implementers have turned increasingly to integrated programming efforts that are not specific to either customer sector. Examples include community-based programs, umbrella marketing, and integrating behavioral aspects into existing programs. The Cross-Cutting research area has been the focal point for evaluation of these efforts. The PAs anticipate leveraging research in the Cross-Cutting area to help increase program effectiveness and meet aggressive savings goals.

The near-term priorities for Cross Cutting are as follows:

Behavior & Education:

- Do behavior change initiatives targeting one fuel-type have an impact on other fuel-types (i.e., are there cross-fuel impacts)? How can the PAs measure and claim cross-fuel impacts resulting from behavior change initiatives?
  - Are there gas savings associated with electric-focused behavior change initiatives? Are there electric savings associated with gas-focused behavior change initiatives? Are there oil savings associated with electric or gas-focused behavior change initiatives? Are there water savings associated with electric or gas-focused behavior change initiatives?

- What are the opportunities for leveraging behavior-based strategies in the context of Demand Response (DR) and time-varying rates?
  - What are the demand savings associated with behavioral programs and can they be claimed?
  - What is the opportunity for leveraging behavior-based strategies with time-varying rates to achieve demand savings? (e.g. Will they be accepted? Will customers respond?)
  - Can targeted conservation and DR activities be used to alleviate grid constraint? If so, how?
- How can Massachusetts use behavior-based strategies to innovate and increase portfolio savings?
  - What are the behavior-based strategies that can be overlaid on existing programs? (e.g. direct installs)
  - How can behavior-based strategies be leveraged to generate and claim greater savings?
- What are the savings opportunities for behavior-based initiatives targeting operations and maintenance (O&M)?
  - E.g., retrocommissioning, residential maintenance
  - What are the underlying barriers by sector that prevent persistence of the changes in O&M behavior?

Statewide Marketing:

- What should the success indicators be for energy efficiency marketing efforts?
  - Is Mass Save effective?
  - Potential indicators:
    - Brand awareness?
    - Program participation?
    - Energy savings?
  - What is the appropriate timeline for moving from simple customer awareness of the Mass Save brand to energy efficient action?

Community-Based Initiatives (CBI):

- Determine the role of CBIs/what are the PA goals as related to CBIs?
  - Testing new program design concepts, energy efficient technologies, marketing and outreach tactics?
  - Increasing program participation?
  - Achieving greater energy savings per participant?
- What do program implementers need to know about community-based programs in order to make a decision about whether to continue to support them?

Top-Down:

- Determine how Top-Down modeling results can be used in conjunction with market effects and net to gross (NTG) results in planning, program design, and attributing energy savings to energy efficiency programs
  - How can Top-Down results be used to provide evidence to support or refute the results of market effects or NTG studies?
  - How do we ensure that we are doing work that is meaningful and not duplicative of other research studies or areas?
  - How should we effectively communicate the results to stakeholders?

Net to Gross/Market Effects:

- Should we pursue additional research with a panel(s) of manufacturers, distributors, and/or contractors to collect sales data necessary to quantify Market Effects?
  - Lighting, Multifamily
  - Can the panel also be used to collect information to support process evaluations?
- How can we improve the development and application of prospective NTG ratios?
- How do we use findings from NTG and Market Effects studies for program planning and design?

3. LONGER TERM PRIORITIES

3.1 OTHER 2016-2018 RESIDENTIAL TOPICS OF INTEREST

Additional topics identified as of interest but not an immediate priority included:

Residential Lighting:

- How can we leverage other research efforts in order to update hours of use estimates? What is the potential for replacing linear fluorescents with linear LEDs?
- Determine how to best plan for EISA II being implemented or EISA I being rolled back (political uncertainty)
- Develop savings projections based upon anticipated changes in:
  - Measure life, delta watts, early replacement, hard to convert fixtures, takeback, NEIs
- Determine the trajectory for incremental costs
- Issues surrounding channels:
  - How do sales differ by channel? (including online)
  - Do we need channel specific strategy?
  - Would this cause channel shifting?

Residential Products:

- Are there spillover effects of product support onto other measures? Is PA support of certain energy efficient products creating an uptake in other efficient products?

Residential Heating and Hot Water Equipment:

- Moving people to condensing equipment
  - How can programs influence people to change from non-condensing to condensing equipment?
    - Incentive levels and structure?
  - What's the appropriate baseline for that type of program design?
- High Efficiency Gas Water Heaters
  - Savings – do we capture standby losses accurately?
  - Instantaneous water heaters – are the savings correct?
- What is the baseline for Central A/C?
- Ducted cold climate HPs
  - Savings
  - Baseline
  - Contractor awareness and installation practices
- What are true incremental costs and lifetimes of equipment?
- Are there upstream program design needs?
- Are there market effects that need to be considered in NTG?

Home Energy Services:

- What can we learn from further mining and developing program delivery indicators?
- Are there non-DSM opportunities that could be integrated into the HES program (ex: roof top PV)?
- Can we improve the forecasting of net-to-gross (NTG) values for HES? How has the NTG for HES changed?

Residential Multifamily:

- How different are oil customers from gas customers?
    - Is leveraging gas research appropriate, or do we need oil-specific primary research?
- Why is there a difference in lighting installation rates between PAs?

3.2 OTHER 2016-2018 NON-RESIDENTIAL TOPICS OF INTEREST

Impact Evaluations:

- Custom gas
- Small Business Direct Install (DI) programs
- Usage of ductless mini-splits in C&I sector
    - What is true baseline?
- Pre/Post Evaluation[11]
    - Expand pre/post metering for controls oriented measures? (Previously did lighting controls, Variable Speed Drives (VSD))
- Review impact evaluation of other commercial behavioral program evaluations with goal of setting interim savings levels for future MA programs

Market Assessments:

- What customer characteristics or third-party data should be incorporated into future studies? What are the implications on other studies?
- How do energy use intensities (EUI) differ by geography and building type over time? What drives the differences?
- Can microbusinesses be targeted by behavioural initiatives, residential strategies or other approaches?
- Supply Side
    - How do we systematically collect data from market actors, especially sales data? What drives participation in data collection efforts?
    - What are the key characteristics of market actors for Heating, Ventilation, and Air-Conditioning (HVAC) controls and building automation, in particular knowledge and training?

Process Evaluations:

- How would the results of the mid-sized customer needs analysis change if multiple years of data were included in the analysis (e.g., incorporating impacts from upstream programs)?
- Are mid-sized gas customers being optimally served by existing programs and marketing strategies?
- How can we leverage the PA program tracking databases to inform marketing to mid-sized customers?
- What barriers are causing customers to drop out of the participation process?

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[11] During pre/post evaluation, on-site visits are coordinated to gather metered data before and after the installation of an energy efficient measure. Metered data, installation and operation information, and weather data, concurrent with the monitoring period, are used to calculate savings.

- Which HVAC technologies are best suited to an upstream program and why?
- How well does MA match up with other states in terms of trade ally best practices?
    - How do we address any identified barriers?
- Combined Heat Power (CHP) process evaluation
    - What are the barriers and lessons learned from previous MA CHP projects?
    - Are there CHP best practices in other states that can be incorporated into MA programs?

3.3 OTHER 2016-2018 CROSS-CUTTING TOPICS OF INTEREST

Behavior & Education:

- Can and should the measure life of behavioral measures be extended (i.e., do behavioral savings persist after the program/behavioral intervention has been suspended)?
- What are the energy saving opportunities for behavior-change models among different customer classes?
    - Examples of different types of customers: Small/Medium C&I, Large C&I, K-12, Higher Education, Low Income
- How can we foster emerging technologies that target behavior change to generate sustainable savings?
    - What is the opportunity for home automation (conservation, efficiency, DR)?
    - Which customer classes are the best targets for new technologies?

Statewide Marketing:

- What is the impact of having multiple competing brands and marketing campaigns promoting energy efficiency?
    - Examples: individual utilities, Mass Save, Energy Star
    - Are they mutually reinforcing? Do they compete with each other?
- What tactics are most effective for marketing energy management?
    - What has been done and what else could be done?
    - What tactics have other successful energy efficiency marketing campaigns used?
- What is the most appropriate marketing strategy for the Mass Save brand?
    - Broad based marketing that attempts to reach all customers versus targeted marketing that attempts to reach specific customers based on likelihood to participate in programs, energy savings potential, or other characteristics?
- Who are the appropriate targets for marketing the Mass Save brand?
    - What is the appropriate balance between targeting contractors versus customers?
- How should PAs define customer segments?
    - Demographics?
    - Attitudes?
    - Community?

Community-Based Initiatives (CBI):

- How can CBIs be used to enhance existing programs, engage more customers, and achieve greater energy savings per customer?
- What is the comparative effectiveness of the various CBI design elements in driving participation/greater energy savings per customer?
- What is the relative effectiveness of the various marketing and messaging strategies in inducing participation/greater energy savings per customer? How does the effectiveness of different marketing strategies vary by target audience/community?
- What are the effective community-based designs/models to engage non-residential and multifamily customers?
- What is the value of increased incentives in driving participation/greater savings per customer?

Top-Down:

- How can we address the key econometric concerns with top-down models going forward to make the results more precise?
  - How do we test hypothesis and discern incremental impacts?
  - How do we assess model specifications?
- How and when should we refine the current models and re-estimate?
  - How do we construct a PA-Municipal Utility model that will result in a tighter confidence interval around the savings resulting from programmatic activity (expenditures) by the PAs and Munis?
  - At what point would re-visiting the PA data model be desirable if we continue to compile PA tracking and consumption data going forward?
- What is the appropriate approach to bringing in data from other states to incorporate into a model?
- Should we construct different types of models and how can these different results inform program/policy questions?
  - Should the model type be focused on comparing electric use in PA service territories vs. municipal electric service territories?
  - Should the model type be focused on comparing Massachusetts to other states? What is the appropriate approach to bringing in data from other states to incorporate into a model?
  - Should the modeling efforts focus on other fuels besides electricity?

NTG/Market Effects:

- Updating baselines
  - How do baseline levels of efficiency of energy-using equipment affect NTG and market effects?
  - How do non-energy efficiency market trends affect baselines?
  - Measuring Upstream impacts comprehensively
- How do customers' structural characteristics affect NTG?
  - Should Memorandum of Understanding (MOU) customers and Chain/Franchise customers be treated the same as other customers in NTG calculations?
- Market effects for other types of equipment besides HVAC and Lighting
  - Building Shell, HVAC Controls, Whole House, Cooking, Boilers, Refrigeration
- Understanding changes in new construction market
  - Opportunity to understand program influence on low-energy buildings
- Should we move to systematic advance scheduled data collection?
  - Rolling data collection
  - Regularly timed data collection

4. PLANNED RESEARCH AND STRATEGIC ISSUES

Research highlighted in this Strategic Evaluation Plan includes studies which are in the Stage 1: Conceptual Framework planning stage (detailed descriptions of research stages can be found in Section 1.9). A number of these studies, particularly for C&I, are in the more advanced stages of Stage 1 plans. Note that studies that are already underway are not discussed here; this document, therefore, is focused on new, prospective research to get underway in late 2015 and in 2016-2018.

In addition, we do not view this as a definitive list of future studies, but as a roadmap for future research that was developed as part of the planning process. Some of the proposed studies may not make it past Stage 1, some may change significantly as they enter Stage 2 and Stage 3 work plan development; plus, new studies are expected to be added as priorities shift and new priorities arise over the next three years. As noted in Section 1.6, flexibility is one of the key principles considered when establishing the evaluation research portfolio.

As part of the evaluation planning process there have also been extensive discussions regarding strategic issues, including how multiple components of evaluation research fit together, key research questions that the proposed studies will address, and additional research areas that are not currently proposed but may be worth adding in the future. Examples of these are provided below.

4.1 RESIDENTIAL STRATEGIC EVALUATION ISSUES

Residential Customer Profile Study

The Residential Customer Profile Study (RCPS) compiles PA, implementer and third party information into a central database that can be mined for insight on patterns, trends or insights such as the:

- Distribution of program participation
- Distribution of savings by region
- Savings by market segments or demographic characteristics

The first RCPS report was finalized in October 2015 presenting the results of the analysis of the 2013 programs. Future iterations of the report will include an assessment of multi-year patterns and trends.

Advantages

The immediate objective for the RCPS is to illustrate the accomplishments of the PAs' energy efficiency programs. The ultimate possibilities for this study include:

- Details and analysis that enable the PAs and implementers to optimize program design and delivery.
- Data to support models that predict program participation, savings, net-to-gross ratios and customer satisfaction.
- Transparency to stakeholders and the public on the effectiveness and return on investment for energy efficiency in Massachusetts.

Going Forward

As additional years of program data and additional sources of data are collected, new hypotheses can be tested and questions researched. Examples include:

- How are savings by PA in a given year being impacted by previous program participation (saturation)?
- How is savings distribution impacted by housing type within census regions?
- What is the theoretical remaining opportunity for savings in different regions or territories by program?
- Based upon previous program participation and adoption, where should implementation be focusing efforts?

Home Automation Research

Home automation as an energy management strategy is becoming increasingly popular as a variety of home energy management systems (HEMS) enter the market. A 2015 HEMS market characterization identified 244 HEMS products available, ranging from smart controls for lighting, HVAC, and appliances to load monitoring and energy analytics software that can be integrated with renewables and energy storage. According to a 2015 market outlook, home automation product market revenue is expected to grow significantly in the coming years, from $7.3 billion to $67.7 billion between 2015 and 2025.

Key opportunities for evaluation in home automation include:

Creating Savings Opportunities. HEMS provide new opportunities for controlling home devices to save energy and reduce peak loads. One example is smart thermostats. Smart thermostats use occupancy sensors or geo-location services with background algorithms to learn user behavior and automatically control heating and cooling. By doing so, they can automatically reduce heating and cooling when the home is unoccupied and take advantage of savings without compromising comfort. In addition, they provide a platform for utilities to administer direct load control, behavioral demand response, and pricing programs that can reduce peak demand.

Identifying New Savings Opportunities. HEMS products provide opportunities to identify underperforming equipment in the home. The performance data collected on smart thermostats, for instance, can be used to diagnose poorly performing HVAC systems or leaky homes. By identifying opportunities for energy-efficiency improvements, they can help program administrators target energy-efficiency program offerings to the appropriate customers.

Accelerating EM&V. Many HEMS products provide an alternative EM&V method by collecting interval data, even in the absence of advanced metering infrastructure. These interval data can be leveraged as an EM&V tool to evaluate savings from measures installed in a home or demand savings from direct load control, demand response, or pricing programs. In addition to energy data, some provide other appliance performance metrics, such as system run time or home temperature. With intervals often at the one-minute level being collected on a real-time basis, program EM&V can benefit both in terms of speed and rigor. Analysis of these data can also help identify program issues mid-cycle, such as problems with contractors or underperforming measures, so they can be fixed mid-cycle.

Engaging Customers and Enhancing Services. Home automation can also help engage customers while providing them with an energy management service they are already looking for. Results from a 2014 home automation market survey, including data collection nationwide, indicate that consumers are already interested in opportunities to save energy through home automation. The study found that “automated energy savings” was the number one reason survey respondents were considering home automation. By engaging customers with an energy management technology they are already interested in, program administrators can initiate a re-engagement cycle to improve programs and maintain customer participation.

4.2 COMMERCIAL AND INDUSTRIAL STRATEGIC EVALUATION ISSUES

C&I Customer Profile Project

The annual C&I Customer Profile project analyzes PAs’ billing and tracking data to provide nuanced insights into the population and participation trends characterizing the Commonwealth’s C&I energy efficiency programs. The foundation for this analysis is the C&I Evaluation Database—a tool supported by the PAs and EEAC Consultants, and developed by the non-residential evaluation team—which collects and standardizes multiple years of data from all Massachusetts gas and electric PAs. This database provides clean data sets to contractors conducting evaluation studies in the C&I, residential, and cross-cutting research areas.

Each year (since 2012, using 2011 data) a Customer Profile report is published to present an up-to-date view of C&I program trends, including the types and quantities of customers participating and contributing the most program savings. Statistical trends are reported for a range of metrics at different levels of granularity—including statewide, by PA, and within PA—to provide both broad and detailed views of the C&I efficiency landscape (see the figure below for a visual representation of this analysis).

The PAs and EEAC can also query the C&I Evaluation Database to obtain efficient, data-driven answers to ad hoc research requests, and the current Customer Profile project (using 2011-2014 data) includes a new task whereby DOER is provided with granular data for analysis (while still maintaining customer-level confidentiality). As part of this ongoing project, the non-residential evaluation team has introduced a series of monthly working group meetings with the PAs and DOER to review preliminary results, troubleshoot potential issues early in the process, and expedite project completion to provide timely insights to program implementation teams.

Advantages

The C&I Customer Profile project provides valuable features that help to improve the efficiency and performance of the Massachusetts non-residential programs. These features enable the PAs and EEAC to:

- Examine changes over time. The C&I Evaluation Database is populated with four years of consistent, standardized PA billing and tracking data. This data is updated and cleaned each year to support reliable, up-to-date comparisons of program participation and savings over time (e.g., savings achieved by the Healthcare sector between 2011 and 2014).
- Ensure confidentiality. The annual Customer Profile studies preserve PAs' customer and IT system confidentiality while allowing PAs to evaluate how their standardized data compares to the standardized data for other PAs and the state as a whole. The data transfer site allows for efficient, secure data transfer with PAs, other evaluation firms, and stakeholders.
- Pinpoint savings opportunities. PAs' billing and tracking data is supplemented with GIS libraries and tax assessor data to identify and target specific areas and customers with high savings potential. Maps from the 2014 Customer Profile report show that the Accommodation and Food Service sector had consistently higher energy use intensities (EUIs) on the Cape than in any other region of Massachusetts. This may represent an opportunity for account-level targeting for efficiency measures, or a more blanketed marketing push.
- Enforce timeliness and coordination. Over the course of four Customer Profile studies, the non-residential evaluation team has refined its approach to ensure regular communication and early presentation of results. This engagement has led to shorter timelines, deeper PA insights into trends and findings, and more advanced analysis.
- Efficiently identify and analyze research questions. The annual Customer Profile reports often identify key researchable questions for subsequent study, and the C&I Evaluation Database provides a common collection and storage point for data that can be leveraged across all non-residential evaluation activities, including impact evaluations, market assessments, and process evaluations. Using a common data source also ensures consistency and comparability across studies.

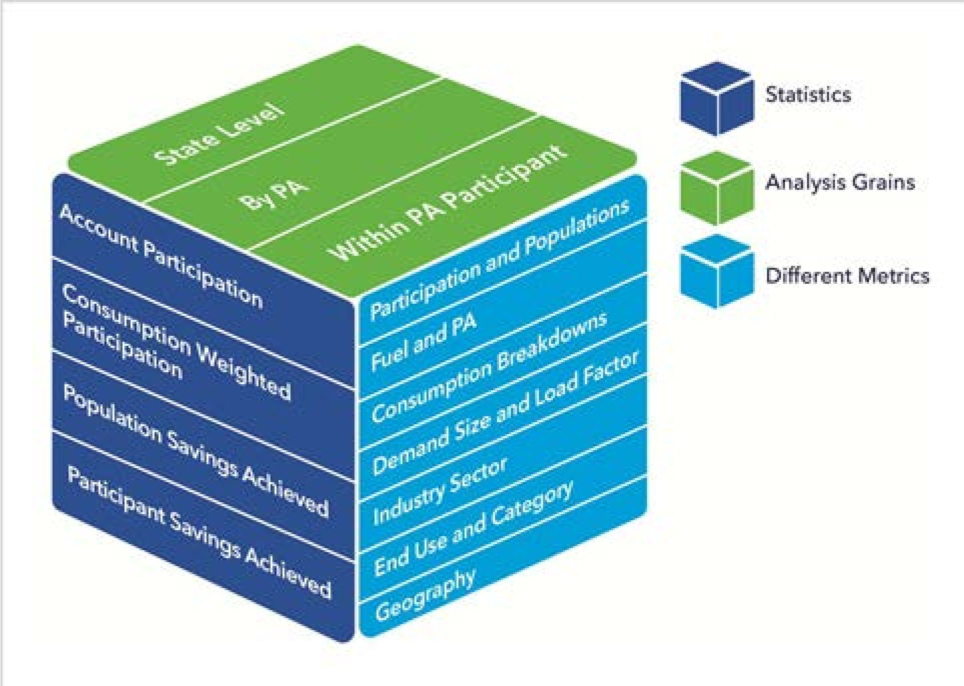
Going Forward

In early 2015, the non-residential team investigated the feasibility of integrating new, third-party data attributes into the C&I Evaluation Database to enable even greater analysis capabilities and the generation of customer-level views (as opposed to account-level views) across PAs and fuels. These enhancements are a prerequisite for conducting more advanced analyses, including:

- Identifying opportunities for deeper measure-level penetration
- Developing profiles of customers who are likely adopters
- Developing a predictive model to quantify the likelihood of measure adoption and expected savings based on customer-specific traits across PAs and fuels
- Building a more comprehensive picture of likely customer attitudes towards efficiency offerings that can be leveraged by additional PA teams, including marketing and account managers

These types of analyses can provide a more complete picture of how different accounts are related to each other, a better understanding of the characteristics of individual accounts, and greater clarity and more focused/actionable recommendations that the PAs can pursue to increase their return on efficiency investments. Database enhancements will also allow the PAs and EEAC to more effectively evaluate the integration of electric and gas programs.

Visualization of the Analysis Cube used for the Customer Profile Report



Refinements to Gross Impact Evaluation Framework

This initiative seeks to refine and more fully document the approach used to determine which Massachusetts C&I impact evaluation studies to undertake, at what level of rigor, and when.

Focused on impact evaluations, this effort is an outgrowth of the substantial planning and documentation work undertaken by the PAs, EEAC Consultants, and non-residential team in Annual Planning meetings (since 2011), in the development of Massachusetts Statewide Electric and Gas Energy Efficiency Evaluation Plans (since 2013), and in evaluation studies quantifying the energy savings impacts of Massachusetts energy efficiency programs for more than two decades.

Historically, evaluators have considered the proportion of savings from programs/measures, proportion of dollars invested, uncertainty, the last time programs/measures were evaluated, and other key factors to identify good candidates for impact evaluations and the appropriate level of rigor for each study. While this approach uses sound logic, the PAs and EEAC Consultants recognized the need for a better-documented decision-making framework and "roadmap" to maximize the value of impact evaluation studies now that the statewide C&I programs and evaluation framework have matured.

This initiative will enable the PAs and EEAC Consultants to:

- Identify and resolve the sometimes-competing priorities that affect planning decisions. The contractor team will document the full range of stakeholder objectives for impact evaluations, and will work with the PAs and EEAC Consultants to prioritize these objectives to more clearly guide future planning decisions.
- Save time and effort by developing a consistent set of indicators and a scoring system to substantiate future research decisions. A preliminary list of indicators developed by the evaluation team includes the following:
    - Relative magnitude of savings tracked or expected from the study population compared to the portfolio
    - Time since the study population was last researched

  - Amount of variability in historical impact evaluation results
  - Changing and/or new technology
  - Confidence in tracking savings value
  - Confidence in utilized evaluation results
  - Confidence in measure or project baselines used
  - Changing industry standard practice, code, baselines
  - Changes in program delivery
- Efficiently determine the appropriate analytical method and level of rigor for each study. The initiative will document various research methods, and the benefits and drawbacks of each method—including which evaluation objectives they achieve well. This resource will enable the PAs and EEAC Consultants to quickly and systematically assess the best approach for each study.
- Establish a uniform process and terminology to assess evaluation needs. In order for the PAs and EEAC Consultants to implement a successful approach to planning, the group needs to be able to articulate why it makes sense to pursue a specific research scope at a given time. The final document delivered as part of this project will establish shared terminology, describe the agreed-upon approach for planning impact evaluations, and provide basic instructions on how to follow it. While moving more toward standardization, the recommended approach will include sufficient flexibility to account for exceptions.
- Improve planning in other research areas. While this initiative is primarily focused on improving planning for C&I impact evaluation studies, the research and documentation can be leveraged to improve planning in other research areas, as well.

This project is currently under development, with the PAs, EEAC Consultants, and Evaluation Contractor actively discussing the issues involved and determining the appropriate method to resolve some threshold issues. For these reasons a specific Stage 1 Work Plan is not included in this document. The evaluation team expects to be fully engaged in this process by the first quarter of 2016 enabling them to utilize the results of this effort as the 2016 year progresses.

Refining the Framework and Practices for Establishing Baselines

Equipment, operations and energy consumption baselines are the foundation for accurate energy savings estimates. Baseline assumptions must be made on an ex-ante basis in the planning stage, and then often vetted on an ex-post basis in the evaluation stage. The rules for establishing ex post baselines should follow principles that apply to all programs, both gas and electric, prescriptive and custom. Impact evaluations have produced a variety of scenarios over the years requiring the development of principles and protocols which are reflected in practice. Evaluators, PAs, and the EEAC consultants have observed inconsistency in baseline characterizations and the methods used to determine them. In response to some of these inconsistences, the Baseline Working Group has been established by the Evaluation Management Committee to clarify new construction or end-of-life baselines where code applies.

In coordination with the efforts of the Baseline Working Group, the C&I Evaluation Team will develop a document articulating the principles by which evaluation baselines are defined and used to calculate savings and the process by which baselines are set for C&I measures (although the effort will be coordinated with the residential sector and it is expected the document could be leveraged for residential programs). The document will be a concise definition of terms, statement of principles, and outline of procedures. This is intended to be a short, living reference document. Since it is expected that there may be differences of opinion about what these principles and protocols should be, a stakeholder process will be required to reach a final decision.

The C&I Evaluation Team’s efforts will address the following methodological approaches and/or questions:

- What are the baseline assumptions built into baseline system forecasts, the EEAC goal setting and planning?

- Where code exists, is baseline for new construction/normal replacement code or standard practice or something different, such as a hybrid? (This will be informed by the Baseline Working Group findings.)
- Where code does not exist, should the baseline be standard practice or the lowest cost, feasible, reasonable alternative?
- What is the best way to account for late in life replacements – dual baselines or through some other mechanism?
- What is the protocol and evidentiary standard for establishing a measure as an early vs. normal replacement?
- For early replacement, how should the remaining useful life (RUL) and incremental cost be calculated?
- What is required by implementation to define the specific existing conditions for a site?
- What is the protocol for establishing a market baseline (either standard practice of least cost, feasible, reasonable baseline)?

The study activities will include research and documentation of practices in other jurisdictions, a definition of the Massachusetts landscape (current practices where there is consensus and those areas where clarity is needed), a straw man proposal including presentation of multiple options/opinions, facilitation of a stakeholder process, and production of a final baseline document meeting the needs of the stakeholders.

4.3 CROSS-CUTTING STRATEGIC EVALUATION ISSUES

There are a variety of methods that can be used to estimate net savings attributable to the PAs' programs and they all have pluses and minuses. Traditionally, net energy savings have been computed using a bottom-up approach that incorporates a range of techniques to estimate net energy savings for individual measures/end-uses, programs, or groups of programs. However, this bottom-up approach is likely not fully capturing all the net impacts because programs are large, interactive, and may extend more widely than just to program participants, making it difficult to isolate the effects of any one program using just a bottom-up approach.

In response, the cross-cutting evaluation team investigated the following four different methods of estimating net savings over the past three-year cycle in MA.

- Participant self-report net-to-gross studies use a bottom-up approach to estimate net energy savings for individual measures/end-uses, programs, or groups of programs. Specifically, these studies provide estimates of free-ridership and like spillover at the end use, program, and PA level through interviews with program participants and trade allies.
- Market Effects. Market Effects studies seek to find evidence of and measure spillover savings from program-induced changes in the structure of the market. Market effects measurement recognizes that programs can also drive non-participant savings through market effects that are not captured by program project measure tracking or participant NTG evaluation. Market effects are an important part of broader net-to-gross evaluation research that if identified, may lead to significant additional program savings.
- Code Compliance Support Initiative (CCSI). The code compliance evaluation seeks to find evidence of and measure net savings attributable to the CCSI for improving code compliance in MA through various avenues over the long term. Codes and standards create a confounding influence on top-down, participant NTG, and market effects as savings may also be driven by compliance to codes and standards that are due to the PAs efforts in improving compliance.
- Top-Down Modeling techniques use a holistic approach by estimating program impacts across all energy-efficiency programs in a given geographical region or service territory, rather than running separate studies for each program (or measure/end-use within a program). Top-down models attempt to measure changes in energy consumption over time that are attributable to programmatic interventions by the utilities. Top-down methods are capable of capturing the full program effect, including free-ridership, spillover, market effects, and snapback.

These four cross-cutting topic areas are interrelated. The Top-Down evaluation area describes the net effect of all the PA programs and efforts on changes in total utility consumption. However, the underlying drivers of these net savings are better understood by using other methods to estimate net savings. These include participant NTG surveys, estimation of market effects, and estimation of savings attributable to codes & standards support. Taken together, these four topic areas identify program-driven savings in programs and markets in areas that overlap and provide different explanations for the net savings.

Although distinct from energy and demand savings, the fifth cross cutting area investigated over the past three year cycle included studies on non-energy impacts. Non-energy impacts play an important role in PA programs. Non-energy impacts may be positive or negative, but understanding their role in customer decision making and how the programs may be driving or utilizing non-energy impacts has two aspects relevant to broad top-down, participant NTG, market effects, and code support. First, non-energy impacts can influence decision making and thus affect the net savings of programs. Second, non-energy impacts can have a significant impact on program cost-effectiveness as a portion of costs or benefits captured in the total resource cost test or societal cost test.

Key Net Savings Research Areas

As the PAs continue to conduct NTG studies over the next three-year program cycle, it will be important to continue to refine net savings methodologies and measurement to ensure that savings attributable to the programs are being fully recognized, as well as to provide program staff with actionable information they can use to refine and improve the effectiveness of their programs.

Given the current state of evolution in the PAs' program portfolios and NTG methods, methodological guidance, informed by research into current best practices, should be explored on the following issues.

- Identification of Best Practices for NTG Evaluation of New Program Types
- Definition of Evaluation Domains and Avoidance of Double Counting Savings
- Combining or Selecting among the Results of Alternate Methods for Estimating Net Savings for a Single Program

Key Market Effects Research Areas

Market effects evaluation may identify program-attributable savings that are not currently being captured by the evaluation teams and credited to the program. Efforts to establish market effects research are underway and will continue to expand during the 2016-2018 plan cycle. With success in the HVAC markets, additional markets may be considered in the 2016-2018 plan cycle, with the PAs and the various evaluation teams collaborating to identify and assess additional promising markets and technologies. The PAs plan to consider a variety of activities for the 2016-2018 plan cycle, including:

- Expanding Market Actor Panels to HVAC Contractors (and Distributors)
- Including Additional Technologies and Markets in Market Effect Evaluation Activities

Key Codes and Standards Research Areas

Codes and Standards Initiatives in Massachusetts have the potential to increase compliance with the energy code and/or enhance the stringency of the codes and standards, both of which could save energy and have the potential to drive an increasing level of savings relative to traditional new construction programs. It is important to evaluate Codes and Standards Initiatives, both because the potential savings are large, and because they prevent a lost opportunity—i.e., it is much more expensive and time-consuming to retrofit a building than to incorporate efficiency measures when it is first built. Also, some of those savings from Codes and Standards Initiatives may overlap with the savings estimated for other programs, necessitating the need to eliminate double counting. The

PAs have identified several strategic research areas for codes and standards evaluation efforts during the 2016-2018 plan cycle, including:

- Continue and Expand Ongoing CCSI Evaluation Activities
- In-depth Interviews with Market Actors
- Comparison of PA and Municipal Residential New Construction Markets
- Stretch Code Support Initiative Evaluation
- Standards Advocacy Evaluation

Key Top-Down Modeling Research Areas

Top-down models are econometric models used to measure the effect of energy efficiency programs on aggregate energy consumption, while accounting for the effects of fuel prices and other factors. The goal of this type of modeling is to isolate the effect of program activity from natural changes and other policy variables. Typically, these methods are applied separately for the Residential and Commercial-Industrial sectors. The analysis looks at the variation in consumption (e.g., per household or per employee) across time periods and across geographic units (e.g., service territories, towns, counties, or states). The consumption is modeled relative to some measure of program activity, along with non-program factors. Top-down methods, in principle, measure the full impact of a program portfolio, including free-ridership, spillover, market effects, combination effects across programs and years, and snapback. Many of these effects are difficult to measure accurately at the program-specific level.

The prior study was successful in laying the groundwork for on-going research by identifying the data requirements and key statistical issues for future research activities. Over the next three years, research efforts should focus on three key activities, with a possible fourth given co-funding outside of Massachusetts:

- Data Compilation
- Exploration of Key Econometric Concerns
- Model Refinement and Testing
- Partnering Opportunities to Expand the Models beyond Massachusetts

Key NEI Research Areas

Estimating NEIs provides utilities, regulators, and customers with valuable information when designing, promoting, implementing, and evaluating energy efficiency programs. In Massachusetts, PAs are allowed to use NEIs as a supplemental source of benefits in regulatory cost-effectiveness testing. Promoting the positive NEIs of a measure or mitigating negative ones can also be important in program design and implementation.

To date, the PAs have focused on select participant NEIs that can be quantified using relatively objective techniques. However, the existing NEI literature suggests that there may be substantial yet unmeasured participant and societal impacts. Many of these benefits are more abstract in nature and estimation techniques for them may be more subjective. Nevertheless, there is ample literature that suggests these impacts exist, may be substantial, and may be measurable.

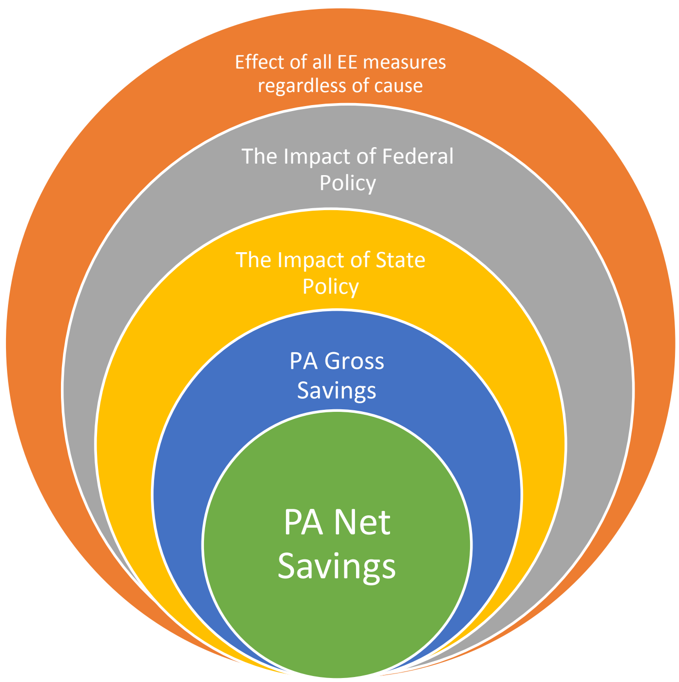
In the 2016-2018 plan cycle, the PAs will investigate several priority topics related to NEIs, including:

- Health and Productivity Impacts
- Market Rate Rental Properties
- Water and Non-utility Fuel Impacts
- Combination Engineering and Survey Based Estimation Approach

Potential Environmental Assessments

Stakeholders and PAs have requested an evaluation effort to better quantify all savings that are used in the calculations of greenhouse gas (GHG) emissions reductions that “are real, permanent, quantifiable, verifiable and enforceable" and should be counted that occur due to program efforts. The PAs can, to a large extent, reliably quantify how energy efficiency savings as reported under the GCA contribute to GHG reductions. There are concerns, however, that the limitations of reporting under the GCA may mean that their quantification does not account for all verifiable emissions savings. The Evaluation team has identified several layers of research, as shown visually in the figure below, that could be studied to determine their impacts on emissions[12]. These include, at increasing scale:

- PA net savings (currently calculated and reported)
- PA gross savings (total amount of energy savings regardless of attribution)
- PA gross savings plus the impact of additional Massachusetts public policy initiatives (e.g. GCA impact on consumer adoption of EE measures)
- The prior categories plus the addition of federal policy impacts (e.g. ARRA funding impact on weatherization programs)
- The effect of all EE measures on emissions without regard to cause (i.e. determining the total amount of the reduction in emissions without concern for for whether or not they were generated by PAs, state policies, federal policies or other causes). This may extend to impacts on the electric system beyond state borders).



The implication for PA research differs depending on the scale at which EE impacts would be analyzed. For example, a smaller gross savings analysis may look at the Gas Heating and Cooling program. While the PAs

[12] Note that the smaller circles are not meant to represent a subset of the larger circles (e.g., PA gross savings are not normally all captured under state or federal policies), but instead represent the typical magnitude of the expected impacts of the different sources of EE measures on emissions reductions. So note the figure is a simplification for illustrative purposes, and the actual relationships between the five levels are more complex than depicted.

quantify the incremental savings that result from incenting a natural gas customer to purchase a new high-efficiency furnace rather than a new standard-efficiency furnace, the PAs do not quantify the emissions reductions related to that customer transitioning from their old oil furnace to a new gas furnace. While those savings may or may not be attributable to EE efforts, the savings are not being counted in other areas and if they can be estimated can help better quantify the impact of the Massachusetts energy efficiency efforts on reduction of GHG emissions.

If a larger scale view is preferred, other research, such as investigating impacts from a top-down approach may be needed. In addition to the question of scale, there was discussion about the nature of the research and that research may need to extend beyond the traditional bounds of the utility system. Quantifying environmental benefits is a specific goal of the GCA and an important goal of the Commonwealth. Accordingly, the PAs will explore efforts through EM&V activities, with the support of the Council's independent EM&V experts and planning consultants, as well as DEP and DOER, to better quantify both the energy impacts used to determine climate and air quality benefits, and the estimates of other environmental benefits. This study could allow the Commonwealth to reassess the accounting of the GHG emission reductions attributable to energy efficiency. The PAs propose to complete this study before the filing of their 2019-2021 Plan.

5. STAGE 1 WORK PLANS

Through a collaborative process between the PAs and the EEAC consultants, the wide variety of topics that were developed during and following the Planning Summit were narrowed down and prioritized into a series of Stage 1 work plans. Those work plans are presented in this section and are organized by research area – Residential, Non-Residential, and Cross-Cutting. It should be noted that not every work plan presented in this section will be turned into a formal study that will be completed in the short term. Conversely, topic ideas that do not have a Stage 1 work plan at this point may actually go through the entire planning process and have formal studies completed in the near term. The point of this section is to illustrate those topic ideas that will most likely be studied in the near term but this is not meant to be an exhaustive list. Additionally, budgets, scopes, and research methodologies are all tentative until they are solidified in the later stages of study planning, and the staging of the listed studies is still under discussion.

5.1 RESIDENTIAL STAGE 1 WORK PLANS

Study Name: Residential Baseline Study (RES 1)
Research Area: Residential
Type of Study: Market Assessment
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

For this study, saturation and penetration data will be collected for all major appliances, mechanical equipment, and electronics in a home. These data will support energy savings calculations for program evaluation and design, as well as provide additional insight on the savings potential in the existing residential homes market. Depending on stratification, a sample size to of 300 to 400 homes will most likely be appropriate.

In designing this study, there are a several options to consider:

- Sampling from the general Massachusetts residential population;
- Targeting specific residential sub-sectors (single-family, multifamily, or manufactured homes).

An additional activity (with a relatively low incremental cost) would be to join in a multi-jurisdictional study to explore using nonintrusive load metering (NILM) to collect data for whole premise electric loads. These data would then be disaggregated into appliance-level loads. This NILM meter could be quickly and easily installed on the outside of a home's existing meter to capture minute and sub-minute electricity consumption where AMI house-level data are not available.

High-Level Description of Approach/Methodology:

Task 1: Develop Sample Design:

Determine study sample frame (i.e., single-family, multifamily, manufactured homes, or combination).

Task 2: Recruit Customers:

Customers will be recruited utilizing the telephone, mail, and the internet. A brief survey of demographic and home characteristics will be administered, to ensure sample quotas are met.

Task 3: Conduct Site Visit and Install Meters:

Site visits will take to capture information on key house characteristics, such as building frame, mechanical, lighting, appliances, and windows. During those visits technicians will install NILM meters on the revenue meter. For a sample of homes, meters will also be installed on electrical panels to develop a baseline for metered appliances for comparison to the disaggregated data to determine accuracy levels.

Task 4: Perform Meter and Data Analysis:

Analyze audit data gathered through all site visits, such as appliance and mechanical equipment, and develop penetration and saturation levels. Where applicable, compare these results to the previous building and appliance stock in Massachusetts for trends and changes. After approximately six months, analyze the whole-house meter data and develop specific appliance and mechanical load profiles.

Task 5: Reporting:

Present results to interested stakeholders. Develop a report outlining the sampling methods, audit collection protocols, and baseline results.

Value Proposition:

Baseline studies are important to conduct periodically to measure changes in customer appliance and building characteristics. Data collected through this study will provide a wide range of benefits, including improved estimates of market characteristics, demonstrating trends in adoption and providing insight into consumption characteristics for specific residential segments. Additionally, benefits of including NILM in the baseline study are:

- Capturing measure-level load shapes that can be used to establish residential appliance load profiles and coincidence factors;
- Providing the Massachusetts Program Administrators (PAs) with a method to align energy-efficiency demand-reduction efforts with specific end uses to optimize carbon emission mitigation;
- Providing the basis for future low-cost metering studies for multiple measures simultaneously; and
- Standalone, or when coordinated with key home energy management studies (e.g., automation), allowing for an increased level of savings detail on individual technologies and a greater understanding of interactive effects.

Potential Budget: $550,000 - $650,000

Study Name: MA Consumer and Saturation Survey, Including Panel (RES 5)
Research Area: Residential
Type of Study: Market Characterization/Assessment
Applicable Fuel(s): Electric

Overall Study Goals:

The goals of this study are to update estimates of lighting saturation and assess consumers' knowledge of and interactions with the lighting market in Massachusetts. As an optional add-on, the Team could expand the on-site data collection for new visits and panelists to include data to support the *Residential Baseline Study* (RES 1).

This study will provide the PAs with updates on critical lighting market indicators, while increasing their understanding of the current and evolving state of the market, especially as related to the continued expansion of the LED market and full implementation of the incandescent phase-out component of EISA. This study will also provide the PAs with information applicable to program planning and implementation in the face of declining delta watts and measures lives.

Research Questions:

The research questions listed below will allow for the continued tracking of some prior critical market indicators, and for examining emerging issues related to changes in the lighting market brought about by technological change and increased efficiency standards. Because practical issues such as budget, timeline, and respondent fatigue (i.e., surveys and on-site visits could become too long) may limit the number and depth of topics the Team is able to explore, the Team will need clear guidance from the PAs and EEAC Consultants about which of these issues is most critical.

- Examine socket saturation, including the presence of linear fluorescents
- Determine (via a panel study) what types of bulbs consumers use to replace those that burn out or removed
- Estimate in-service rates (ISRs) over time to the extent allowed through examining bulbs installed, in-storage, and newly purchased during panel home visits
- Provide information on various savings parameters such as delta watts, early replacement, and take back
- Explore possible ways of assessing measure life (especially given the expected long-life of LEDs), hard-to-convert fixtures, and non-energy impacts (NEIs)
- Assess customer awareness, purchase, use, and storage of energy-efficient bulbs, and their connection to the Residential Lighting Program participants
- Understand consumer decision making regarding bulb purchases and uses (e.g., pricing, preferences for room type)

High-Level Description of Approach/Methodology:

Task 1: Administer Consumer Surveys and Recruit On-Site Participants:

For this task, the Team will continue tracking key lighting market indicators for CFLs and LEDs, and documenting consumer responses to EISA. During the consumer surveys, the Residential Evaluation Team will also recruit participants for the new on-site saturation visits. The Team anticipates using a pre-paid incentive and mixed mode delivery, similar to the last two survey waves.

Task 2a: Conduct On-Site Saturation Visits:

Through on-site visits at 150 newly identified homes, socket saturations will be measured by type, location, and style of bulb and fixture; estimate the number of efficient light bulbs in use and in storage will be catalogued; evidence of stockpiling incandescent bulbs will be documented; and any other factors affecting lighting purchase behaviors will be recorded.

Task 2b: Conduct On-Site Panel Visits:

Households will be revisited that previously took part in on-site visits to understand bulb purchase and replacement behavior. This will include 354 households, first visited in 2013 (89), 2014 (114), or 2015 (151). Of these possible households, approximately 270 panelists may be interested in continuing the study.

At panel study homes, the evaluators will continue to test for possible reactive effects on bulb purchase and replacement behavior and on participation in other PA programs.

Task 3: Reporting

Key patterns, findings, and recommendations across all the evaluation tasks described above will be summarized. These results will be incorporated into an overall annual report together with all other lighting evaluation tasks.

Value Proposition:

Since 2002, the PAs and EEAC Consultants have fielded consumer surveys with Massachusetts consumers almost annually (and sometimes semi-annually). While the content and population of interest for these surveys has varied, they have yielded the longest, continuous time series of data on residential consumer use, awareness, understanding, and purchase of energy-efficient lighting in the nation.

For the 2015/2016 consumer survey effort, the Residential Evaluation Team will expand the existing series of data at a critical time in the lighting market, as the recently implemented—and looming new—efficiency standards limit the annual and lifetime savings per bulb, and LED sales and adoption continues to rise as prices fall. Informed program planning and implementation will require a careful assessment of trends in the lighting market that give the PAs and EEAC Consultants an understanding of how the market will respond to programmatic change, and perhaps most critically, if and when to exit the residential retail lighting market completely.

Potential Budget (Total):	$900,000 - $1,200,000
Base Study Budget:	$800,000 - $1,000,000
Incremental Budget:*	$100,000 - $200,000

* This incremental budget is for *Residential Baseline Study* (RES 1) data collection, with the data analysis and reporting costs included in that study's budget.

Study Name: New York Saturation Comparison Study, Including Panel (RES 6)
Research Area: Residential
Type of Study: Market Characterization/Assessment
Applicable Fuel(s): Electric

Overall Study Goal:

The goal of this study is to continue assessing lighting market trends in Upstate New York to understand how the market has responded to the ongoing absence of incentives from NYSERDA for all residential light bulbs (CFLs and LEDs, standard and spiral).NYSERDA ceased offering standard CFL incentives in 2012, and stopped all support for specialty CFLs and LEDs in December 2014, so New York serves as an optimal comparison area for Massachusetts to understand the "counterfactual" of what Massachusetts lighting sales might look like in absence of program support. The Team performed telephone surveys and on-site visits in 2014, which revealed critical differences in the rates of lighting market changes between Upstate New York and Massachusetts from 2013 to 2015. The Massachusetts market exhibited statistically higher rates of efficient bulb saturation for both CFLs and LEDS in 2015 compared to 2013, while the total efficient bulb saturation in Upstate New York remained relatively static (with CFL saturation dropping and LED saturation increasing from 1% to 3%).

Given the demographic similarity between the two states and the timing of NYSERDA's cessation of incentives, this study will provide continued and important insights into the impact of the Massachusetts program post-EISA. On-site visits in New York require substantial budget, and NYSERDA and the electric utilities in the state have not been willing to co-sponsor the research. Therefore, the Team offers two options for the timing of this task, and discusses the possibility of performing a panel study (which will also affect the choice of timing).

Research Questions:

With this study, the Team seeks to:

- Continue tracking consumer purchases of efficient light bulbs in the absence of program incentives;
- Compare consumer purchase and saturation trends between Massachusetts and New York to determine if they continue to diverge; and, if so,
- Determine whether the lack of NYSERDA incentives contributes to these divergences in efficient bulb socket saturation and household penetration between New York and Massachusetts.

High-Level Description of Approach/Methodology:

Task 1: Finalize Work Plan:

Feedback from the PAs and EEAC Consultants is needed on two issues:

1. **Timing of the data collection:** The data collection and analysis for any lighting on-site saturation studies is expensive—and these expenses are typically higher in comparison areas because potential participants have no direct investment in the outcome of the study (i.e., they are not Massachusetts residents). The expense—and the fact that the last New York study also occurred at a two year interval—suggests planning for field collection in late 2016 and early 2017. However, with rapid changes in the lighting market and the possibility that either NYSERDA or the electric utilities in the state could choose to offer lighting incentives again, it may be better to collect data in New York in late 2015 and early 2016, coincident with the planned timing for Massachusetts field collection.
2. **Potential panel study:** The PAs and EEAC Consultants have expressed a high level of satisfaction with the Massachusetts lighting panel study and related insights gained. In fact, the Residential Baseline Study (RES

1) panel includes the potential for expansion to include other products. This task could include a panel in New York: the Team prepared homes visited in 2015 for a panel study by marking bulbs installed and in storage and following a set of protocols meant to facilitate return visits.

The Residential Evaluation Team would also need to recruit new homes to replace those who decide not to let us revisit their home or are otherwise unavailable. The sample of new homes will also allow us to test for any reactive effects of being a study participant.

Panel studies work best with annual visits, which limits drop-outs and possible study contamination. The panel will require regular—and somewhat substantial—investments in on-site visits in both New York and Massachusetts. Therefore, while there is value in tracking bulb replacement behavior and saturation in the same homes over time in both states (despite whether the New York electric utilities or NYSERDA restart incentives), it may not be cost-effective.

Task 2: Conduct Recruitment Surveys:

The Team will conduct short (seven to 10 minute) random digit dial telephone surveys with residents of select areas of Upstate New York and Westchester County (n=400), based on a sample of landline and cell phone numbers. The Team will work with the PAs and EEAC Consultants to seek permission from the electric utilities and NYSERDA to mention their names during recruitment and to provide their call centers with information about the study in case customers call with questions.

Task 3: Perform On-Site Saturation Inventories:

The Residential Evaluation Team will conduct detailed on-site lighting inventories (n=150) in portions of Upstate New York and Westchester County. We anticipate that 65 of the 150 visits will be revisits, and 85 will be new visits. We recommend 150 visits because the 2015 sample of 101 households was inadequate to determine a ±10% statistically significant difference in CFL saturation between New York and Massachusetts. However, a sample of 125 homes would have yielded significant results; and 150 visits will provide greater statistical power in order to ensure the accuracy of results.

The Team will compare the results to those obtained in earlier lighting studies in New York and Massachusetts, continuing to track trends in the saturation, use, storage, and purchase of energy-efficient bulbs. If the PAs and EEAC Consultants decide to have the Team conduct a panel study, the Team will mark bulbs and collect the necessary information to identify bulb replacement behavior during future visits.

Task 4: Reporting:

The Team will summarize the New York and Massachusetts results from the same time period (2015/2016, 2016/2017, or both) in a high-level memorandum. We will then incorporate these results into the overall annual report that addresses all lighting evaluation tasks.

Value Proposition:

By understanding consumer reactions to the removal of incentives for CFLs and LEDs in New York, the PAs and EEAC Consultants would have critical information to help with program planning in the face of declining delta watts and measure lives stemming from the adoption of lower-wattage bulb types and EISA regulations. These data will inform decision of whether to continue CFL and/or LED incentives, for how long, and in what retail channels, which is critical to cost-effective program planning and implementation.

This study presents a rare opportunity for the PAs and EEAC Consultants to determine what might happen in Massachusetts under a "no program" scenario based on a similar comparison area. While the study is expensive, the value is clear, with the greatest value gained by performing New York data collection coincident with Massachusetts data collection (in late 2015 or early 2016) and by convening a panel study in New York.

Suggested Timeline:

The work to develop a panel in New York would begin in the fall of 2015, with recruitment surveys fielded no later than November 2015 and on-site visits beginning no later than December 2015.

If the PAs and EEAC Consultants select to have no panel conducted, the recruitment surveys and on-site visits can be performed in late 2015/early 2016 or late 2016/early 2017.

Potential Budget: $355,000 - $430,000

Study Name: Lighting Supplier Interviews and Surveys (RES 7)
Research Area: Residential
Type of Study: Market Characterization/Assessment
Applicable Fuel(s): Electric

Overall Study Goal:

The Massachusetts PAs and EEAC Consultants have historically relied on supplier interviews with manufacturers, high-level buyers, and store managers to provide insights into the residential lighting market and the Massachusetts program, processes, and impacts. This study would build on past supplier interview feedback by tracking critical long-term market and program indicators, while also determining suppliers' assessments of the degree of market effect from the Massachusetts program (in terms of causing long-term, lasting changes to the structure and function of the lighting market).

Research Questions:

With this study, the Team seeks to gain suppliers' perspectives of these:

- Price and market share trends of various bulb types through 2020;
- Impact of the program on CFL and LED sales (including interim determinations of NTG, if desired);
- Degree of market effect from the Massachusetts program and its impact on the regional and national markets; and
- Effects of any specific design changes to the Massachusetts upstream lighting programs (such as the phase-out of specialty CFL rebates, reductions in the LED discounts, and a greater emphasis on hard-to-reach retail channels).

High-Level Description of Approach/Methodology:

Task 1: Identify Sample and Develop Sample Design:

Working with the PAs and their implementation contractor, the Team will gain access to recent program tracking data. We will use these data to identify the population of manufacturers, high-level buyers, and retail store managers who took part in the program through the fall of 2015, as well as to sales weight their price predictions and the NTG estimate.

For the Computer Automated Telephone Interview (CATI) survey of participating retail store managers, the Residential Evaluation Team will design a stratified sample to ensure adequate representation of all retail channel and bulb types. For Task 3 below, the Team will attempt to complete in-depth interviews with the full population of participating lighting manufacturers and high-level retail buyers.

Task 2: Develop In-Depth Store-Manager Interview:

The Team will work with the PAs and EEAC Consultants to prioritize interview and survey topics for store managers, paying attention to both the appeal of stakeholder input and the value of that input to understanding program processes and impacts, and to informing program planning, design, and implementation.

Task 3: Interview Manufacturers, High-Level Buyers, and Retail Store Managers:

The Team will conduct 25 in-depth interviews with participating manufacturers and high-level buyers (attempting to interview the full population of these program partners if possible). We will combine the results with the results from Task 4 in a memorandum, which will be integrated into the overall annual lighting report with results from all lighting-related studies.

Task 4: Survey Retail Store Managers:

The Team will perform 225 CATI interviews with retail store managers, or those most knowledgeable about lighting ordering, shelf-stocking, and purchasing patterns. We will combine the results with the results from Task 3 in a memorandum, which will be integrated into the overall annual lighting report with results from all lighting-related studies.

Value Proposition:

Over the past few years, supplier interviews have provided the PAs and EEAC Consultants with supplier perspectives on the current and emerging Massachusetts and national lighting markets, as well as with critical indicators of the importance of the Massachusetts program on the promotion of energy-efficient lighting. The PAs are likely ready to deprioritize some of the topics previously explored (such as partner program satisfaction, which has been consistently high), while other topics could be better addressed through a different evaluation design (e.g., the adequacy of the hard-to-reach definition). The Residential Evaluation Team will work with the PAs and EEAC Consultants to ensure that the Team focuses the 2016 interview questions on those of critical importance to program evaluation, planning, and implementation.

Suggested Timeline:

The Team would develop in-depth interview guides for manufacturers, high-level buyers, and retail store managers in the late fall of 2015 and conduct interviews in early 2016. We would develop the store manager interview guide in early 2016 and conduct interviews in the spring of 2016. We anticipate delivering the summary memo in the late spring or early summer of 2016.

Potential Budget: $175,000 - $240,000

Study Name: Market Adoption Model Update (RES 8)
Research Area: Residential
Type of Study: Market Characterization/Assessment
Applicable Fuel(s): Electric

Overall Study Goal:

This study will result in an updated market adoption model (MAM) with the most current lighting data available in order to illustrate the current and emerging status of the Massachusetts lighting market and to establish a delta watts estimate for general service CFL and LED residential lighting.

The residential lighting market is transitioning rapidly, which is accelerated by the federal phase out of most incandescent bulbs. EISA legislation has promoted the adoption of LEDs and encouraged a decrease in incandescent market share, as intended, but has also encouraged the adoption of inefficient halogens and decreased the market share of CFLs. By updating the MAM with the most current lighting data—from saturation surveys, supplier interviews, and lighting panel data—it will reveal how consumers are currently reacting to EISA, and allow the Team to estimate the rate of consumer adoption of various bulbs types through 2023.

A further goal of updating the MAM is to display the data graphically and provide corresponding explanations for stakeholders who may not use the spreadsheet-based tool but are interested in the model inputs, outputs, and uses.

Research Questions:

For this study, the 2015 MAM will be updated in order to produce a timely representation of the rapidly changing residential lighting market in Massachusetts and estimate current delta watts while predicting delta watts out through 2023.

High-Level Description of Approach/Methodology:

Task 1: Update the 2015 MAM:

The MAM will be updated with the most current Massachusetts lighting data on socket saturation data, bulb replacement behavior, and supplier forecasts for market share. This will make the MAM residential lighting scenario reflect the latest information of what bulbs are actually in Massachusetts consumer homes, and enable the Team to use the MAM to best assess the direction of the lighting market for the next few years.

The MAM will also include updated predicted values (which are currently in years 2016–2023) to reflect the most likely consumer lighting adoption scenarios, then will generate delta watts for every year of the prediction period. The budget below assumes updates only to the existing MAM inputs or other minor items. More substantial edits, such as to the contents or factors considered, will require additional budget.

Task 2: Reporting:

The MAM is not well understood by users who have not worked directly or extensively with the tool. Accessible graphics and explanatory materials will be developed that communicate what inputs the model uses and what outputs the model produces, as well as how to appropriately interpret and use these outputs.

The model and corresponding graphics and explanatory materials will be presented to the PA and EEAC Consultants. The budget below includes material development, assuming typical stakeholder comments and revisions, as well as one or two presentations. Additional budget would be required for substantial revisions to the explanatory graphics and/or materials, and for extensive or numerous presentations.

Value Proposition:

By understanding the residential lighting market and consumer reactions to EISA, the Massachusetts PAs and EEAC Consultants would have critical information to help with program planning, including estimates of current and future delta watts based on actual Massachusetts lighting data and accounting for the adoption of lower-wattage bulb types due to EISA regulations. These data will inform decisions of whether to continue CFL and LED incentives, and for how long, and will allow the PAs and EEAC Consultants to plan proactively by continuing to predict consumers' lighting purchases through 2023.

Suggested Timeline:

The Team would update the 2016 report MAM in the late spring and early summer of 2016, after completing supplier interviews and surveys. A timeline for updating the 2016 to 2018 planning MAM will be determined collaboratively with the PAs and EEAC Consultants regarding their needs for the revised planning model.

Potential Budget: $35,000 - $55,000

Study name: Lighting Decision Making (RES 48)
Research Area: Residential
Type of Study: Market Assessment
Applicable Fuel(s): Electric

Overall Study Goal:

The goal of this study is to conduct market research to help PAs understand how customers make purchasing decisions related to lighting and how that knowledge could be applied to improve in-store marketing and improve program performance.

Close coordination with implementation staff and vendors will be needed to understand current marketing efforts and perceptions of strengths and weaknesses. In addition, the Team will contact key retail allies to solicit feedback and suggestions for improving current in-store marketing efforts. The Team will then lead focus groups with consumers. Based on the results of previous tasks, the Team will partner with one or more retailers to conduct a revealed preference analysis of an actual retail environment.

Research Questions:

What factors influence consumer lighting purchase decisions? How well does current program marketing align with consumer purchasing decisions? How could marketing materials and efforts be improved to increase program performance?

High-Level Description of Approach/Methodology:

Task 1: Stakeholder Interviews:

Draft and conduct in-depth interviews with implementation staff, contractors, and key retail partners. Interviews will focus on understanding the customer decision-making process and current marketing activities to learn perceived strengths, weaknesses, effectiveness, and any opportunities for improvement. During interviews, the Team will also attempt to identify any prior market research available from key stakeholders.

Task 2: Consumer Focus Groups:

Based on feedback from stakeholder interviews, the Team will design and lead focus groups with consumers to explore their understanding of lighting products, to what extent they value various lighting elements, and how much attention they pay to various marketing messages. The Team anticipates working closely with program implementation staff to develop and refine the focus group design and anticipates inviting evaluation and implementation staff to observe the focus groups. The Team also intends to give focus group participants lighting products and in-store marketing materials and solicit their feedback and reactions.

Task 3: Optional Retail Revealed Preference Study:

Based on the stakeholder interviews and focus groups and depending on whether the outcomes appear promising, the Team will design and execute a retail-based study, testing various marketing messages and delivery mechanisms in an actual retail environment. To successfully execute such a study, the Team will need to identify one or more retail partners willing to allow their customers to participate in the study.

Initially, the Team believes that a pop-up retailer may offer the best scenario as this will allow for high traffic and a greater number of participants. However, studying customer responses to scenarios in traditional stores may also be desirable. Designing the study will require close cooperation with PAs and implementation contractors to develop alternative messages and delivery mechanisms. The cost for this task is high and cost estimates are imprecise and may need to be revised in discussions with the PAs.

Value Proposition:

Over the past few years, bulb purchasing has become increasingly more complicated for consumers. Terms like lumens, color temperature, and color rendering are confusing and frustrating. The strategies and approaches consumers have and will develop for choosing among bulb alternatives are unknown and may not entirely align with what they have used in the past or assumed by the lighting industry. This research will help the PAs understand what factors influence consumer choice and what tradeoffs consumers make. A better understanding customer decision-making processes and influences will help the PAs design more effective program materials that may result in increased program performance. Note that the Team lists the Revealed Preference Study as an option because the cost for this task is triple that of the other tasks and the estimate is soft as it may change based on final scope.

Potential Budget:	**Tasks 1 – 2:**	$80,000 - $100.000
	Task 3:	$150,000 - $300,000

Study Name: Appliance Recycling Research (RES 11)
Research Area: Residential
Type of Study: Impact Evaluation
Applicable Fuel(s): Electric

Overall Study Goal:

The primary goal of this study is to update the current Appliance Program per-unit gross energy savings and net-to-gross estimates to inform both annual reporting and the 2016–2018 implementation plan. A secondary goal is to apply appliance recycling-specific evaluation methodologies that have been identified as industry best practice since the previous evaluation.[13]

Research Questions:

With this study, the Residential Evaluation Team seeks to answer the following research questions:

- What is the current per-unit program gross savings?
- What percentage of the program units were manufactured after the U.S. Department of Energy (DOE) published its first national conservation standard in 1990? What was the effect of subsequent DOE standards in 1993 and 2001?
- Is the current per-unit gross savings likely to change over the 2016–2018 cycle as the mix of post-standard recycled appliances changes?
- What would have happened to participants' refrigerators and freezers had they not recycled them through the program?
- How does the program interact with the Commonwealth of Massachusetts and the regional secondary appliance market, and how do these interactions impact net savings?
- Do gross or net savings differ in any meaningful way across PAs, regions, customer segments, or program delivery channels (if applicable)?

High-Level Description of Approach/Methodology:

Task 1: Convene Kick-Off Meeting:

Following the PAs' and EEAC Consultants' approval of a work plan, a kick-off meeting with study stakeholders will be scheduled to refine research objectives, review the proposed methodology, establish the most relevant secondary metering data to use, and finalize the study timeline.

Task 2: Review Tracking Data:

Following the kick-off meeting, all program data collected since the previous evaluation will be reviewed to ensure that all the data necessary to accurately complete an evaluation is collected. Specifically, complete information

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[13] National Renewable Energy Laboratory. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* Chapter 7: Refrigerator Recycling Evaluation Protocol. NREL/SR-7A30-53827. Prepared by Cadmus. April 2013. Available online: http://www1.eere.energy.gov/wip/pdfs/53827-7.pdf

regarding key appliance characteristics, such as age, size, and configuration, as well as critical customer contact data (name, phone number, and participation date) is needed. The evaluators will work closely with the PAs and program implementer to resolve any issues identified.

Task 3: Survey Participants and Nonparticipants:

To understand what likely would have happened to the recycled appliances in absence of the program, the Team will survey a sample of recent program participants and of nonparticipants (customers who discarded an operable, program-eligible refrigerator or freezer outside of the program). Because surveyed participants often exhibit socially responsible response bias, the Team can assess the reliability of their hypothetical responses by collecting information from nonparticipants regarding how they actually discarded their operable appliance outside the program. Collectively, these surveys will enable the Residential Evaluation Team to determine the percentage of appliances that would have remained active without program intervention (in a participant home or another Massachusetts home).

The Team will determine the sample sizes and potential stratification schemes as part of the planning process. The budget below is based on 500 participant surveys and 100 nonparticipant surveys.

Task 4: Interview Market Actors:

To understand the eventual fate of older appliances, absent the program, that are picked up by retailers when delivering replacement units, as well as those collected by haulers, the Team will interview a sample of local market actors. The information from these interviews and from the participant and nonparticipant surveys will enable the Team to determine the program net-to-gross ratio.

The sample sizes and potential stratification schemes will be determined as part of the planning process. The budget below reflects 50 interviews.

Task 5: Analyze Impacts:

An analysis of gross and net savings impacts will be completed. To estimate average per-unit gross savings, the evaluators will combine detailed program database information regarding key appliance characteristics with regression model outputs (developed using data from previous appliance recycling metering studies in other jurisdictions) that relate appliance characteristics to observed energy consumption. This cost-effective approach leverages existing metering data to produce a Massachusetts-specific savings value.

During the kick-off meeting, the evaluators in collaboration with the PAs and EEAC Consultants will determine the most appropriate metering studies to use. Options include studies from California, Michigan, Wisconsin, and New York. Although New York data (collected as part of a National Grid study) are the most regionally appropriate, adding other state data would improve the explanatory power of the model.

To estimate net savings, the approach detailed in the Uniform Methods Project will be followed to combine information from participants, nonparticipants, and market actors, and to account for factors such as secondary market impacts and induced replacement.

Value Proposition:

Appliance characteristics change over time as recycling programs mature, as do primary versus secondary usage behaviors. The Uniform Methods Projects recommends updating gross and net savings every two years for mature appliance recycling programs to capture these changes over time. Additionally, updating the metering database with data collected in New York will improve the annual consumption estimates with recent, regional data.

Potential Budget: $121,000 - $183,000

Study name: Oil Early Replacement Market Characterization (RES 15)
Research Area: Residential
Type of Study: Impact Evaluation
Applicable Fuel(s): Electric

Overall Study Goal:

As part of the 2015 High Efficiency Heating Equipment Impact Evaluation, the study investigated the performance of baseline heating equipment, but did not attempt to quantify the typical rated efficiency mid of early retirement units. For this study, a combination of field visits and heating contractor surveys will be used to assess the average early retirement baseline for oil equipment, and then current savings estimates will be revised.

Research Questions:

This study will enable PAs to determine the average rated and in-situ efficiency of oil furnaces and boilers replaced by gas heating equipment, as well as assess which specific customer markets the PAs should target to maximize potential program savings.

High-Level Description of Approach/Methodology:

Task 1: Develop Contractor Survey Instrument

Coordinate with the Heating Contractor Survey task to integrate contractor survey questions and recruit contractors to participate in this study. Contractors will be asked about the typical age, condition, and estimated efficiency levels of replaced oil furnaces and boilers, and be recruited to participate in field training.

Task 2: Design Field Data Collection Approach

Further refine field data collection recruiting approach (in conjunction with Task 1) through discussions with PAs. The Team will also design field data collection forms and conduct field staff training. The field visits may be conducted by the participating HEHE contractor.

Task 3: Collect Field Data

Conduct site visits to collect information on oil equipment age, condition, maintenance history, actual operating efficiency, and conduct spot measurements.

Task 4: Analyze Data

Conduct any specific, additional analyses of survey data beyond that reported. The Team will integrate the relevant survey results and field data from this study, focusing on estimating the average rated and actual efficiencies of oil furnaces and boilers.

Task 5: Reporting

Report findings to PAs through an initial results presentation, followed by draft and final reports, and a final presentation.

Potential Budget: $160,000 - $200,000

Study Name: Gas Condensing Heating Equipment Barriers Research (RES 16)
Research Area: Residential
Type of Study: Impact Evaluation
Applicable Fuel(s): Gas

Overall Study Goal:

The 2015 *High Efficiency Heating Equipment (HEHE) Impact Evaluation* showed that condensing boilers are not achieving maximum energy savings, in part due to installation practices and controls configuration. Specifically, the study indicated that the use of more energy savings-optimized outdoor reset controls in combination with better thermostat settings and customer education could increase realized savings.

This follow-on study is designed to field test the proposed solution, and will include reanalyzing existing data from the HEHE impact study, additional field data collection and metering, surveys, and field work to:

- Measure the savings associated with specific improvements to condensing boiler installations
- Estimate the costs associated with specific improvements to condensing boiler installations
- Determine the incidence of specific correctable boiler installation issues
- Explore possible program mechanisms to incent greater adoption of these practices
- Understand other barriers to adoption and quality installation of condensing equipment, including water heaters.

Throughout this plan, the evaluation team refers to two types of installation improvements: Controls-only solutions and higher-cost solutions:

- Controls-only solutions
    - Implementing more energy savings-optimized outdoor reset control settings
    - Reducing thermostat setbacks
    - Educating homeowners on what to expect from their boiler
- Higher-cost solutions
    - Increasing distribution in high-load zones
    - Reducing loads by improving insulation and/or air sealing in high-load zones

The team proposes focusing field work on controls-only solutions as the lowest-cost option, while conducting research on costs and other barriers associated with higher-cost solutions through contractor interviews.

Research Questions:

The study will seek to answer these questions:

- What are the specific actions that contractors need to take in order to use more energy savings-optimized outdoor reset controls during condensing boiler installations?
- Do customers need to use different thermostats and thermostat settings in order to maintain expected comfort while using more energy savings-optimized outdoor reset controls?
- What are the costs associated with taking these actions?
- What are the savings associated with controls-only solutions?
    - Can smaller setbacks improve comfort and performance when combined with more energy savings-optimized outdoor reset controls?
    - How often can a simple, controls-only solution make a significant impact on savings?
- How often do customer comfort complaints arise from using a more energy savings-optimized outdoor reset?
- What is the prevalence of higher-cost barriers (not enough baseboard length, not enough boiler capacity) that limit the implementation of energy savings-optimized outdoor reset?
- What are current best practices around implementing energy savings-optimized outdoor reset and how often do contractors currently use these practices? What training and financial support would contractors need to implement these practices more often?

High-Level Description of Approach/Methodology:

Task 1: Reanalyze existing data from HEHE impact study:

The team will assess the data collected during the earlier HEHE Impact Evaluation to determine what additional data will need to be collected onsite to determine what actions need to be taken at each site to use a more energy savings-optimized outdoor reset control. To the extent possible, we will reanalyze the existing data to determine how aggressive an outdoor reset could be implemented at *each* site with the existing emitters and different setbacks, in effect predicting whether a controls-only solution is feasible for *each* site or whether higher-cost solutions would be required. The team will develop a list of required data to provide a controls-only prescription for each site.

Task 2: Design Field Data Collection Approach:

Based on the results of Task 1, we will design field data collection forms and analysis tools to capture required data and update controls prescriptions for each site. This will include piloting data collection and analysis tools before starting field data collection. The field data collection design will include scripts or protocols for the following components:

- **Recruiting**. The recruitment script will be designed to make further participation in this next phase of condensing boiler research attractive to the approximately 60 participants from the 2015 study with usable data. In addition to participation incentives, the script will be personalized as much as possible with Task 1 findings such that potential energy savings and comfort benefits can be articulated to customers at the time of recruitment.
- **Site Visit to Ascertain Solution Viability, Implement Solution, Meter Equipment, and Survey Customer.** This first site visit will determine whether the customer is a good candidate for controls-only operational improvements. Where that is the case, the controls-only strategy will be implemented, along with the necessary metering and monitoring equipment necessary to estimate saving Improvements from improved supply and return water temperatures.
- **Metering Equipment Removal Site Visit**. During this second site visit we will collect all removable study equipment, and conduct a brief customer satisfaction / engagement survey.

Task 3: Field Data Collection:

The team will recruit previously-metered sites for participation in this study. As shown in Figure 1, we will conduct initial site visits for a sample of 50 previous participants, and ultimately correct and meter 25 of those that can be most easily corrected.

Initial Site Visit (50): The primary objective of the initial site visit is to identify necessary controls and other solutions onsite. This will include collecting the following information at the initial site visit:

- Zone-level housing envelope details

Heat emitter (baseboard) characteristics (including length, etc.)

- Thermostat schedules and homeowner occupancy and usage characteristics

The team will determine during the initial site visit whether or not each home and condensing boiler represents a good candidate for controls-only operation improvements (easy correction sites) or controls and emitter or envelope improvements (difficult correction sites). In addition, all sites will receive a short customer satisfaction survey.

Metering Easy Correction Sites (25): The team will plan on implementing controls solutions at all of the customers that have a controls-only correction available, up to 25 sites. As part of the initial site visit, we will implement the controls changes and install home metering equipment to monitor the return water temperature and thermostat.

We recommend installing wireless communicating thermostats that allow ramping operation to implement "soft starts" when returning from setbacks.[14] The data from these thermostats may also provide an important customer engagement tool by providing an "early warning" about heating problems in the home. We intend to leave meters in for 2-3 months, spanning a range of outdoor temperatures. Customers complaining about comfort or heating quality will be given the option to either get their controls adjusted or drop from the study.

Cost Estimates for Difficult Correction Sites (Up to 25): For sites that cannot be corrected via controls alone, the team will develop a list of work options to achieve the required outdoor reset (zone-level emitter or envelope improvements) and get estimates from contractors to perform the work. We will not have the work performed or meter these sites at this time.

Task 4: Field Data Analysis:

The evaluators will analyze the metered data to determine the new efficiency curves for each site as a function of outdoor temperature and load. We will compare the post-controls optimization efficiency curves to the curves derived from metering during winter 2013-2014 and estimate percentage improvement in performance. Additionally, we will summarize customer satisfaction issues captured in the onsite surveys.

Task 5: Develop Contractor and Plumber Survey Guides:

In parallel with the field study, the team will develop a survey to determine typical practices and barriers to improved installation practices. We anticipate that the participating contractors will include heating equipment contractors and plumbers who install hydronic heating and water heating equipment. Through the contractor survey, we will assess:

- Condensing boiler installation practices, in particular controls
- Condensing water heater installation practices
- Barriers to installation of condensing equipment
- Barriers to improved controls commissioning for condensing equipment

As part of this work, the team will conduct in-depth interviews with five market experts[15]/leading contractors to identify key best practices and market barriers to ask about.

Task 6: Conduct Contractor and Plumber Surveys:

The team will conduct surveys with 30 contractors and plumbers who install condensing heating and water heating equipment. The survey will stratify the contractor sample according to how many pieces of condensing equipment they installed through the HEHE program in recent years and talk to 10 of the largest, 10 medium-sized, and 10 small contractors.

Task 7: Survey Analysis:

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[14] We would like to discuss this point further, including who would install the wireless thermostat. We are considering including a contractor at each of the initial site visits.

[15] Market experts include manufacturers, distributors, and boiler technician trainers.

This analysis will focus on assessing current installation practices, barriers to improvements and possible program solutions. We will identify the most important barriers to implementing better condensing boiler controls. We will reach out to PA implementation teams to discuss possible solution development, as needed.

Task 8: Cost Analysis:

This analysis will draw on findings from the controls-only field portion of the study and contractor and plumber surveys to estimate costs for controls-only and higher-cost solutions for condensing boiler installation.

Task 9: Reporting:

Findings will be reported to the PAs and EEAC Consultants through initial results presentation, draft and final reports, and final presentation.

Potential Budget: $280,000 - $465,000

Study Name: Impact Study of Heat Pump Water Heaters (RES 20)
Research Area: Residential
Type of Study: Impact Evaluation
Applicable Fuel(s): Electric

Overall Study Goal:

The goal of this study is to conduct research to quantify savings associated with heat pump water heaters (HPWH).

This evaluation will determine the savings associated with heat pump water heaters in retrofit and new construction applications and quantify the impact of different installation practices.

Research Questions:

- What are the savings associated with heat pump water heaters in Massachusetts in retrofit and new construction applications? What is the appropriate baseline in retrofit applications?
- How do savings vary based on heating, cooling, and dehumidification equipment type, heat pump water heater installation location, and home type? What are the secondary energy impacts on heating, cooling, and dehumidification?
- What is the value of dehumidification and other comfort impacts of the equipment?

High-Level Description of Approach/Methodology:

<u>Task 1: Review of existing deemed savings assumptions and participating equipment performance characteristics:</u>

Review the current assumptions used to estimate savings. Review existing data being collected and assess the factors that should drive variations in savings associated with the equipment being installed through the program.

<u>Task 2: Finalize Work Plan and Data Collection Tools</u>:

Based on the results of Task 1, develop an improved data collection methodology that will capture data on the drivers of savings.

<u>Task 3: Participating Customer Survey</u>:

Conduct online surveys to fill gaps in savings drivers, including HVAC equipment usage patterns, type of previous equipment, and whether it was in good working order or replaced upon failure, equipment installation location, household demographics, and equipment impact on customer comfort.

<u>Task 4: Participant billing analysis on retrofit projects</u>:

Conduct billing analysis on participants, using customer survey data as additional explanatory variables. Use results of billing analysis to quantify total net energy impacts. Use explanatory data from billing analysis to extrapolate to new construction baseline case.

<u>Task 5: Estimate non-energy impacts of dehumidification</u>:

Estimate dehumidification delivered based on best available manufacturer performance data. Based on NEI research from RES 27, estimate the NEIs associated with improved humidity in the occupied and unoccupied space.

These should include comfort impacts and health impacts associated with maintaining lower humidity in the space and accompanying reduction in dust mite prevalence.

Optional Task 6: Conduct Detailed Pre-Post Metering of Equipment:

Work with contractors to install metering equipment before installation of the equipment to assess energy usage and humidity impacts of the equipment. This will include energy metering of the HPWH and humidity metering in the space containing the HPWH as well as the occupied spaces of the home. Metering will include at least eight weeks pre-installation and six months post-installation. These data will then be incorporated within additional billing analysis to extrapolate to the overall population.

Potential Budget: $125,000 - $200,000 (+$150,000 - $300,000 for pre-post metering and humidity impact assessment)

Study Name: Heating Contractor Survey (RES 25)
Research Area: Residential
Type of Study: Process and Impact Evaluation
Applicable Fuel(s): Gas

Overall Study Goal:

At least two other studies *Oil Early Replacement Market Characterization* and *Gas Condensing Heat Equipment Barriers Research* would rely on collecting information from heating contractors. The goals of these heating contractor surveys and the market research study are to:

- Avoid duplication and gain synergies across these research efforts
- Provide a standalone report describing overall heating contractor satisfaction, such as program elements that work well and those that can be improved

Research Questions:

The details of research question that will be addressed through heating contractor surveys are outlined in the *Oil Early Replacement Market Characterization* and *Gas Condensing Heat Equipment Barriers Research* summaries.

High-Level Description of Approach/Methodology:

Task 1: Define Contractor Tiers

Define the following three tiers for collecting information:

- Tier 1- This is the top 10 to 20 contractors in terms of participation volume, or could be the top 10% based on another indicator of interest to the PAs and EEAC Consultants.
- Tier 2- This middle tier of contractors have just over a handful of participant installations annually.
- Tier 3- This tier of contractors have just a handful of installations but are large enough to provide additional HEHE volume if they choose.

Task 2: Conduct Qualitative Research

This task would involve detailed open-ended interviews with tier 2 contractors and focus groups with tier 2 and tier 3 contractors to ask general program questions and to test the survey questions to ensure the Team receives appropriate responses to aid in analysis.

Draft and final interview guides will be prepared for PA and EEAC Consultant review prior to implementing this task. A draft and final memorandum of qualitative research findings will also be prepared.

Task 3: Design Contractor Survey

As stated previously, the survey will be designed in coordination with needs of other studies, based on the results of Task 2. The survey will focus on program satisfaction, participation drivers, and other additional questions as outlined in the other studies.

Task 4: Conduct Contractor Surveys

Survey contractors and plumbers who: (1) participate in oil to natural gas heating conversions, (2) install condensing heating and water heating equipment, and (3) other strata by tier level as desired by the PAs and EEAC Consultants.

Task 5: Analyze Data

Conduct analysis of the survey data and integrate qualitative and quantitative analyses into a cohesive narrative focusing on gas heating contractor satisfaction (e.g., elements of the program that work well, elements that can be improved).

Task 6: Reporting

Report findings to PAs and EEAC Consultants through an initial results presentation, followed by draft and final reports, and a final presentation (if needed).

Potential Budget: $100,000 - $200,000

Study Name: HVAC Non-Energy Impacts Assessment (RES 27)
Research Area: Residential
Type of Study: Impact Evaluation
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

The goal of this study is to conduct research to quantify secondary fuel savings associated with heat pumps and other HVAC systems.

Non-electric, non-gas savings associated with HVAC systems installed through initiatives runs by the PAs will be assessed. Secondary fuel savings may be significant for HVAC equipment installed with a retrofit baseline.

Research Questions:

- What are the take-back impacts on non-electric, non-gas savings associated with ductless heat pumps?
- What are the non-electric, non-gas savings associated with other heat pumps?
- How much of those savings comprise oil, propane, kerosene, and wood?
- How efficient are the non-gas, non-electric equipment being displaced?

High-Level Description of Approach/Methodology:

Task 1: Assess likely secondary fuels and likely changes in consumption:

Review results of previous studies to determine which secondary fuels are present and which ones were asked about and determined to be negligible. Also examine the available data regarding changes in behavior associated with installation of new equipment. Examine current estimates of secondary fuel use.

Task 2: Finalize Work Plan and Data Collection Tools:

Based on the results of Task 1, develop an improved data collection methodology that will capture data on the drivers of behavioral change and available billing data.

Task 3: Participating Customer Survey:

Conduct online surveys with nested phone interviews. Use these surveys to improve estimates of the portion of participants with different secondary fuels and the portion of these participants who significantly changed their heating and cooling patterns. Allow customers to “opt in” to supplying additional information via phone interview and collection of billing/consumption data (e.g., how many gallons of oil did you use in winter of 2013–2014, winter of 2014–2015). The online survey will provide sample bias correction on the interview billing data results.

Task 4: Analyze billing data to estimate secondary heating adjustment factor for each stratum:

Conduct site-specific billing analysis on participants, utilizing customer survey data and usage data for additional data opt-in survey participants. Develop savings estimates both in raw terms and per Btu of annual load displaced for secondary heating fuels, and the approximate take back effect measured in increased annual thermal load on the heating systems.

Potential Budget: $100,000 - $200,000

Study Name: HES Audit Optimization Study (RES 30)
Research Area: Residential
Type of Study: Process Evaluation
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

The goal of this study is to conduct research to identify opportunities for optimizing the Home Energy Services (HES) initiative audit tool and delivery for program contractors and customers. This study builds upon findings from the 2014 HES initiative delivery assessment, which found that there is an "opportunity for information overload" because of the variety of offerings and programs presented to customers during the audit and that some Energy Specialists struggle with having enough time to deliver all of the program components and promote other Mass Save incentives during their limited time in customers' homes. Employing a variety of qualitative research methods, in-depth insights will be gathered from a range of program stakeholders and make recommendations for optimizing the home energy assessment process.

Research Questions:

This research seeks to identify opportunities for improving the HES home energy assessment for lead vendors, home performance contractors (HPCs), and customers to more effectively disseminate information, encourage cross-program participation, and increase close rates.

High-Level Description of Approach/Methodology:

Task 1: HPC Roundtable Discussion and Lead Vendor Interviews

Qualitative insights will be collected from representatives of both HES delivery channels. A roundtable discussion will be facilitated with eight to ten participating HPCs and interviews will be conducted with four to eight lead vendor field staff to identify Energy Specialists' suggestions for audit tool optimization and delivery improvements. The PAs and EEAC Consultants will be asked to identify high-priority research topics and help develop discussion guides.

Task 2: Participant Customer Focus Groups

The evaluators will conduct six focus groups with HES participant customers to explore customer experiences with the home energy assessment process in depth and identify suggestions for improving assessment content and delivery. Screening criteria, group segmentation, and discussion guides will be developed collaboratively with the PAs and EEAC Consultants. Focus groups will be segmented based on one or more factors—e.g., geography, delivery channel, and/or participation type (audit-only versus installed major measure)—and qualitative findings from these groups will identify similarities and differences between customer segments.

Task 3: Analysis, Reporting, and Study Design for Future Research

Key themes, findings, and recommendations will be summarized across all research tasks, which will be incorporated into an overall HES annual report. In addition, the Team will make research design recommendations for a follow-up study that will explore several different approaches to delivering the home energy assessment (based on findings and suggestions from the focus groups, roundtable discussion, and interviews) and perform an experimental design to determine the effectiveness of each approach. These research design recommendations will identify methods for assessing strengths and weaknesses of different approaches using different protocols and strategies for separate participation populations.

Value Proposition:

The 2014 HES initiative delivery assessment found that both HPCs and lead vendors believed that customers often did not fully understand the Mass Save offerings and could easily be confused and overwhelmed; findings from the participant customer survey support that belief—some customers reported being unsure of what they qualified for, while others felt there were too many Mass Save options and too much information presented to them. In addition, the study identified differences in cross-program participation rates by delivery channel. The study determined that HPC customers had lower rates of cross-program participation than lead vendor customers, which is probably, in part, a result of a lack of understanding by the HPCs regarding program offerings and less proactive promotion among the HPCs of non-HES initiative offerings. This proposed research will help inform improvements to the current HES initiative audit tool and delivery to increase close rates and rates of cross-program promotion and participation by helping Energy Specialists optimize their limited time in customers' homes. In addition, the insights gathered through this study will inform recommendations for an experimental study design, which the PAs may implement to determine the effectiveness of various approaches.

Potential Budget: $160,000 - $185,000

Study Name: HES Quality Control Study (RES 31)
Research Area: Residential
Type of Study: Process Evaluation
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

The goal of this study is to conduct a comprehensive review of the HES initiative quality control procedures and outcomes and to gather supplementary insights regarding stakeholder experiences with the quality control process. The 2015 *Home Energy Services Initiative and HEAT Loan Delivery Assessment* qualitatively explored HPC and lead vendor experiences with the quality control for the initiative. However, that study did not assess the HES quality control procedures or outcomes in-depth and did not explore the quality control process from the perspective of the third group of contractors—the independent installation contractors (IICs)— who perform work on behalf of the program. This study will complement findings from the HES delivery assessment by conducting in-depth interviews with program stakeholders, reviewing quality control procedures, and assessing quality control outcomes.

Research Questions:

This research seeks to:

- Assess HES initiative quality control procedures and processes
- Identify key quality control outcomes
- Explore IIC experiences with the quality control process

High-Level Description of Approach/Methodology:

Task 1: Review Quality Control Standards and Conduct Stakeholder Interviews

The evaluators will conduct a comprehensive review of existing program quality control standards and protocols from PAs, lead vendors, and the statewide quality control auditor to identify standard quality control procedures. To provide additional context and understanding regarding quality control, 10-15 interviews will be conducted with a range of program stakeholders, which may include the statewide quality control auditor, PA program managers, and lead vendors.

Task 2: Collect and Analyze Quality Control Data

Aggregate and analyze available quality control data collected by the lead vendors and statewide quality control auditor to identify key outcomes of the quality control process. These key outcomes may include the number of quality control visits conducted, proportion of quality control visits resulting in callbacks to fix work, proportion of callbacks by contractor type, and frequent issues identified through the quality control process. Other high-priority quality control outcomes desired through this research will be identified collaboratively with the PAs and EEAC Consultants.

Task 3: IIC Interviews

To complement the HES initiative delivery study, interviews will be conducted with 10-15 IICs to understand the IICs' experience with the quality control process, including the feedback they receive from lead vendors and the statewide quality control auditor and any issues they have encountered with the process. These results will compare findings from interviews conducted with HPCs in 2014 to identify similarities and differences between HPC and IICs.

Task 4: Analysis and Reporting

Key themes, findings, and recommendations will be summarized across all research tasks, which will then be incorporated into an overall HES annual report.

Value Proposition:

Through the 2015 HES initiative delivery assessment, an extensive review of the quality control process, procedures, and outcomes was identified as a high-priority evaluation issue for future research. The HES initiative delivery assessment did not assess the HES quality control procedures or outcomes in depth and did not explore the quality control process from the perspective of IICs. This proposed study will conduct a comprehensive review of the HES initiative quality control process to explore quality control in greater depth and provide a quantitative assessment of quality control outcomes. Furthermore, interviewing IICs will provide an additional perspective to complement and provide additional context for the qualitative insights gathered from HPCs and lead vendors in the 2015 study.

Potential Budget: $60,000 - $95,000

Study Name:	Explore Opportunities to Overcome Split Incentive Barriers for Multifamily Program Participation (RES 33)
Research Area:	Residential
Type of Study:	Process Evaluation
Applicable Fuel(s):	Electric & Gas

Overall Study Goal:

According to PA representatives, the 2015 Multifamily Process Evaluation revealed that the split incentive was second only to the lack of program awareness as the biggest barrier to program participation. This study would explore the opportunities available to the PAs for mitigating the split incentive barrier.

Research Questions:

This study would collect information about the feasibility and potential for combining various approaches to understanding and resolving the issue of split incentives in the PAs' multifamily program.

High-Level Description of Approach/Methodology:

Task 1: Finalize Work Plan

The first task will be to develop a more detailed work plan. As noted below, the study will rely on secondary research (such as literature and best practices reviews) as well as primary research (such as in-depth interviews with program managers of benchmarking programs and focus groups or surveys with both renters and multifamily property owners).

Task 2: Literature/Best Practices Review

The Team will conduct secondary research specifically to identify and understand successful approaches to address the split incentive barrier in multifamily or other tenant/landlord situations that have been undertaken in other jurisdictions with a similar program offering. This research will better inform the PAs understanding of the split incentive barrier and will also suggest possible program solutions. One program strategy that is growing in popularity is the idea of benchmarking the energy efficiency of the multifamily building stock and sharing related operating cost information with multifamily building owners, managers, and investors. Other approaches include regulatory mechanisms, energy concierge services, green leases, and promotion of non-energy benefits of energy efficient projects.

Task 3: Interviews with Program Implementers

Once identified through Task 2, the Team will conduct interviews with program implementers who have employed a benchmarking approach (or other identified approaches) to address split incentives. The goal of these interviews is to gain an understanding of the approaches taken and the program and market conditions necessary for these approaches to succeed.

Task 4: Focus Group/Survey of Multifamily Tenants and Landlords

Under this task, the Team will interview both tenants and landlords of multifamily housing units in Massachusetts. The purpose is to increase the Team's understanding of the split incentive barrier, while testing the market receptiveness to benchmarking and other potential approaches to overcoming the split incentive barrier from both perspectives. This research will build on the primary research conducted during the 2014 Process Evaluation and will be informed by the research conducted in Task 2 and Task 3 above.

Task 5: Analysis

Once data collection is complete, the Team will conduct the analyses required to address the specific researchable questions identified in the final scope of work.

Task 6: Reporting

The PAs and EEAC Consultants will be provided with a written report containing the analysis results.

Value Proposition:

The split incentive barrier remains a challenge for the multifamily program. By understanding best practice program designs from other jurisdictions, the PAs can better align their multifamily program design to address this barrier. In addition, by exploring potential program design enhancements with rental customers and landlords in their own service territory, the PAs will obtain feedback from their own customers on the potential program design. Finally, by conducting this research in late 2015/early 2016, the PAs will have this information in a timely manner to revise the multifamily program early in the 2016–2018 program cycle.

Potential Budget: $50,000 - $75,000

Study Name: HES Impact Evaluation (RES 34)
Research Area: Residential
Type of Study: Impact Evaluation
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

The goal of this study is to recalculate realization rates of vendor calculated savings in the HES initiative.

High-Level Description of Approach/Methodology:

Task 1: Data Cleaning/Processing

The data management team will be responsible for all data cleaning, screening, and preparing the data for analysis. In addition, the data management team will ensure all personally identifiable information are handled properly and all data are cleansed before handing over to the analysis team.

Task 2: Billing Analysis

An in-depth exploration into saving estimation (whole house and measure specific) through a combination of PRISM and Conditional Savings Analysis (CSA). The results will enhance understanding of achieved savings and support the assessment of the accuracy of the *ex ante* savings. The team anticipates billing analysis servings as the primary approach for estimating impacts for average households, as well as measures with large energy savings or those having been installed at high frequency in the population.

Task 3: Simulation Modeling

As a compliment to Task 2, the evaluators will run simulation models on a statistically significant sample of homes that covers all configurations of home types, locations, fuel type, end-use combinations, and energy consumption levels. This approach will be used to estimate impacts for measures without reliable billing data (e.g., oil) and that have smaller expected savings. Tasks 2 and 3 will be conducted in tandem. A billing analysis (PRISM and CSA models) will be run on the population of the participants and on a comparison group. The realization rates from these models will be estimated. On another set of homes that have received simulation models, billing analysis will be used with the simulation results as explanatory variables and then readjust the simulation models to reflect what billing analysis reveals. The process will be iterative to obtain the best possible *ex ante* values for future programs. All simulation models will also use billing data to calibrate their estimates.

Task 4: Engineering Algorithm Analysis

The Team will conduct the engineering assessment of the algorithms along with the iterative process described in Tasks 4 and 5.

Task 5: Savings Calibration

Tasks 2, 3, and 4 running in tandem along with careful calibration against actual (and weather normal) consumption will provide best estimates of measure-level and whole-house savings.

Optional Task 6: Follow-up QA/QC On-sites

Because the proposed billing analysis will allow savings to be determined at individual sites, the Team proposes rating site in terms of their performance (both in absolute terms and relative to the *ex ante* values). The Team will conduct billing analysis, CSA, simulation modeling, and detailed engineering assessment (methods described above) and conduct site visits to identify the reasons for observed performance. During site visits, the Team will meter whole house and selected end uses for appropriate durations to estimate savings at the measure level.

Value Proposition:

In addition to the large expected savings and significant contribution to the overall portfolios, HES is the gateway to many other PA offerings. An understanding of its impacts and overall delivery is critical to achieving the planning goals.

Potential Budget:	**Tasks 1 – 5:**	$200,000 - $300,000
	Task 6:	$175,000

Study name: Determine Appropriate Multifamily Program Interventions for Condominiums (RES 41)
Research Area: Residential
Type of Study: Process Evaluation
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

The 2015 *Multifamily Process Evaluation* found that condominiums differ enough from other multifamily buildings in size and ownership characteristics to warrant an investigation into alternative program strategies to achieve success in this market subsector. This study is intended to be a quick but detailed study of the unique characteristics and challenges of the condominium market and any possible program design opportunities that could serve these customers.

Research Questions:

The Team will research specific approaches to increasing energy efficiency program participation in the condominium subsector that have been successfully implemented by other jurisdictions with similar program design. This evaluation seeks to gain a deeper understanding of these condominium-focused program strategies and the market and program conditions necessary for these approaches to succeed.

High-Level Description of Approach/Methodology:

Task 1: Document Current Program Approach

To gain a complete understanding of each PA's program approach to multifamily buildings and internal best practices, the evaluators will interview each PA's program manager and program implementer to ask for about the current approach to the condominium market. Any findings will be included in the discussion of specific approaches in the final memo.

Task 2: Literature/Best Practices Review

Under this task, the initial research conducted during the 2015 *Multifamily Process Evaluation* will be built upon to gain additional information about successful approaches to engaging condominiums in other jurisdictions with a similar program offering. For example, Puget Sound Energy and Energy Trust of Oregon have undertaken an approach where the multifamily market is segmented and a single program representative focuses on each segment, including condominiums. This research will suggest potential program solutions to increasing uptake in the condominium market.

Task 3: Interviews with Program Implementers

Once successful condominium-focused programs have been identified through Task 2, interviews will be conducted with the program implementers who have employed one or more of these approaches. The goal of these interviews is to gain an understanding of the approaches taken and the program and market conditions necessary for these approaches to succeed.

Task 4: Analysis/Reporting

Once data collection is complete, analyses will be conducted to address the specific researchable questions identified in the final scope of work.

The PAs and EEAC Consultants will be provided with a written memo containing the analysis results.

Value Proposition:

The condominium market requires a different approach to customer engagement than have been employed historically. By understanding best practice program designs from other jurisdictions, especially in Massachusetts, the PAs can more effectively engage the condominium market in the multifamily program.

Potential Budget: $30,000 - $60,000

Study Name: Zero Net Energy Home Potential (RES 46)
Research Area: Residential
Type of Study: Assessment
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

The goal of this study is two-fold: (1) to conduct a market characterization study to understand the current stock of Zero Net Energy (ZNE) homes in Massachusetts and (2) to determine if any additional savings that can be obtained from these projects going forward. This will answer questions such as how many ZNE homes there are, where they have been constructed (in the state and PA territory), and whether homeowners and builders have been taking advantage of current program offerings in the construction and furnishing of the houses. If these homes have been participating in current programs, this portion of the study will also assess how much energy savings and incentive dollars have been coming from/going to these projects. The study will also identify potential savings, costs, cost-effectiveness, and the likelihood of success of two to three hypothetical initiatives that could promote new ZNE single-family homes in Massachusetts.

A report will document the home design strategies, high-performance building practices, energy-efficient products and materials, and distributed generation strategies that builders can use to construct a ZNE home rather than a standard code-built home. The report will include:

- List of architectural elements, energy-efficient building products and construction materials, and renewable energy systems that builders can use to build a ZNE home
- Associated costs for each identified measure/product
- Labor costs for construction/installation
- Three to four packages of measures and building strategies that are commonly bundled in ZNE homes but which, individually, may not enable a building to reach the ZNE standard
- Cost-effectiveness analysis of each package and a hypothetical average complete building
- Assessment of modifications that would be required to maximize the peak demand reduction contribution from existing ZNE home projects (this is a demand reduction-centric perspective rather than an energy-centric focus) and the impacts these would have on demand reductions, energy savings, and cost.

Research Questions:

The Team proposes to conduct research to inform these questions:

- What is the current state of the ZNE home market in Massachusetts and in each PA territory, to what extent are these projects taking advantage of existing program offerings, and, if they are, how much savings are these projects generating (and how much incentive dollars are going to them)?
- What are the total savings available from ZNE homes by kW, kWh, and therm relative to:
  - A standard home built to code and/or a standard home built to current market practices?
  - An ENERGY STAR® home?
- What are the costs associated with building practices, equipment, and systems used in each of these scenarios?

- What are the savings and costs associated with three to four packages of selected measures/ building practices that are needed to get to a ZNE home (or are common in these homes) but which individually may not be sufficient to reach the ZNE standard?
- Is it feasible to design and develop a cost-effective ZNE homes initiative and, if so, what target measures and incentive strategy will produce the best results?

High-Level Description of Approach/Methodology:

Task 1: Collect, Compile and Analyze Secondary Research

There are numerous existing reports, studies, and articles on ZNE homes. The Team will review these materials, including ZNE certification records, to help identify completed homes and determine the appropriate research questions in Tasks 2 and 3.

Task 2: Market Characterization

Cadmus will develop a summary of ZNE homes by PA territory, work with implementers to screen those projects for participation in existing programs, and assess the energy savings from those projects attributable to the current programs and associated incentive payments. This task will be conducted parallel with Task 3 to capture any projects not identified in Task 1 and to minimize the number of surveys/interviews administered to individual customers/builders to obtain the information needed for each task.

Task 3: Primary (Survey) Research on Practices

The Team will conduct interviews with home builders, architects, tradesmen, and owners to understand common building practices and materials used in both code-built and ZNE homes in general, and in Massachusetts projects specifically, and any variations from nationwide practices that may be the focus of some of the secondary research.

Task 4: Report: The Team will prepare a largely data-focused summary of findings from Tasks 1, 2, and 3. This summary will mainly comprise lists and prices of the design features and materials for the ZNE home and comparison home(s), measure packages, and the savings and cost-effectiveness analysis associated with each.

(Optional) Task 5a Load Shapes from PA Time-of-Use (AMI) Meters

By analyzing existing AMI meter data, the Team can refine the savings estimates—in particular peak demand—derived in Tasks 1 and 2. Depending on home characteristics, because of the on-site renewable component of ZNE homes, the peak demand savings could be worth investigating in greater detail.

(Optional) Task 5b: Load Shapes from Site Visits

If AMI meter data are not available in enough ZNE homes and additional understanding of load shapes is of interest, the Team can conduct site visits to install whole-house metering equipment. While on site, the Team could also obtain information on building comfort, satisfaction, and other characteristics and verify the performance of on-site renewable energy equipment.

(Optional) Task 6: Market Adoption/Interest Study

After assessing the cost-effectiveness of ZNE homes and/or packages of relevant measures, the Team would conduct a survey of targeted Massachusetts residents and builders to assess their interest in hypothetical program offerings. Targets would include recent homebuyers, potential homebuyers, builders, and architects. This research could involve telephone surveys and/or focus groups.

Value Proposition:

The Evaluation Team understands that there has been significant stakeholder interest in ZNE homes. This study will assess the opportunity for cost-effective savings from ZNE homes, and provide the basis for and informed response from PAs to stakeholders.

Potential Budget: $200,000 - $350,000

Study name: Customer Profile Study, Phase 2 (RES 47)
Research Area: Residential
Type of Study: Market Characterization/Assessment
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

Building upon the findings of the 2013 *Residential Customer Profile Study (RCPS*), this study will incorporate data from 2014 and 2015 program years to provide a similar understanding of program participation, savings, and incentive expenditures across Massachusetts during these years. With three years of program data receiving consistent analysis, an analysis of patterns and trends can be undertaken.

Research Questions:

The Team proposes to conduct research to answer these questions:

- How are program participation, savings, and incentive payments in 2014 and 2015 distributed across Massachusetts and across PAs?
- How have these distributions changed from year to year?
- Do the demographics of participants stay the same or exhibit some change over time?

High-Level Description of Approach/Methodology:

Task 1a: Request Data

A data request for 2014 and 2015 PA program tracking and billing data for all residential and low-income customers will need to be submitted to the PAs. By applying the lessons learned from the 2013 RCPS, the Team will define data needs and request 2014 and 2015 data in standardized format from the PAs and implementers. The Evaluation Team data management team will also acquire necessary third-party data and software to replicate the full dataset developed for the 2013 report.

Task 1b: Summarize/Pre-Reconciliation of PA/Implementer 2014 Data

Prior to making any modifications to the database architecture in which 2013 data are housed and into which multiple databases and files will be merged, the Team will conduct a high-level analysis will need to be conducted of, and report summary statistics on, on t the 2014 data received in response to the data requests. This will ensure that the files received are correct and sufficient for proceeding with a high degree of certainty that final reconciliation efforts will require minimal adjustments.

Task 1c: Summarize/Pre-Reconciliation of PA/Implementer 2015 Data

As with the 2014 data in Task 1b, the Team will conduct high-level analysis of, and report summary statistics on, will need to be conducted on the 2015 data received in response to the data requests. This will ensure that the files received are correct and sufficient for proceeding with a high degree of certainty that final reconciliation efforts will require minimal adjustments.

Task 2: Finalize Project Scope and Timeline

In parallel with Task 1, the Team will coordinate with PAs and EEAC consultants to define the key patterns and trends of interest, determine any additional analysis desired (for 2013 and subsequent years), and any necessary database architecture changes to create an outline of the final report/deliverables for this study.

Task 3a: Integrate 2014 PA Data

2014 data obtained from PAs and implementers will be cleaned of personally identifiable information (PII) and integrated into a single database with the existing 2013 data.

Task 3b: Integrate 2015 PA Data

2015 data obtained from PAs and implementers will be cleaned of PII and integrated into a single database with the existing 2013 and 2014 data.

Task 4a: Integrate External 2014 Data

2014 data obtained from external sources—including U.S. Census, address validation, and GIS data—will be integrated into a single database with the existing 2013 data.

Task 4b: Integrate External 2015 Data

2015 data obtained from external sources—including U.S. Census, address validation and GIS data—will be integrated into a single database with the existing 2013 and 2014 data.

Task 4c: 2014 Data Reconciliation

The Team will create summary reports from analysis of data imported into the database and meet with individual PAs and implementers to validate the import reconciliation results. This task assumes that because of the validation step in Task 1b, no additional files will be needed from PAs or implementers; this will be a discussion of refinements to the Team's analysis to improve consistency with RCPS savings, participation, and incentive levels with those available on masssavedata.com, benefit-cost ratio (BCR) tables, and other PA records.

Task 4d: 2015 Data Reconciliation

As with the 2014 data from Task 4a, the Team will create summary reports will need to be created from analysis of data imported into the database and meet with individual PAs and implementers to validate the import reconciliation results. This task assumes that because of the validation step in Task 1c, no additional files will be needed from the PAs or implementers; this will be a discussion of refinements to the Team's analysis to improve consistency with RCPS savings, participation, and incentive levels with those available on masssavedata.com, BCR tables, and other PA records.

Task 5: Final Analysis and Reporting

The Team will complete analysis and develop final deliverables according to the outline and products defined in Task 2. Should enough time elapse between the completion of Tasks 1b and 1c, Task 5 could be broken into two to three parts with separate 2014, 2015, and three-year deliverables.

(Optional) Task 6: Online Reporting

In addition to, or in place of, a PDF report described in Task 5, the Team could develop an interactive, updatable reporting site to allow users to obtain specific data.

(Optional) Task 7: Ad Hoc Data Management Consulting

Where data are not available in standard formats for inclusion into the RCPS database, consulting services are available to individual PAs and implementers to assist in the development of data that will meet Task 1a data request needs. These services will be charged on a time and materials basis as individually negotiated.

(Optional) Task 8: Custom Reporting and Data Extracts

Where needed by individual PAs, implementers, or for other evaluation/program contracts, ad hoc database analytic and reporting services are available. These services will be charged on a time and materials basis as individually negotiated.

Value Proposition:

While stakeholder interest has been high in the results of the 2013 RCPS, the greater value of this type of analysis comes from repeating the effort across multiple years. In addition to increasing the reliability of the analysis by filling in gaps from programs that may not have a lot of activity in certain areas in a single year, multi-year analysis will begin to provide insights on program trends and patterns.

Potential Budget: $750,000 - $1,000,000

5.2 NON-RESIDENTIAL STAGE 1 WORK PLANS

Study Name: C&I Lighting and Controls Market Effects Study
Research Area: Commercial & Industrial
Type of Study: Market Effects Study
Applicable Fuel(s): Electric

Overall Study Goal:

The goals of this research are to quantify market effects associated with high-performance T-8 lamps, and conduct a market effects baseline study for C&I Lighting Controls as DNV-GL recommended through the February 26, 2015 memo "Recommended Methods for Assessing Market Effects of C&I Lighting and Controls Programs (Final)" submitted under the Cross-cutting research contract. While these are two distinctly different studies, this research will leverage DNV-GL team's market effects expertise and combine the studies under one project.

High-Level Description of Approach/Methodology:

Work Plan Development and Working Group Meetings

While the framework for the retrospective T-8 market effects study and the prospective lighting controls baseline study was established through the Cross-cutting research area, that research was intended to identify the general market effects approach, leaving the detailed work plan for the C&I Evaluation team. DNV GL will hold monthly working group meetings to inform the PAs and EEAC Consultants of interim findings and key decision points.

Retrospective T-8 Market Effects Study

DNV GL will work closely with PA program and evaluation staff and EEAC consultants to develop the program logic and market models in graphic form. As discussed in detail in the February 26, 2015 memo, DNV GL's proposed approach to assessing program influence on the market for HP T8s will use the following analytic steps:

1. Leverage existing research to map the supply chain for low-wattage T8s.
2. Identify a comparison area.
3. Recruit and initiate distributor panels/conduct surveys in Massachusetts and the comparison area.
4. Conduct interviews with a sample of retailers and contractors, if indicated by the results of Step 1.
5. Compile data required to estimate gross and net savings.
6. Estimate net savings.

Prospective Lighting Controls Baseline Study

Given the relatively low level of program activity for controls, the team would undertake fairly low-cost research before proceeding to a full-scale baseline study. This study would begin with a review existing lighting controls research in Massachusetts. The team will also look to collect information on trends in sales, customer response, observed program effects, pricing, and performance from Massachusetts distributors and electrical contractors. The C&I evaluation team will present the results of this research to the PAs along with recommendations regarding whether to proceed to a full baseline study and, if so, the team will develop a high-level work plan and budget. If we do not move forward with the baseline study now, the evaluation team will continue to monitor program activity and developments in lighting control technology and markets via the aforementioned distributor panel. If purchases of controls begin to increase through the program, outside the program, or both, we will notify the PAs and seek their views on whether to proceed with a baseline study. If the PAs decide to proceed to a full baseline study, the C&I evaluation team will develop a detailed work plan.

Potential Budget: $300,000 - $450,000

Study Name: Comprehensive Design Approach (CDA) evaluation
Research Area: Commercial & Industrial
Type of Study: Impact
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

The primary goal of the impact evaluation of the CDA programs will be to quantify the electric and natural gas savings, as well as the electric demand reduction, attributable to the program in 2014. This will enable the team to assess whether the program is achieving the expected savings. Five years have elapsed since the last similar evaluation occurred (for electric savings only), and while realization rates from that effort were fairly high, the program has grown and changed in ways that make it important to reassess program performance.

High-Level Description of Approach/Methodology:

The DNV GL team's approach and methodology will be consistent with the procedures and protocols developed for previous rounds of custom site-specific impact evaluations. That said, CDA projects are unique in their complexity and analytical difficulty, given they require calibrated hourly building simulation models to estimate savings from measures that tend to be highly interactive. As a result, establishing a reasonable level of effort is key. As noted in the Task 1 description below, decisions about sample sizes and analysis rigor affect study costs dramatically, and the budget figures at the end reflect ranges for both.

Task 1: Work Plan Development

Establishing clear sampling objectives is critical because of the significant effort needed to perform rigorous M&V of each sampled CDA participant. The team will work with the PAs and EEAC Consultants to develop a work plan and sample design that addresses the desired statistical precision by PA, fuel type, and savings parameter. The work plan will also address these important scoping considerations:

- The appropriate level of data collection and analysis necessary to yield reasonably accurate results at the whole-building level. It may be worthwhile to reduce the rigor for some M&V aspects to allow for larger sample sizes.
- The need to calculate and report more granular results (such as at the measure level) for each project.
- Whether or not to include Advanced Buildings (AB) projects, as well as multiple program years.

Once these major factors have been established, the team will develop a project schedule that ensures we will complete the study within one year of work plan approval.

Task 2: Site M&V Planning

The team will develop detailed measurement and evaluation plans for each sampled project for PA approval. These plans will outline on-site methods, strategies, monitoring equipment placement, calibration and analysis issues.

Task 3: Data Collection

This will include physical inspection and inventory, interviews with facility personnel, observation of site operating conditions and equipment, short-term metering of usage, and perhaps even billing analysis. The team will incorporate customer energy management system (EMS) data should it be reliably available. Generally, both summer and winter monitored data are desirable to fully calibrate the building models. Monthly electric and gas billing data – or interval data if available – will be necessary for model calibration to actual performance. If desired, interviews could also assess progress implementing recommendations from the 2011 CDA process evaluation.

Task 4: Analysis

Using the program-developed building simulation models as a basis, the team will analyze collected data to verify measure implementation, and estimate hourly energy use and diversified coincident peak demand. Each site report will detail the specific analysis methods used for each project including algorithms, assumptions and calibration methods where applicable.

Task 5: Site Reporting

The team will prepare and submit site reports that document methodology and findings for each sampled project to the PAs for review.

Task 6: Program Reporting

The team will develop a comprehensive report that describes the methodology, findings, and recommendations from the combined site-level analyses and the extrapolated results.

Potential Budget: $200,000 - $400,000 (smaller sample, n=5)
$1,000,000 - $1,500,000 (larger sample, n=25)

Study Name: Impact Evaluation for Upstream Lighting Programs
Research Area: Commercial & Industrial
Type of Study: Impact
Applicable Fuel(s): Electric

Overall Study Goal:

The primary goal of the impact evaluation of the Upstream Lighting program will be to quantify the electric energy savings and demand reduction attributable to the program. This will enable the team to assess whether the program is achieving the expected savings as well as to identify any recommendations for improvement. The Upstream Lighting program was last evaluated in 2012, with a follow-up study of in-storage lamps conducted in 2014. Since the time of the prior evaluations, the program has grown and changed in ways that make it important to reassess program performance. Due to this growth and the implementation of programmatic changes, a secondary goal may be to conduct some process evaluation work along-side the impact evaluation. This one-pager focuses on impact evaluation, but process evaluation can be included in additional tasks.

High-Level Description of Approach/Methodology:

The DNV GL team's approach and methodology will be consistent with the procedures and protocols developed during the previous round of Upstream Lighting impact evaluation. The impact evaluation will require on-site visits and metering of lighting hours of use for a randomly selected sample of locations which purchased bulbs through the Upstream Lighting program. A process evaluation would use a series of surveys conducted with end-users, program implementers, lighting distributors and contractors.

Task 1: Work Plan Development

The DNV GL Team will work with the PAs and EEAC Consultants to develop a work plan that satisfies the objectives of this study.

Task 2: Sample Design

The DNV GL team will develop a sample design that meets the desired statistical precision targets for key savings parameters such as energy and peak demand savings, as well as other factors such as peak coincidence factors and HVAC interactive effects. The team will work with the PAs and EEAC consultants to determine if disaggregation by measure group is now appropriate within this program. An additional process evaluation sample design may be developed depending on the PA/EEAC desire to conduct some process work. A process evaluation sample would include participating end-users, lighting distributors and contractors.

Task 3: Data Collection

Data collection for the impact work would include physical inspection and inventory, interviews with facility personnel, observation of site operating conditions and equipment, short-term metering of lighting hours of use. Evaluators will attempt to determine pre-existing lamps from interviews with facility staff while performing the on-site data collection. If a process evaluation is undertaken, the team will conduct telephone surveys with participating customers, which will also be used as a data point for estimating net-to-gross savings as well as providing information on baseline technologies for the impact study. The process team will also conduct in-depth interviews with lighting distributors and contractors; these too can inform the net-to-gross analysis.

Task 4: Impact Analysis

The DNV GL team will combine the data gathered during the site visit with data provided by the PAs to estimate gross savings realization rates for annual kWh. We will also use the combined data to estimate gross savings results for other relevant savings factors. The study will also strive to produce new estimates of delta watts and annual hours of use that may be applied by the PAs going forward. All reporting at this level will be sample weighted and statistically representative of the population or appropriate population sub-groups.

Task 5: Estimating Net-to-Gross

Similar to the earlier evaluation, the process team will use a triangulation of lighting distributors, contractors and participating end-users to estimate net-to-gross.

Task 6: Reporting

The DNV GL team will develop a comprehensive report that describes the methodology, findings, and recommendations from the combined site-level analyses and the extrapolated results. The report would also include findings and recommendations from the process evaluation.

Potential Budget: $250,000 - $350,000 (Impact Evaluation)
$125,000 - $175,000 (Process/NTG)

Study Name: Prescriptive/ Custom Gas Steam Trap Measure Phase 2 Evaluation
Research Area: Commercial & Industrial
Type of Study: Impact
Applicable Fuel(s): Gas

Overall Study Goal:

The Steam Trap Measure Phase 2 Evaluation will improve the accuracy of both custom and deemed savings estimation for steam trap repair/replacement measures as well as increasing the consistency of savings estimation for the former. It also will take advantage of the expertise of a "steam trap stakeholder group" convened for tool development to recommend changes to increase broader participation and increase savings in the program.[16]

High-Level Description of Approach/Methodology:

Task 1: Work Plan Development

DNV GL team will work with the PAs and EEAC Consultants to develop a work plan and project schedule that ensures we will collect information needed for the plan by mid-September. The plan will include a preliminary list of candidate stakeholders.

Task 2: Data Gathering Phase with Preliminary Analysis

- Supplement Phase 1 with MA custom results and any additional information
- Prepare material for workshop, including test cases, calculators, and BCRs

Task 3: Convene Stakeholder Group

- Recruit attendees and convene a half-day in-person work shop, potentially with a webinar option, on tool design and ways to increase measure penetration

Task 4: Proposed Final Tool

- Build a standardized steam trap savings calculator with a limited number (nominally between 5 and 10) of system and trap variables that affect leak rate.
- Calibrate the tool using results from prior pre/post trap replacement billing analysis conducted during past program evaluations and possibly other sources.
- Develop a prototypical mixture of the aforemented variables such that the mixture is representative of the MA leaking steam trap population. In this manner, one would be able to estimate a single deemed savings value from the calculator.
- Distribute the calculation tool to the PAs along with test cases, and integrate on any final modifications.
- Work with PAs, their technical assistance providers, and steam trap vendors to support widespread adoption of the new calculator in custom projects.

Task 5: Primary field research to measure flow rate as a function of tool variables

- Identify a vendor willing to allow accompaniment during diagnostic visits
- Conduct site visits and leak characterization at up to 15 sites, until there are at least 10 sites with expected trap savings in excess of 8% of bills. Conduct billing analysis of those 10.

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[16] The recently completed steam trap phase 1 study set the stage for roll-out of a consistent tool. It included a survey of practices in other jurisdictions, a survey of local vendors, an analysis of the two existing tools, and a recommendation for measure life.

- Supplement the relatively moderate number of prior evaluation-based billing data sites with this new data to make the calibration effort more defensible.

Task 6: Re-convene Stakeholder Group for webinar presenting results

- Refine tool calculations and usability. Estimate deemed savings and report on ways to increase market penetration.

Task 7: Reporting

The team will report on the findings of the survey and associated analysis. We will work with the PAs to ensure they understand the how to interpret the results for use in the next three-year plan.

Potential Budget: $75,000 - $125,000

Study Name: Methods to Increase Participation and Energy Efficiency of Mid-sized Customer
Research Area: Commercial & Industrial
Type of Study: Market Assessment
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

The goal of this study is to develop useful strategies to increase the level of service to mid-sized customers. It will provide a needs assessment and gap analysis of electric and gas mid-sized customers. This study will contrast savings and participation rates of mid-sized electric and gas customers to those of small and large customers over time (2011-2014). This research is intended to expand on the 2013 Mid-sized Customer Needs Assessment by considering depth of savings and participation across both fuel types and multiple years of analysis. The analysis will seek to better understand both the barriers to and opportunities for participation by this important group. We will investigate level of service and program engagement differences across fuels, and recommend approaches for engaging market actors to increase the depth of savings.

We recommend exploring the following research questions:

1. To what extent are mid-sized customers aware of the full range of energy efficiency programs available?
2. How are mid-sized participants and non-participants most likely to receive and respond to the PAs' program outreach efforts?
3. What are the characteristics as well as program and vendor experiences of mid-sized program participants, and do these characteristics and experiences result in lost opportunities and/or suggest new forms of targeted communications, outreach or services?
4. How can the PAs enhance their existing eligible measure lists, incentives, delivery mechanisms, and vendor practices to maximize participation and depth of savings across electric and gas measures?

High-Level Description of Approach/Methodology:

<u>Task 1: Work Plan Development</u>

The DNV GL team will work with the PAs and EEAC Consultants to develop a work plan that satisfies the objectives of this study.

<u>Task 2: Exploratory Data Analysis</u>

We will work with the PAs and EEAC Consultants to update the definitions of customer size, particular focus is needed for gas customers to meet the study objectives that will be discussed in detail in the Stage 2 work plan. We will work with the PAs to address differences in customer size classifications across service territories. We will employ DNV GL's account-matching process that geocodes accounts to a physical location, and standardizes billing, program tracking, and other firm-o-graphic data sources. This will enable us to link electric and gas accounts, and to identify the electric and gas provider and size for each account in Massachusetts.17 The budget for this task will depend upon the level of confidence in the logical rules used to isolate unique customers. We also recommend mining the Existing Buildings On-site Assessment Study data and C&I Evaluation Database to identify groups of mid-sized customers that may represent opportunities for targeted services. The DNV GL team will coordinate

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[17] Linking of electric and gas accounts is also being proposed in a separate Stage 1 Work Plan underdevelopment (i.e., Enhanced Customer-Level Database Capabilities). If the PAs and EEAC decided to move forward with both studies DNV GL will coordinate and modify the budgets, timelines and analysis.

with the (proposed) Assessment of Share of Incentivized High Efficiency Equipment study to include survey questions targeted at mid-sized customers to better understand their energy decision making practices.

Task 3: Assessment of Marketing Strategies and Vendor Practices

We will conduct a series of IDIs and focus groups with program staff, participating and non-participating vendors, and mid-sized, large and small participants and non-participants that serve this market to determine the most effective means of targeting mid-sized customers, overcoming barriers to participation, and coordinating services across fuel types. The goal is to identify barriers to and drivers of participation through extended conversations. Budget scenarios for this task vary depending on the number of in-depth interviews and whether off-site or on-site focus groups are also completed.

Task 4: Hypothesis Testing and Upstream Analysis

For the medium and high budget scenarios, we will execute a series of customer and contractor surveys to obtain information on barriers and opportunities for mid-sized, small and large gas customers who have the same and differing size classification based on their electric consumption. For the high budget scenario, we recommend supplemental interviews with participating and non-participating contractors. This information will be used to test hypotheses developed from the data mining and market analysis tasks.

Task 5: Reporting Products to Complete the Feedback Loop to Implementation

Depending upon the rigor-level desired by the PAs and EEAC Consultants (note wide budget range); we will develop up to three interrelated products that will complete the feedback loop between evaluation and implementation:

Reporting Product	Description	Level of Rigor
Summary of approaches and marketing analysis	Summarize the existing approaches and marketing practices for providing solutions for mid-sized customers, and recommend improvements or new approaches based on our analysis.	All
Enhanced marketing tools	Linking electric and gas customers to provide the PAs with linked electric and gas accounts.[18] We will define potential barriers to increased depth of savings by measure according to customer and program characteristics identified through data mining and primary research to map potential barriers to customers based on known characteristics.	Medium and High
	Database of electrical, mechanical, thermal, and comprehensive vendors who	Medium and

[18] We will work with the PAs to develop the level of detail the PAs are comfortable sharing without violating customer confidentiality

Reporting Product	Description	Level of Rigor
	may provide services to mid-sized customers.	High
Review of non-traditional approaches to measure savings	Summarize alternative approaches – memo summarizing approaches for targeting mid-sized electric and gas customers such as midstream and upstream incentives, recommended process changes. Best practices for custom program implementation for mid-size electric and gas customers, leveraging the team's past and ongoing impact evaluation experience in Massachusetts as well as research into marketing practices in other states and industries such as telecom, banking and financial services.	Medium and High High

Potential Budget: $300,000 - $650,000

Study Name: Assessment of the Share of Incentivized High Efficiency Equipment
Research Area: Commercial & Industrial
Type of Study: Market Assessment
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

Develop a better understanding of the share of recent high efficiency purchases that were incentivized by energy efficiency programs in order to provide information helpful in the process of baseline characterization and to assess market spillover and program influence on customer purchasing practices.

The Existing Building On-site Assessment Study ("C&I On-site Study") data is a rich set of information on the purchasing practices of non-residential customers. Combining these data with end use and measure group level energy efficiency program tracking data can inform the PAs on the share of recent high efficiency purchases incentivized by the energy efficiency programs and the share purchased outside the programs.

If the share of high efficiency measures purchased outside the programs is high, it may indicate that standard practice is higher than code and baselines and programs may need to be adjusted to encourage or move the market to a higher level of efficiency. A large share of high efficiency measures purchased outside the programs may also indicate that there is a substantial amount of program spillover. Assessing the level of non-participant spillover found in the C&I On-site Study customers could provide the PAs with a more informed measure of program attribution. Phone surveys can be used to distinguish standard practice installations from installations where customers indicate program influence in their decision to install a high efficiency measures, implying spillover. The project team will utilize the experience gained and methods developed for an on-going study in California using similar C&I on-site data.

High-Level Description of Approach/Methodology:

Task 1: Work Plan Development

The DNV GL team will work with the PAs and EEAC Consultants to develop a work plan and project schedule.

Task 2: Identify Technologies with Significant High Efficiency Purchases and Program Tracking Data

The team will mine the C&I On-site Study data and the program tracking data to identify customers and technologies with recently purchased high efficiency equipment that was not incentivized by the utility energy efficiency programs. This work will expand the analysis undertaken in C&I On-site Study to incorporate end use and measure group tracking data to determine if the specific high efficiency equipment identified in C&I On-site Study received a utility rebate. This process will lead to a characterization of recent purchases within C&I On-site Study as incentivized or not incentivized at the measure level. The process will also characterize the non-incentivized measures as being installed at sites that did or did not participate in energy efficiency programs for other measures. This process will lead to the development of a sub-sample of C&I On-site Study customers with detailed efficiency information on recently purchased equipment that can be used to better characterize the recent purchase market. Evaluation of these sites will lead to the development of a list of customers and technologies warranting additional analysis to help characterize program influence, attribution, and provide insight into baseline research. After the non-incentivized high efficiency measures are identified, the work will be coordinated with evaluation team efforts to update baseline assumptions. The team will also review the measures and determine which of the technologies may warrant further attribution research and develop a prioritized list for additional research.

Task 3: Primary Research

The team will conduct primary research to better characterize why customers are installing high efficiency measures outside the program. This research will lead to a spillover analysis and could aid with the baseline research. The findings from this research may also reveal information on why mid-sized customers appear to be under-represented in energy efficiency programs. Two research approaches for consideration include:

- Customer surveys – telephone survey based data collection from sites identified in the C&I On-site Study.
- Contractor and/or Trade Ally surveys – Contact contractors or other trade allies that were identified in the Customer Surveys as highly influential in the decision making process.

Task 4: Reporting

The team will report on the findings of the survey and associated analysis. We will work with the PAs to ensure they understand how to interpret the results for use in the next three-year plan.

Potential Budget: $185,000 - $300,000 (Dependent on number of high efficiency installations in P41/50 and how many contractor/trade ally surveys).

Study Name: Drivers of Net-to-Gross
Research Area: Commercial & Industrial
Type of Study: Net to Gross
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

The primary objective of this study will be to identify factors that influence Net-To-Gross (NTG) ratios so that program designers and implementers can adjust their programs accordingly. Understanding the drivers behind NTG ratios is important, particularly because NTG is applied prospectively in annual reports and program planning filings. The factors that influence NTG ratios may include characteristics of the program design as well as characteristics of the participating customers; either of these could be addressed via program design and targeting. This study would identify the drivers behind NTG in order to provide actionable recommendations regarding program design and implementation.

Using secondary data sources including survey data already collected in Massachusetts, we will attempt to identify the key factors influencing NTG ratios and the degree to which they do so. These factors may include the following: rebates, program services, past participation, and firmographics, as well as research methodology, stage of program life cycle, and general economic conditions to the extent that supporting data is available. As we explore the data sources available for this study, we will refine the list of factors considered. In addition, we will explore how these NTG drivers may vary for different program designs (i.e., retrofit vs. new construction, custom vs. prescriptive) as well as by major measure types (e.g., lighting, HVAC, etc)..). To the extent that supporting data are available, we will investigate the effect of memorandums of understanding, multi-year agreements and chain/franchise status on NTG. Lastly, if supporting data are available, we will explore how these factors affect the various components of NTG, including freeridership and spillover, in order to better understand the underlying influences.

Because this study will rely on secondary data sources, it will be constrained by the type and granularity of the data collected by previous studies. Therefore, we envision this study as the first phase of the research; by leveraging existing data to inform the key research issues we can provide insight into the key drivers of NTG. If the results of this study indicate that further research is warranted, it will help shape the scope of the second phase.

High-Level Description of Approach/Methodology:

Task 1: Work Plan Development

The DNV GL team will work with the PAs and EEAC Consultants to develop a scope of work that meets their needs. As part of this task, we plan to conduct a few interviews with program managers in order to understand their perspectives and expectations.

Task 2: Literature Review

We propose to begin the study with a literature review of recent NTG studies to summarize the current state of the research regarding NTG drivers. As a starting point, we will review C&I NTG reports from Massachusetts and other regions (in particular California). We will review the C&I NTG studies conducted under the Cross-Cutting research area, which should provide a valuable source of information for Massachusetts programs. The electric NTG study was finalized in February 2015 and the gas NTG study was recently completed. In addition, we will review prior C&I NTG studies in Massachusetts, as appropriate. Lastly, we will review other Massachusetts NTG studies for sector-specific information, such as the LED spillover report.

Task 3: Re-analysis of Prior Survey Data

In this task we plan to mine the survey data collected for the Cross-Cutting C&I NTG studies in order to identify factors that influence NTG ratios. In particular, the survey of 1,407 electric respondents includes questions regarding program services provided such as rebates, financing, and energy audits as well as questions regarding prior program participation. We plan to analyze these survey data to assess the drivers of NTG by program type, measure type, and NTG component, to the extent that the survey data supports these analyses. In addition, we recommend leveraging the ongoing Existing Buildings On-site Assessment study as well as the associated Market Share Assessment study to identify measures with likely spillover and then explore possible reasons behind it.

Task 4: Overall Reporting

The team will provide interim reports on the findings of the literature review and the data re-analysis. In addition, we will develop an overall report that integrates the results of these two tasks and provides recommendations regarding the need for and outlines the scope of a possible second phase of the study.

Potential Budget: $75,000 - $125,000

Study Name: Process Evaluation of Upstream HVAC Program
Research Area: Commercial & Industrial
Type of Study: Process
Applicable Fuel(s): Electric

Introduction:

The Commercial & Industrial (C&I) Upstream HVAC/Heat Pump (HP) Program was launched in Spring 2013. The objective of the program is to increase sales of energy-efficient HVAC equipment in the C&I sector using an "upstream" program design. The program compensates participating HVAC distributors for discounting qualifying equipment. The program also works with participating HVAC manufacturers to insure the continued availability of the qualifying models and to help gain access to their product distributors.

Energy Federation Inc. (EFI) implements and markets the program with the Massachusetts Program Administrators (PAs) providing administrative oversight. EFI maintains an online service which allows participating distributors to apply for incentive rebates by entering sales data and other required information. The program is supposed to pay the distributors within 60 days of their online application. Currently the program provides buy-down discounts for the following types of HVAC equipment:

- Commercial unitary and split air conditioning systems (air cooled, including all types of heating);
- Commercial unitary air conditioning systems (evaporatively cooled, including all types of heating);
- Commercial unitary air conditioning systems (water cooled, including all types of heating);
- Commercial unitary heat pump systems (air cooled);
- Commercial unitary heat pump systems (water source);
- Ground water – water source heat pump equipment (open loop);
- Ground loop - water source heat pump equipment (closed loop); and
- Energy savings control and fan motor options.

Representatives of the PAs and the EEAC Consultants first expressed interest in the evaluation of this C&I Upstream HVAC/HP Program in early 2014 at which time, participation was lower than anticipated. At the time they decided to delay this research because the program implementer had started contacting HVAC contractors as part of their own research into barriers to participation. The PA representatives were concerned that if evaluators started contacting HVAC distributors so soon after the program implementer had, it would lead to confusion and respondent fatigue.

However, at the C&I evaluation planning meeting in February 2015, and in subsequent meetings and discussions, the PA representatives and the EEAC Consultants expressed new interest in a process evaluation of the C&I Upstream HVAC/HP Program. In August 2015 the evaluation team submitted a Stage 1 work plan for such an evaluation. In September 2015 the PA representatives and EEAC Consultants approved this Stage 1 plan to move to the Stage 2 scoping process. This document is the Stage 2 work plan.

Overall Study Goal:

The primary goals of this research are to investigate:

1) Why the Upstream HVAC Program is not getting a higher level of program activity (e.g., more units of rebated equipment) from participating distributors;
2) Why some HVAC distributors are not participating in the program; and
3) What changes in program design or delivery would lead to increased program activity.

Other important objectives of this evaluation include finding out what the program is doing successfully and better understanding the program's current impact on the market and options to further increase its reach into the market.

High-Level Description of Approach/Methodology:

Task 1: Work Plan Development

The DNV GL team will develop a more detailed work plan to guide our evaluation effort. This more detailed plan will expand on the research activities we are describing in this Stage 2 plan. It will contain information on sampling approaches, the research issues that will be addressed within the in-depth interviews, more additional detail on how we plan to measure market potential and detailed budgets. Because it is necessary to have a thorough understanding of the program to develop a good evaluation plan, we expect to complete this detailed work plan in parallel with the background research task described below.

Task 2: Background Research

The research task will allow us to gain a thorough understanding of the C&I Upstream HVAC/HP Program's design and delivery. It will include the following activities:

- *Review of program documents:* We will review all program documents including program informational and marketing collateral, process flow diagrams, marketing plans, logic models, etc.
- *In-depth interviews with PA program managers:* We plan to complete up to five in-depth interviews with PA representatives who are involved in managing this program. The topics we plan to cover include their roles in the design and delivery of the program, any recent or planned changes in the program, the program's marketing and outreach efforts, barriers to participation, aspects of the program that are going well, and any challenges the programs may be facing. Another program topic we plan to cover is whether there is any evidence of the downstream Custom program claiming projects that should be funnelled into the upstream program. Our 2014 interview with a PA program manager indicated that this was a concern, although the recent elimination of the downstream incentives for unitary HVAC equipment may be mitigating this effect.
- *In-depth interviews with implementation contractors:* We plan to complete five in-depth interviews with representatives of EFI who are involved in implementing the program. These would include interviews with program managers as well as with three field representatives who try to recruit HVAC distributors and manufacturers into the program.

  The topics we plan to cover with the EFI program managers would be similar to those we describe above for the PA program managers. However, we would also ask them about the high-level lessons learned from their 2014 trade ally research which we mentioned above.

  Our interviews with the EFI field representatives would focus on their outreach efforts. The topics we plan to cover would include how they contact HVAC distributors and manufacturers, how frequently the interact with them, sales pitches they use to promote the program, questions or concerns the distributors and manufacturers have about the program, barriers to program participation, and what could be done to streamline the process for getting more HVAC distributors on board.

- *Review of recent HVAC-related Massachusetts research:* We would review recent research which has been done on the Massachusetts C&I HVAC market under both the C&I and Cross-Cutting contracts with a special focus on market structure and market barriers.

Task 3: Best Practices/Benchmarking Study

The research task will allow us to learn about program designs and best practices for upstream HVAC programs from outside of Massachusetts. It will include the following activities:

- *Literature review:* We will conduct secondary research to identify other upstream/midstream HVAC programs offered in the market. This literature review will first compare key attributes of these non-Massachusetts programs with the Massachusetts program such as the type of equipment types they rebate and the size of the rebates they offer. In addition to benchmarking these program design features, we will also look for indicators of programs success such as participation levels, energy savings normalized by market size, higher benefit/cost ratios, and positive evaluation findings. We will summarize this research in a memorandum of key findings. From this research we will also identify up to five program managers of non-Massachusetts HVAC upstream/midstream programs to interview.
- *In-depth interviews with non-MA upstream HVAC program managers:* We plan to complete in-depth interviews with up to five program managers of non-Massachusetts HVAC upstream/midstream programs. While ideally these interviews should be limited to successful programs based on criteria mentioned above, we believe that interviews with managers of less successful programs can also produce useful information in the form of lessons learned and mistakes to avoid. Topics covered in these interviews could include: program design (e.g., HVAC products rebated, rebate levels, market actor eligibility requirements); marketing, outreach, and education and training activities; paperwork requirements; barriers to participation; lessons learned, and; programmatic elements that are particularly effective. In the 2014 and 2015 discussions with EEAC and PA representatives there was interest in learning more about California's Upstream HVAC Program specifically which has apparently had some success.

The deliverables for this research task will be the interview guide for the non-Massachusetts program managers and an interim findings memorandum.

Task 4: Market Penetration/Potential Analysis

This research task will help provide the PA representatives and EEAC consultants with an understanding of the C&I Upstream HVAC/HP Program's current impact on the market and its future potential. It will include the following activities:

- *Program activity and trends:* We will use program tracking data to analyze trends in the type of HVAC equipment being rebated and which distributors/contractors are selling this equipment. We will work closely with EFI which is responsible for compiling the program data.
- *Market penetration/potential:* To better understand the program's market penetration/potential, we would mine data from the ongoing Massachusetts Existing Building Market Characterization Onsite Study (P41/P50). Specific types of data that may be useful include:

- *Energy efficiency:* The evaluators have been using nameplate information collected onsite to estimate the energy efficiency of the installed equipment.
- *Whether the EE equipment received a program rebate:* For equipment which was reportedly installed in 2009 or later, the onsite engineers asked whether the installed equipment had received a program rebate.
- *Year of installation:* The evaluators asked the onsite customer representatives to estimate when HVAC equipment was installed.
- *Year of manufacture:* In addition to providing information needed for the determination of energy efficiency, the nameplate information on the HVAC equipment can also provide information on the date the equipment was manufactured. It is our understanding that the evaluators did not collect this information for Wave 1 of the P41/P50 project but they could do so for Wave 2 (and they could go back to the Wave 1 data to collect this, if needed).

Each of these data sources has their limitations. For example, the evaluation engineers did not always collect information on whether the HVAC equipment received a program rebate or the year of installation. This is because sometimes the onsite customer contact was unavailable to talk or had not been working there when the equipment had been installed. Even when the onsite contact was available to provide an estimate of installation date, they often provided a range of dates rather than a precise year.

As another example, the manufacturer year is not available in all nameplate information and, in many cases, we will have ranges of dates for when a given model was in production rather than a precise year. Furthermore, even when a precise year is available, there will inevitably be some unknown amount of time between when the equipment was manufactured and when it was installed. For these reasons, we will likely do a cross comparison of the reported year of installation and the manufacture date from the nameplate for the same pieces of equipment to see how well correlated these different information sources are.

Taking all these limitations of the data into account, this data mining should produce some useful indicators of program penetration and potential including:

- The proportion of program-eligible HVAC equipment which received a program rebate;
- The proportion of recently-installed HVAC equipment which was
  - Program eligible;
  - Energy efficient; and
  - Received a program rebate; and
- The proportion of HVAC equipment which is past its Estimated Useful Life (EUL).

We will choose which of these metrics to focus on after discussion with EEAC consultants and PA representatives. To the degree possible (e.g., the sample sizes remaining large enough to be meaningful), we will also look for any variations in these indicators depending on industry sector or building type.

The deliverables for this research task will include a brief memo summarizing the feasibility and pro/cons of these metrics (for stakeholder discussion) and an interim findings memorandum.

Task 5: Interviews with Participating and Nonparticipating HVAC Manufacturers and Distributors

The PA representatives and EEAC consultants are interested in knowing: 1) why HVAC distributors and manufacturers are not participating in the program; and 2) why HVAC distributors and manufacturers who are officially program participants are not more actively promoting the upstream incentives.

We plan to conduct in-depth interviews with 10 participating HVAC distributors, 10 nonparticipating HVAC distributors, and five HVAC manufacturers. These interview targets may change once we become more familiar with the participant population. For example, the current (October 2015) list of participating HVAC distributors has only 18 unique companies but the largest of these companies has 25 different locations. So if all equipment purchase decisions are made at the corporate level rather than at the location level, it will be challenging to hit our target of 10 completed interviews. But if we find that there is some autonomy in purchasing decisions among the local offices, then our sample frame will expand significantly.

The topics that we plan to cover with the participating distributors/manufacturers include:

- How they first found out about the program;
- Their motivation for joining the program;
- Their self-reported level of program activity;
- Barriers to increased program activity;
- How they use program rebates in their sales process;
- How they keep track of program changes (both actual methods and preferred methods);
- Their perspective on the mix of EE measures rebated by the program;
- Their perspective on the level of rebates offered by the program;
- Program satisfaction (with program staff, paperwork, rebate processing, marketing, program overall, etc.);
- Suggestions for program improvement; and
- Firmographic information (company size, service area, equipment/service offerings, market focus).

The topics that we plan to cover with the nonparticipating distributors/manufacturers include whether they are aware of the program, their barriers to program participation, their perspective on the mix of EE measures rebated by the program (once these have been described to them), their perspective on the level of rebates offered by the program (once these have been described to them), their suggestions for ways that the program could increase participation levels, and their firmographic information.

We will be careful to coordinate these data collection efforts with the Cross-Cutting research team working on the HVAC panel study. To develop our sample frame, we will not only use the program tracking data from Task 4 but will also leverage information collected from the recent Massachusetts Characterization of Supply Side Populations study as well as market sales information from the HVAC panel study.

The deliverables for this research task will be a sampling plan and the trade ally interview guide.

Task 6: Reporting

The deliverables for this evaluation will include:

- A memorandum summarizing the interim findings from the best practices/benchmarking study;
- A memorandum summarizing the interim findings from the market penetration analysis; and

A written report which will summarize the key findings from all the research activities and recommendations on how the C&I Upstream HVAC/HP Program can increase participation and improve its operational efficiency. The format of this report will be consistent with other DNV GL reports.

Potential Budget: $138,000

Study Name: CHP Process Evaluation
Research Area: Commercial & Industrial
Type of Study: Process Evaluation
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

CHP projects in Massachusetts have demonstrated significant C&I energy savings. They have also been used selectively for relieving T&D constraints. There are indications that more benefits from increased CHP usage could be realized if certain market barriers could be overcome. This study would identify the key barriers which discourage broader implementation of CHP projects, explore how these barriers might be mitigated, and discuss how CHP projects might produce other benefits (e.g. relieving T&D congestion) besides energy savings. Among the barriers to be examined include the following:

- CHP technologies have important but-difficult-to monetize benefits (e.g., to the T&D system; to utility business models and to host sites).
- CHP systems have an unproven ability to provide firming on an as-needed basis, which will gain in importance with increased penetration of intermittent resources or to help relieve “weak” spots in the distribution system.
- Many potential users are unaware of CHP performance aspects and their potential benefits which has limited broader use of CHP.
- There is a misperception that CHP systems are inherently high emission sources of NOx and cannot help with GHG emission reductions, which impedes their broader use even though natural gas prices are forecasted to remain low for the foreseeable future.
- There are misunderstandings on how best to incorporate CHP systems to help support the utility business models now and in the future.
- CHP systems have helped microgrids increase resiliency of T&D systems yet it is not clear to utilities the best way in which to use CHP systems to help improve system reliability and responsiveness.
- Utilities are concerned that increased levels of CHP will lead to more complex interconnection requirements for utilities.

One research objective is to provide suggestions on how CHP projects could be implemented more efficiently and effectively. In particular, this study will investigate approaches utilities are adopting to help streamline interconnection of CHP systems. In addition, this study will examine cases where CHP systems are being used within the grid to help provide firming of intermittent renewables as well as help improve system reliability and responsiveness.

Another critical research objective of this study is to identify factors that make certain utility customers good candidates for hosting CHP systems. For example, customers most likely to benefit from CHP systems are those with high thermal energy loads throughout the year, which have matching coincidental electrical loads or companies that may be expanding operations that will result in higher thermal and electrical loads. Other factors that may help certain customers be better candidates for hosting CHP systems include existing familiarity with mechanical systems, staff trained to support mechanical and electrical systems and a business approach and model that can incorporate more complex operations.

This study will also follow up on past CHP impact evaluation work that examined different methodologies used by Massachusetts utilities in estimating potential energy savings of CHP projects. The specific research objective is to determine if the utilities have adopted a more common methodology for estimating energy savings recommended in the past study. If a common methodology has not been adopted, this study will assess the barriers to adoption of a common methodology.

High-Level Description of Approach/Methodology:

Task 1: Work Plan Development

The DNV GL team will work with the PAs and EEAC Consultants to develop a work plan, budget and project schedule to achieve the outlined research objectives.

Knowledge gained from a 2011 Massachusetts CHP Market Characterization[19] and two Massachusetts CHP Impact Evaluations (one in 2012[20] and one in 2013[21]) will inform the research of this study and help establish the approach.

In addition, Itron is currently involved in a distributed energy resources market transformation study that encompasses CHP technologies being deployed in states across the country. Information gleaned from that ongoing effort will also help guide this research study.

Task 2: Establish Survey Designs and Sample Design

We will collect data on CHP barriers and possible barrier resolution from four sources: CHP system manufacturers and project installers; utility program administrators; utility distribution planners; and program participants and non-participants. Data collected from the earlier CHP market characterization study and existing literature research will help in developing draft survey instruments for each of the target groups and in developing sample population estimates.

The surveys will focus on obtaining a better understanding of how the different groups approached CHP projects; who was involved in development of the project; what were the different goals of the project; what were the expected benefits; what were the types of barriers (e.g., technical, economic, financial, institutional, etc.,) encountered from project concept through project installation and operation; lessons learned along the way and opinions about what changes are needed to help ensure successful adoption of CHP in Massachusetts. Examples of specific questions to be included in the surveys include the following:

- Where did the idea for this CHP project come about?
- What were the objectives of this project (just energy savings, T&D relief also)?
- Who was involved in the technical design and scope of the project?
- Was adequate technical assistance readily available?
- How was the project financed? What were the paperwork requirements for this project and were they reasonable?
- How long did the project take to implement?
- What stages of the project took longer and how could these stages be streamlined?

We will submit draft survey instruments to the PAs and EEAC and finalize them based on PA and EEAC feedback.

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[19] "Project 1C Combined Heat & Power Market Characterization," prepared for Massachusetts Energy Efficiency Program Administrators, KEMA Inc.; Itron; Energy & Resource Solutions, June 1, 2011

[20] "2010 Combined Heat and Power Impact Evaluation Methodology and Analysis Memo," prepared for Massachusetts Energy Efficiency Program Administrators and the Massachusetts Energy Efficiency Advisory Council, KEMA Inc.; Itron; Energy & Resource Solutions, January 11, 2012

[21] "Massachusetts Combined Heat and Power Program Impact Evaluation: 2011-2012," prepared for Massachusetts Energy Efficiency Program Administrators and the Massachusetts Energy Efficiency Advisory Council, KEMA Inc. and Itron; November 2013

Task 3: Data Collection

Using approved survey instruments, the team will collect primary information on how these CHP projects are typically implemented and which barriers complicate project implementation and limit more widespread adoption of CHP in Massachusetts. We expect to conduct five in-depth surveys with program administrators and up to thirty in-depth surveys with CHP project installers and CHP manufacturers active in Massachusetts to identify specific market or institutional barriers confronting CHP adoption in the state. Particular emphasis will be placed on identifying methods by which barriers can be addressed through near-term activities. Similarly, we anticipate conducting five in-depth surveys with utility distribution planners to identify operational issues that might arise due to increased CHP growth in the distribution system, limits associated with current methods for incorporating CHP systems into the system, and if CHP growth in the distribution system is to occur, ways in which that growth could result in benefits to customers and the utility.

A combination of up to seventy telephone and internet surveys will be conducted with participants to determine the origin of the CHP project, to identify reasons why participants elected to install CHP systems, specific objectives of the CHP project (including those beyond just energy savings), the way in which the project was financed, the paperwork and permit requirements of the project, the length of time it took to install the project, what benefits or issues resulted from installation of the systems, what unanticipated benefits resulted, lessons learned about CHP performance and costs and what considerations should be given to growing CHP in Massachusetts. In addition, participants will be asked to identify what messaging, information, source of information and outreach method most influenced their decision to move forward with the project. The collected information will help identify characteristics of participants that may be better candidates for targeting CHP outreach efforts.

Similarly, telephone and internet surveys will be conducted with approximately 200-300 non-participants (i.e., utility customers who were targets of the CHP program offering through utility outreach or who may have applied to the CHP program but then elected not to participated in the program) to identify reasons why they chose not to pursue CHP systems; the extent they were or are knowledgeable about CHP performance and costs; the extent to which market versus institutional barriers acted as decision points for them; and what factors may have induced them to install CHP systems (but were not present at the time they were making their decision).

Depending on the results from the surveys, the team will also consider holding several focus group meetings among a combination of project installers, program administrators, participants and non-participants to discuss the primary barriers facing increased adoption of CHP systems and possible resolution to those identified barriers.

Task 4: Reporting

The team will provide a draft and final report which will contain key finding from our research as well as recommendations on ways in which to incorporate the findings into action items for the CHP program.

Potential Budget: $125,000 - $200,000

Study Name: How PA Differences Affect Program Outcomes, Phase 3
Research Area: Commercial & Industrial
Type of Study: Process
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

Overall, this project seeks to identify the factors that lead to differences in the depth and cost of savings among the PAs. This project is intended to provide information and insights that will be useful for the PAs and contractors to identify best practices. All stakeholders agreed to time this project so it can leverage the data from the 2014 Customer Profile report (Project 51). Discussions with stakeholders about the outstanding questions from Phase 2 identified the following activities and/or researchable topics of most interest to the PAs and EEAC Consultants:

- How saturated are the large customers in the various PA territories? Is there a relationship between saturation and freeridership? What strategies could PAs with more saturation employ to increase attributable savings? Integrate with the technical potential studies PAs produced for new Three Year Plan and DNV GL's Onsite Assessments study (Project 41).
- Define or update the definition of mid-sized customers, particularly for gas. What are the differences in services, measures, and savings with mid-sized customers? What are the commonalities and unique aspects of this market segment across the state? Expand on the Mid-sized Customer Needs study from 2013.
- Investigate approaches/successes within specific market segments, contrasting and comparing unique strategies for targeting and affecting specific market segments across the PAs. For instance, the PAs have multiple ways of serving grocery.
- How could the PAs achieve greater savings from office and retail buildings (customer types that have potential savings that are expensive to achieve)? What are the different characteristics (e.g. size) and savings potential of office and retail customers by PA? What strategies could PAs employ to increase savings in these sectors? How does National Grid compare to Eversource after restructuring?
- Conduct a longitudinal analysis of HVAC savings. Specific questions include, but are not limited to: Is Eversource still achieving better HVAC savings than National Grid? Does National Grid's new organization improve its achievement of HVAC savings?
- Provide a focused, longitudinal comparison of the PAs' New Construction programs, similar to the Large Retrofit comparison conducted in Phase 2.

High-Level Description of Approach/Methodology:

<u>Task 1: Work Plan Development</u>

The first step in this evaluation will be to develop and agree upon a work plan. In addition to scope, budget, and timeline, key activities during this stage are to articulate and prioritize precise researchable questions, establish definitions of key concepts, and determine data sources that will be necessary to address the researchable questions. Other important activities during this stage are to identify content overlap with other ongoing evaluation efforts and decide which project will include that content. It is possible this could result in moving of some of the topics listed above from the final scope of this project to another project. This project is dependent on the data from Project 51, so finalization of the Project 51 scope of work is required before finalizing this project's work plan.

<u>Task 2: Data Collection</u>

The exact data sources used for the project will depend on the final scope articulated in Task 1. DNV GL anticipates using the following data sources: the database constructed by DNV GL for Project 51, Project 41 on-site survey results, and the technical potential studies produced by the PAs for the 2016-2018 Three Year Plan. The scope will probably require additional in-depth interviews with PA staff, other program stakeholders, subcontractors, and customers to help focus and add depth to the quantitative analyses.

Task 3: Analysis

Conduct analyses to answer the specific researchable questions articulated in the scope of work.

Task 4: Reporting

The team will provide the PAs with a written report containing the analysis results. Reporting will be consistent with the MA CIEC Contract Management guidelines currently under development. Based on past experience with Phase 2 and similar reports, DNV GL anticipates a vigorous report revision process between the draft and final report.

Potential Budget: $350,000 - $450,000

5.3 CROSS-CUTTING STAGE 1 WORK PLANS

Study Name:	Stretch Code Market Effects (TXC 3)
Research Area:	Cross-Cutting
Type of Study:	Market Effects
Applicable Fuel(s):	Electric & Gas

Overall Study Goal:

The primary goal for this study will be to assess whether or not the trainings sponsored by the Massachusetts Program Administrators (PAs) have influenced changes in practices among market actors in stretch code cities and towns. Beginning in 2010, Massachusetts municipalities began adopting the stretch energy code[22], which is one of the requirements to become a green community under the Green Communities Act[23]. As part of the Code Compliance Support Initiative (CCSI), the PAs are conducting trainings with various market actors (e.g., builders, code officials, and HERS raters) to enhance compliance with the stretch code.

A secondary goal of this study will be to begin developing a comprehensive set of stretch code data that can be used to inform a Delphi panel and aid in the assessment of attribution of savings in stretch code municipalities to PA efforts. In addition to attribution from the CCSI trainings, the PAs may be responsible for compliance enhancement through a number of indirect factors. These indirect factors may include the following:

- Initial support and contributions to the Massachusetts Department of Energy Resources (DOER) in their development and adoption of the stretch code
- The development of a robust HERS rater market in Massachusetts through the Residential New Construction (RNC) program
- Training and information sessions held in communities considering adoption of the stretch code by the RNC Program
- Spillover from stretch code municipalities into non-stretch code municipalities due to a change in practice from market actors that work in both segments of the market.

Research Questions:

- Are the CCSI trainings influencing changes in practices for key market actors in stretch code municipalities?
- What comprehensive stretch code data can be gathered and used to assist a future Delphi panel?
- What are the indirect effects of the stretch codes and what can be attributed to the CCSI trainings?

Note that this Delphi study will serve other purposes as well, as discussed in the broader strategic approach to evaluating codes and standards activities.

High-Level Description of Approach/Methodology:

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[22] Stretch Code Provisions
[23] How to Become a Green Community

As part of the ongoing CCSI evaluation, the evaluation team is conducting follow-up surveys with various market actors to assess whether or not the trainings have influenced their practices. The work suggested here, which is not included in the already approved work, is to investigate the responses from stretch code communities in particular to identify what type of influence the CCSI has had on trainee practices.

An additional task that can added to a future Delphi study is to begin documenting stretch code data to help inform the assessment of PA attribution in stretch code communities and from any stretch code spillover. Specifically, the evaluation team will review data from stretch code towns that were included in the 2011 Single-Family Baseline study and compare it to the data from stretch code towns that are currently being included in the ongoing Single-Family Compliance/Baseline study. Stretch code towns that were in the 2011 baseline study had not yet begun enforcing the stretch code and therefore will offer a pre-stretch code baseline that can be compared to results from the current study to inform the Delphi panel's assessment of attribution. In addition to compiling these data, the evaluation team will begin compiling detailed documentation of any PA efforts that went into developing the stretch code and participation of market actors from stretch code communities in initial trainings that took place prior to the implementation of the CCSI.

Potential Budget: $130,000 - $185,000

Study Name: Commercial & Industrial Top-down Modeling Exploration of Key Econometric Concerns (TXC 22)
Research Area: Cross-Cutting
Type of Study: Impact (Commercial & Industrial)
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

The goal of this study is to further investigate key econometric concerns identified through the Year 1 top-down modeling method review and PA-muni and PA-data pilot studies.

Research Questions:

The general research question addressed by this project is how best to specify, test, and apply the models. Specific questions include:

- What is the best approach for handling weather variation (weather-normalized annual data vs. weather terms in the econometric model)?
- How should models account for cumulative program effects of programmatic activity over time--.i.e., whether to use cumulative lagged terms, individual lagged terms, or indexed lagged terms?
- What is the most appropriate method for constructing portfolio-level savings estimates and error bounds from the model results?
- How should models account for the recession years (2008-2010) to determine impacts on energy usage?

High-Level Description of Approach/Methodology:

Phase 1 of this work will expand on the literature review conducted for the 2015 top-down efforts to examine best practices in evaluation using aggregate econometric analysis for non-energy federal programs. Also included will be a discussion of theoretical advantages and disadvantages of particular methods. If the PAs elect to continue with the second phase, we will apply the techniques identified through Phase 1 to the models developed through the Year 1 top-down pilot studies.

The specific tasks for Phase 1 of this study include the following:

<u>Task 1: Develop the work plan</u>

The evaluation team will develop a detailed work plan for the study.

<u>Task 2: Extended methods assessment: Literature review, in-depth interviews, and theoretical assessment</u>

The evaluation team will build on the 2015 methods review by examining literature regarding other federal programs that employ top-down modeling to assess programmatic impacts, as well as academic literature concerning the appropriate treatment of the relevant econometric concerns. We will conduct five to ten interviews with academics, public officials, or other individuals regarding the relevant econometric concerns. We will also develop some primary assessments of pros and cons from a theoretical perspective.

Task 3: Reporting

The evaluation team will prepare a draft and final report consolidating the findings from Task 2 together with the prior MA Top-Down studies into recommended approaches and guidance for top-down model development.

Potential Budget: $47,000 - $63,500

Study Name: Top-Down—Exploring Enhancements to the PA-Muni Model (TXC 23)
Research Area: Cross-Cutting
Type of Study: Impact
Applicable Fuel(s): Electric and Gas

Overall Study Goal:

A major limitation of the PA-Muni top-down modeling conducted previously is that much of the programmatic activity is consistent across the PA territories, as are the socioeconomic characteristics. This limits the amount of variation within and across observational units. Adding another year of data from MA, including if at all possible more detailed geographic breakdowns, could provide additional variation to the models. In addition, it may be possible to develop gas models as well as electric models if town-level data are available.

This study will first explore whether these additional data are available and whether the approach appears promising, and, if so, would develop additional models making use of those data. Although the PAs have indicated that town-level data are not available, it will be beneficial to explore if there are any useful geographic-based aggregate consumption and program data that might be available for an extended historic period, even for a subset of the PAs.

Research Question:

The study seeks to obtain data with greater variation across time and across municipal utilities and PAs, and if possible to develop more robust Top-Down PA-Muni electric models, both residential and commercial/industrial, and possibly for natural gas as well.

High-Level Description of Approach/Methodology:

The previous models utilized data from 1990 through 2012. However, the municipal utility association supplied data through 2013 for most municipal electric utilities. In the first, exploratory phase, this new study will seek usage and program expenditure data for 2013 from the electric PAs in Massachusetts. Also in the exploratory phase, the evaluation team will explore with the MA PAs whether any within-PA geographic breakdown of electric usage and program expenditure data are or could be available, and if so for what years. In addition, the evaluation team will explore whether similar usage and expenditure data are or could be available from the gas PAs, and if so for what years. Before requesting the data for natural gas, however, the evaluation team will examine the likelihood of success based on the average percentage of savings per household and the range of variation in program activity level over time for gas versus electricity.

If the data are available and the approach appears feasible, the evaluation team will develop additional models. These models could include residential and commercial electric PA-muni models with 2013 data included, town-by-town residential and commercial PA-muni electric models, and/or town-by-town gas PA models.

Potential Budget:

The potential budget range for the exploratory phase of this project is $45,000 to $65,000. The modeling phase, should it occur, would involve the development of two or several models, and will have a budget range of $150,000 to $320,000.

Study Name: Commercial & Industrial PA-Data Top-Down Modeling Refinements (TXC 25)
Research Area: Cross-Cutting
Type of Study: Impact (Commercial & Industrial)
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

The goal of this study is to expand the C&I top-down modeling database created in the 2015 C&I PA Top-down Modeling study to include more years of data and to then re-estimate the C&I PA Top-down model. The evaluation team will continue to compile additional years of billing and tracking data as they become available through the C&I Customer Profile Database. Re-estimating the C&I models is not included in the study plan. The team will determine the timing for re-estimating the models when sufficient long-term data are available.

High-Level Description of Approach/Methodology:

Task 1: Develop the work plan

The evaluation team will develop a detailed work plan for the study. The work plan will build upon the data collection activities used in the 2015 C&I PA-data Top-Down Modeling study.

Task 2: Compile C&I Customer Billing and Program Tracking Data

The evaluation team will extract and compile additional customer billing and tracking data from the C&I Customer Profile Data Base. The data will be appended to the database used for the 2015 study.

Task 3: Compile Other Input Data

The evaluation team will compile and process other economic and firmographic data. These data will also be appended to the 2015 top-down data base.

Task 4: Determine Timeline for TDM C&I Model Updates

The evaluation team will work with the PAs and EEAC consultants to determine the requirements for length of time series needed for re-estimation of the PA-data model.

Deliverable:

Task 3 – Expanded C&I PA-data SAS data base.

Potential Budget: $42,000 - $58,500

Study Name: Market-Rate Rental Property NEIs (TXC 29)
Research Area: Cross-Cutting
Type of Study: Impact
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

The Market-Rate Rental Property NEIs study will examine and quantify non-energy impacts (NEIs) for the owners and managers of market-rate rental properties. NEIs can be an important driver of and outcome to energy efficiency programs and market decisions. In 2011, a NEI study sponsored by the Massachusetts Program Administrators (PAs) estimated NEIs that accrue to owners and managers of low-income rental properties. However, the study did not include owners and managers of market-rate rental properties. NEIs for this market segment include, but are not limited to, changes in monthly apartment rental rates, operations and maintenance savings, and reduced vacancy rates.

In order to estimate these NEIs, we recommend adapting the methods used by DNV GL in the C&I NEI study[24]. Through interviews with owners and managers of rental properties, the evaluation team will estimate a number of NEIs that may result from the installation of energy efficiency measures and if possible quantify their value.

Research Questions:

- What are the NEIs experienced by the owners and managers of market-rate rental properties?
- How can the NEIs be quantified and how do they compare to energy impacts?
- Are some measure categories, such as lighting or heating equipment, associated with higher NEI values than other measure categories?
- How do NEIs relate to energy efficiency purchases or decisions in the market-rate rental segment? Are they anticipated prior to decision making or emerge after projects are implemented?
- How might NEIs affect program design or market engagement options?

High-Level Description of Approach/Methodology:

Through interviews with owners and managers of rental properties, the evaluation team will estimate a number of NEIs that may result from the installation of energy efficiency measures. The interviewer will use closed-ended questions to determine whether the rental property experienced the NEIs and then open-ended questions to quantify NEI values. The interview guide will be designed to allow the interviewers to probe deeply into potential sources of NEIs and allow owners and managers to estimate NEIs in metrics with which they are familiar. For example, NEI values can be estimated as hours of labor saved from fewer light bulb changes or hours of labor saved due to fewer tenant complaints, resulting in wage savings. They can also be estimated in terms of increased monthly rental rates, or reductions in vacant apartment units. These data will be used to quantify the NEIs into

[24] Massachusetts C&I NEI Final Report (2012)

dollar values (i.e., hours of reduced labor multiplied by the hourly wage rate). These data will allow the evaluation team to develop a set of monetized NEI estimates for each owner or manager.

Potential Budget:

We have developed three budget scenarios. The budget scenarios are largely determined by the number of measure categories, such as lighting, heating and cooling equipment, shell measures (e.g., insulation and air sealing), and hot water measures addressed by the study. Each interview will address a minimum of two measure categories and we will target 30 to 50 completed interviews for each measure category. We will prioritize measure categories by the magnitude of expected energy savings. The low-, medium- and high-budget scenarios will attempt to estimate NEI values for two, three and four measure categories, respectively. The three research options and costs are summarized in the following table.

Tasks	Budget range
Low	
Task 1: 50 in-depth interviews	$150,000 - $180,000
Task 2: NEI estimates for two measure categories	
Task 3: Final report	
Medium	
Task 1: 75 in-depth interviews	$175,000 - $215,000
Task 2: NEI estimates for three measure categories	
Task 3: Final report	
High	
Task 1: 100 in-depth interviews	$210,000 - $260,000
Task 2: NEI estimates for four measure categories	
Task 3: Final report	

Study Name:	Net-to-Gross Methodology Research
Research Area:	Cross-Cutting
Type of Study:	Impact (Commercial & Residential)
Applicable Fuel(s):	Electric & Gas

Overall Study Goal:

The goal of this study is to examine the general methods used in Massachusetts (MA) for estimating free-ridership and spillover, comparing current methods in MA to those used in other regions of the US. The study will also investigate and document the strengths and weaknesses of conducting net-to-gross (NTG) studies at different levels of measure, program, customer, and/or other level of aggregation. Additionally, the study will investigate NTG practices related to the time delay between project inception, completion, and NTG data collection. A report will provide options, trade-offs, and recommendations for modifications to the existing approaches for consideration by the Massachusetts PAs.

This study will continue to build on the methodological reviews that have been done for the PAs. In 2011 a pair of detailed studies developed suggestions for more standardized guidelines for quantifying net savings for commercial and industrial programs (Tetra Tech et al. 2011) and for residential programs (NMR 2011). Since then, the cross-cutting research area has conducted four NTG surveys (two electric and two gas) with C&I downstream participants—electric C&I studies conducted in 2011 and 2014 and gas C&I studies in 2012 and 2014-2015. In addition, one cross-cutting study identified possible overlap among various NTG estimates for non-residential new construction (NMR 2015); such overlap should be taken into account for other programs and markets as well.

Research Questions:

- What new techniques are being utilized to assess NTG and which can be incorporated into the existing NTG studies?
- What are relative advantages and disadvantages of the various new and existing methods for different program types and conditions, and for different NTG-related questions?
- What are key program, definition, and methodological differences that contribute to differences in measured NTG results?
- What customer segments drive NTG ratios?
- What are the implications of different levels of aggregation when conducting studies and calculating NTG ratios?
- What are the benefits and challenges of conducting customer survey-based NTG studies soon after customer participation on a more “real-time” basis?
- What are alternative approaches and methods for understanding spillover?
- What are effective ways to coordinate market effects studies with NTG efforts?
- Can the consistency question battery in the current MA NTG surveys be simplified to reduce respondent burden?
- What methods are available to properly account for net savings when multiple programs affect a single set of decisions in regard to implementing energy efficiency measures? Examples of this include interactions between residential retrofit incentive and home energy report programs and between new construction incentive and code enhancement/enforcement efforts.

- What methods are available for deciding how to select and/or combine the results of alternative methods applied to estimate net savings for the same program?

High-Level Description of Approach/Methodology:

Task 1: Develop the research plan

The evaluation team will develop a detailed research plan for the study. The research activities are likely to include the following:

- Best practice and literature review to examine techniques currently being used to measure NTG and possible sources of overlap
- Review existing cross-cutting reports to identify impacts of market effects on NTG
- Analyze existing NTG results from the prior four studies (gas and electric) to identify potential drivers (e.g., organizations guidelines for purchasing equipment)
- Interviews with PA program and evaluation staff.

Note also that the potential list of research questions is quite extensive, and the actual research may instead focus more deeply on a subset of the issues listed above.

Task 2: Conduct the activities and analysis

The evaluation team will conduct the activities and analysis specified in the research plan. The team will conduct an internal review of the findings and consider their implications for current MA NTG practices and effects on NTG ratios.

Task 3: Produce a draft and final report

The Evaluation team will develop a report based on the findings from Task 2.

Additional activities could include pretesting new approaches or question wording once best practices and approach recommendations have been identified and agreed upon.

Deliverable:

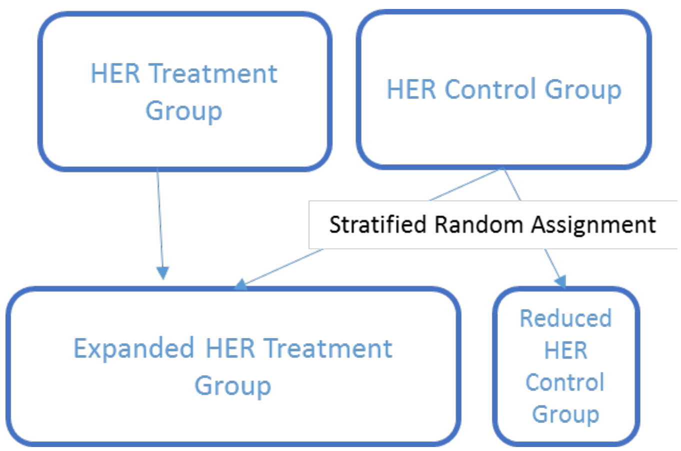
Task 3 – Draft and final report. This report will document the studies and reports reviewed for the analysis and recommend an approach for the PAs to consider.

Potential Budget: $130,000 - $185,000

Study Name: Reducing the Size of the Control Group in the Home Energy Report Program
Research Area: Cross-Cutting
Type of Study: Impact and Process
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

Approximately 400,000 Massachusetts households are ineligible to receive Home Energy Reports (HER) because they have been randomly assigned to the control group. The goal of this study is to assess the opportunity for transitioning existing control group customers into the treatment group as depicted in the figure below.



High-Level Description of Approach/Methodology:

Task 1: Power Analysis of Existing HER Cohorts

Using the savings estimates developed in the 2014 evaluation, the team will conduct a power analysis to determine the largest ratio of treatment-to-control customers while maintaining the desired level of confidence and precision. The level at which the power analysis will be conducted will be determined by the PAs, EEAC, and the Navigant team (e.g., cohort, PA and fuel-type). Additional studies expected to be implemented in the near term (e.g., combined behavior and Wi-Fi thermostat program, persistence study) will be factored into the analysis. This analysis will result in the number of control customers that can be transitioned into the control group. Average savings per household are expected to remain stable due to the RCT-design.

Task 2: Develop a Transition Protocol

The team will work with the Implementation Contractor to develop a protocol for transitioning customers from the control group to the treatment group, while maintaining randomization.

Task 3: Implement Transition Protocol

The team will implement the transition protocol, re-assigning customers from the control group to the treatment group and validating that randomization has been maintained. The team will use the results of Task 1 to inform how many control customers should be transitioned.

Task 4: Analysis and Reporting

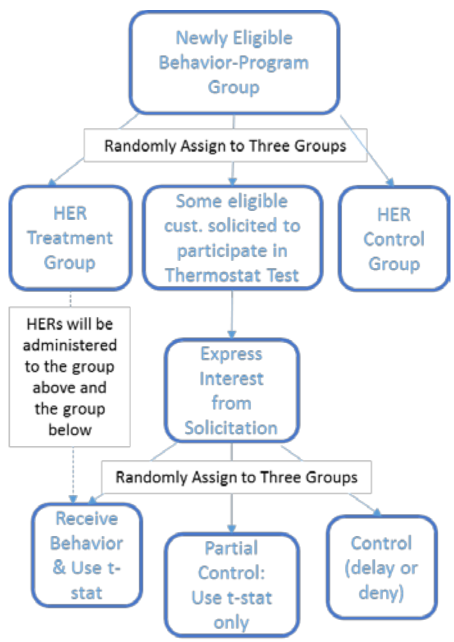
The team will provide the PAs with a written report containing the results of the Power Analysis, the Transition Protocol, and a summary of implementation of the Transition Protocol.

Potential Budget: $40,000 - $75,000

Study Name: Assessment of Combined Behavior and Wi-Fi Thermostat Programs
Research Area: Cross-Cutting
Type of Study: Impact and Process
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

The PAs are interested in assessing combination behavior and technology through Wi-Fi thermostat technology. Through careful experimental design--including the development of a control group who receive Wi-Fi thermostats without behavioral messaging--this study will estimate savings associated with Home Energy Reports (HER) only, Wi-Fi Thermostats only, and HERS + Wi-Fi. To test a wide variety of thermostats, and to reduce costs, this effort will be implemented using a "bring your thermostat" model that has been adopted by organizations like Energy Trust of Oregon and Southern California Edison. The thermostat model(s) will be chosen in consultation with the PAs and EEAC. The figure below contains the preliminary study design. As explained in the next Stage 1 plan, *Leverage Wi-Fi Thermostat Data in other Residential Evaluations*, another important benefit if this study is that the control groups can be used to evaluate impacts of Wi-Fi thermostats as an individual measure offered within Home Energy Services and other residential programs. Given this cross-over to Residential programs, the PAs may employ a budget sharing mechanism to allocate funding to the Cross-Cutting and Residential sectors.



High-Level Description of Approach/Methodology:

Task 1: Literature Review

As a first step, our team will perform a literature review for current and past research conducted on integrating Wi-Fi thermostats with behavioral interventions with a specific focus on the integration challenges, advantages, fielding strategies, and savings impacts.

Task 2. Design Experiment and Identify Participant and Control Groups

The team will develop an experimental design that crosses PA's using a recruit and delay/deny method (see the supplemental diagram/model). A new HER-eligible group of customers will be identified to support this study.

Task 3. Planning Workshop with PAs, EEAC and HER and Residential Audit Program Implementers and on-going Coordination

A true field trial, this study will require close upfront coordination and planning with the MA PAs and the program implementation teams, including the HER program administrator and the residential audit teams. The Navigant team, PAs and EEAC will be present to develop a set of goals, which will include a requirement that the thermostat manufacturers and customers provide data to the PAs, as well as coordination and communication guidelines. We will also cover ways to support customers who purchase thermostats to ensure low attrition in thermostat purchase and installation.

Task 4. Recruit Customers to Participate

Customers who are eligible to participate in the study will be recruited using post card solicitations. All customers who are willing to participate will be screened for eligibility and then assigned to the various groups identified in the figure on the previous page.

Task 5: Monitor Experimental Validity

During fielding, we will carefully monitor the integrity of the experiment throughout the fielding process. Any issues that emerge will be documented and remedied through adjustments to the methodology or other field strategies.

Task 6: Surveys of Treatment Groups

The goal of this task is to conduct targeted in-depth interviews followed by surveys with all three treatment groups: HER only, Wi-Fi only and Wi-Fi/HER participants using email-based survey methods. Surveying all three groups will allow for a comparison across groups in their response to treatment. A key focus of the Wi-Fi/HER participant survey will be to understand the intersection of education and technology and customers' perceptions of their combined value.

Task 7: Impact and Process Analysis and Reporting

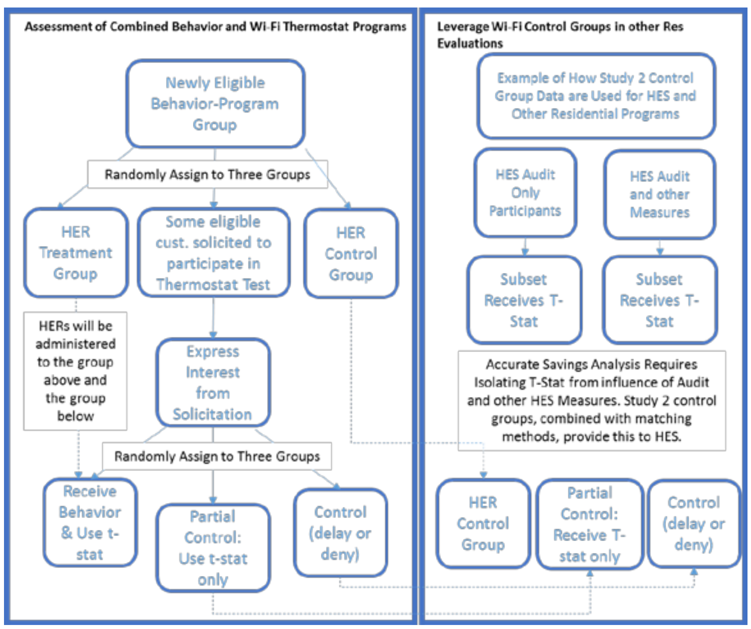
Using regression-based approaches, our team will conduct impact evaluations of the savings associated with each treatment condition, factoring in seasonal effects and other areas of interest, such as fuel source. We will also prepare a report on the qualitative findings. The team will provide the PAs with a written report containing the results of the impact and process findings as well as a summary and strategy guidance document for future integration efforts.

Potential Budget: $300,000 - $500,000

Study Name: Leverage Wi-Fi Thermostat Control Groups in other Residential Evaluations
Research Area: Cross-Cutting
Type of Study: Impact and Process
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

The PAs are beginning to deploy Wi-Fi thermostats through the HES program, and are considering other delivery channels for Wi-Fi thermostats (e.g., low income). Impact evaluation of measures offered through these programs require a control group -- this study effectively uses the Wi-Fi only control group developed as part of the "Assessment of Combined Behavior and Wi-Fi Thermostat programs" study for other residential evaluations. This is shown in the figure below, where the control groups from that study (left panel) are used in this study (right panel). Given this cross-over to Residential programs, the PAs may employ a budget sharing mechanism to allocate funding to the Cross-Cutting and Residential sectors.



High-Level Description of Approach/Methodology:

Task 1: Data Repository

The team will build a data depository allowing the Residential team access to the billing data and thermostat data for the Wi-Fi Thermostat control group. Availability of this data will lead to more precise billing analysis estimates and smaller metering samples for all residential HVAC and envelope-related evaluations.

Task 2: Modeling the Energy Consumption and the Creation of Load Shapes of End-uses

The team will use the Wi-Fi Thermostat-only control group to model the energy consumption and create load shapes of specific end uses and measure savings, including CAC/HP/Furnace/Boiler, etc. The Wi-Fi thermostat data will make it possible to observe differences in HVAC load shapes between participants installing different HES measures, allowing for the development of improved savings load shapes, including for oil and propane.

Task 3: Analysis and Reporting

The team will provide the PAs with a written report describing the Data Repository, and the modeled end loads / load shapes. The load shapes will also be provided consistent with the requirements of the PAs existing load shape database.

Task 4: Ad Hoc Analysis Requests

This task would involve data queries and analyses as desired/necessary for evaluations. For example, suppose Wi-Fi thermostats are considered as an additional measure for the low income program. Through matching procedures, a subset of the HES and control households resembling low income households could be identified, along with estimated impacts. This is just one example; in practice, the idea is to set aside a task budget that would be available to the PAs/EEAC but would not be accessed without prior approval.

Potential Budget: $125,000 - $300,000

Study Name: Effectiveness of Community-Based Program Design Elements and Marketing Tactics
Research Area: Cross-Cutting
Type of Study: Process
Applicable Fuel(s): Electric & Gas

Overall Study Goals:

Massachusetts Program Administrators (PAs), as well as PAs across the country, have been relying on community-based programs (CBPs) to reach customer segments of interest, provide education, overcome specific barriers to measure adoption, drive participation, and achieve deeper savings. Interventions, program design elements, and marketing strategies and tactics of CBPs vary extensively, and so does the success of these program efforts. With the abundance of CBP implementation experiences, PAs lack understanding of the causal effects of the various design elements and marketing tactics on customer participation rates and resulting savings.

The goal of this study is to assess the relative effectiveness of 1) distinct design elements of CBPs, such as increased incentives, new measure (or measure bundles) offerings, and the availability of customer specific technical or administrative support (e.g. designated program concierges), etc. and 2) distinct marketing and messaging strategies and tactics on program participation and savings.

Below we outline an integrated research approach that combines the assessment of various CBP program design elements and marketing strategies and tactics into a single study[25].

The results from this study will inform future CBP designs by providing PAs with a toolkit of the most effective program elements and tactics.

Research Questions:

The following are the prioritized research questions that we will answer as part of the study:

- What are the most effective CBP design elements in driving participation and savings?
- What are the most effective marketing and messaging strategies and tactics in driving participation and savings?
- How does the effectiveness of program design elements and marketing and messaging tactics vary by target audience and geography?

High-Level Description of Approach/Methodology:

To answer the research questions specified above, we will draw on several research and analytical strategies.

We will complete an extensive literature review of the community-based programs in Massachusetts and across the country to understand the variety of design elements and marketing approaches used and assess their relative success. The literature review will include recent evaluation studies, white papers, conference proceedings, and other relevant publications. At the outset of the study, we will work with the Massachusetts PAs to arrive at a consensus regarding a comprehensive definition of a “community-based program” for purposes of scoping the breadth of our literature review.

We will supplement the literature review with expert feedback. We will complete a series of in-depth interviews with a range of stakeholders involved in planning and executing CBPs or who are otherwise knowledgeable in this

[25] They were posed as two separate research questions in the Summit proceedings.

area. The sample of stakeholders will include representatives from Massachusetts PAs, PAs from other jurisdictions, local and state governments (both in Massachusetts and in other parts of North America), non-profit, community, and other organizations involved in planning and implementing these programs. These interviews will not only provide a perspective on the effectiveness of different program elements, but will inform our understanding of any barriers that may stand in the way of deploying the winning program elements successfully. Moreover, we will leverage these interviews to characterize the goals of each program effort, the types and size of communities targeted by various programs, and the performance metrics for and goals of each the programmatic activities.

To quantitatively assess the effectiveness of the CBP elements, we will perform multi-level regression analysis of the past CBPs. To support the analysis, we will assemble a custom database with past CBPs deployed in Massachusetts. We will plan to go five years back and capture the programs implemented during this timeframe. For each program, we will record the geographic area the program covered, design elements it featured, marketing and outreach tactics it deployed, the times (in month-years) it was in effect, and program participation rates and savings for each area and time period. We will draw on program tracking databases, marketing tracking databases, and the interviews with Massachusetts PAs and other stakeholders to accurately record CBP details. If possible and feasible, we will leverage any primary data collection efforts (past and future) to capture attitudinal and other information and include it in the database and subsequent analysis. For example, we will leverage statewide umbrella marketing survey, Efficient Neighborhoods+® participant and non-participant surveys, and other efforts.

The final analysis dataset will contain one record for each program-tactic-census block group-time period combination. This means coding each design element and marketing or program effort by the geographic area in which it was deployed, and the time period within which it was deployed.

Multi-level modeling is an effective method to provide understanding about the relative effectiveness of the many program design elements and marketing tactics deployed both in terms of flexibility of analysis and error reduction. It is a regression technique that creates coefficients for multiple 'levels' of predictors, with 'levels' referring to variables at different levels of aggregation. The analysis will leverage multiple levels, including census block group during a calendar month, towns or municipalities, custom defined "communities" based on homogenous sociodemographic, housing, and other characteristics of its residents, PA territories, and state as a whole.

The outcome variables for this analysis would be participation rates and savings for any community-based program or a set of programs. The outcome variables would be 'predicted' or 'explained' by the program design elements and marketing tactics deployed. The modeling will estimate the effect of each program element and allow to compare the effects across all available elements. Comparison of effects can be performed at various geographic and temporal levels. The results of this analysis, combined with the other research activities described above will serve as inputs into the development of the toolkit of effective elements and practices to designing and implementing CBPs.

Potential Budget: $150,000 - $225,000

Study Name: 2015 Mass Save Statewide Campaign Post Campaign Study
Research Area: Cross-Cutting
Type of Study: Process
Applicable Fuel(s): Electric & Gas

Overall Study Goal:

The Opinion Dynamics Evaluation team recommends a post-campaign study of the 2015 Mass Save Statewide Campaign. The main objective of the study is to measure customer awareness and understanding of the Mass Save campaign and compare 2015 results to previous years. We will complete surveys with both residential and commercial and industrial (C&I) customers.

We provide two study options. The first option is similar to the post-campaign studies we have conducted in previous years and includes a review of marketing materials and a full written report of the study results. The second option is does not include a material review and presents the survey results as a slide deck and a top line rather than a written report.

Research Questions:

Specific research objectives include the following:

Options 1 and 2

- Explore brand awareness, knowledge and associations with Mass Save

Option 1 Only

- Assess content of marketing materials
- Assess effectiveness of campaign messaging
- Assess the influence of Mass Save marketing on participation in PA programs

High-Level Description of Approach/Methodology:

Task 1: In-Depth Interview with Marketing Staff (Options 1 and 2)

For both study options, the team will conduct check-in interviews with PA marketing staff, as well as representatives from the marketing campaign implementer to understand how the marketing plan was ultimately executed in 2015. This task will provide the team with a basis for updating the survey instruments if needed.

Task 2: Review Marketing Materials (Option 1 Only)

The team will request all 2015 marketing materials and review them for their inclusion of the Mass Save logo and website. We will also note the messaging that is used and if it is consistent with stated campaign objectives. Finally, we will request web analytics and compare the level of activity and customer reach to previous years.

Task 3: Survey Design (Options 1 and 2)

As part of this task, the team will update existing survey instruments to ensure that they capture 2015 campaign activities and messaging.

Task 4: Sample Design and Survey Fielding (Options 1 and 2)

For the C&I survey, the team plans to use a sample design that is consistent with past studies and draw a random spample of customers from a combined PA customer database. For the 2014 study, we drew our sample from the 2013 C&I database that DNV GL assembled. We feel it is best to draw a sample from more recent customer data. We will request customer data from the PAs, create a combined customer file in which customers who are served by more than one PA are aggregated into a single contact, and draw a random sample of customers for fielding the survey.

For the residential survey, we will also request updated 2015 customer data from the PAs (the 2014 study used 2013 customer data). We will combine the data files into a single file and draw a random sample of customers following the 2014 sample design. We used a multi-mode fielding approach in 2014, which we will continue to use in 2015. This approach uses two different methods of customer outreach so that we effectively split the sample in two. We will conduct an outbound telephone survey with one portion of the sample. For the other portion, we will mail customers an invitation to complete the survey on-line or call into our telephone center and complete the interview with an interviewer over the telephone. This second approach helps us reach customers who increasingly do not answer telephone calls from unknown numbers. We will offer an incentive to encourage respondents to complete the survey.

For budgeting purposes, we have assumed 300 interviews C&I customers. We assume 500 residential completed interviews with 200 completed through the outbound telephone mode and 300 completed either on-line or as in-bound telephone interviews.

Task 5: Analysis and Reporting (Option 1 Only)

The team will provide the PAs with a written report containing the results and analysis of the materials review and survey data. The format of this report will be consistent with that provided for previous evaluations of the Mass Save statewide marketing effort.

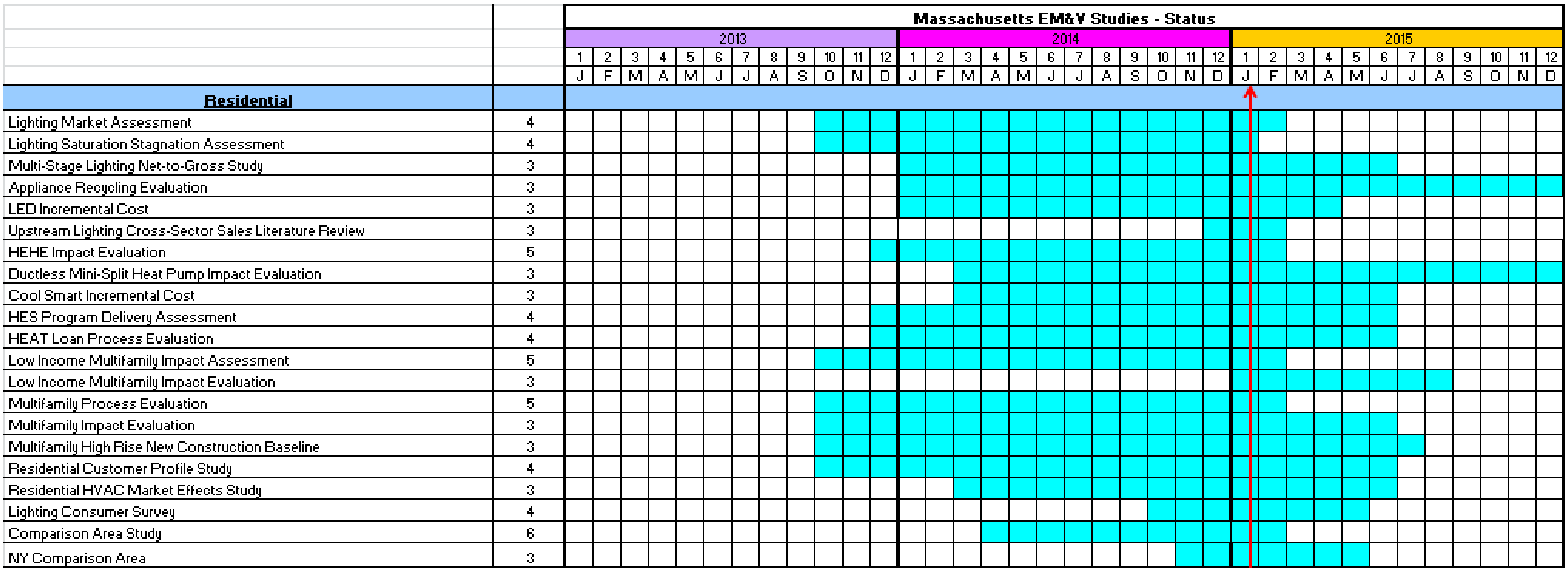
Task 5: Analysis and Reporting (Option 2 Only)

The team will provide a slide deck presenting key results and trend analyses from the C&I and residential surveys. We will also provide a topline that provides results to all survey questions.

Potential Budget: $172,000 (Option 1)
$153,000 (Option 2)

A APPENDIX A: GANTT CHART

The PAs and the EEAC consultants worked together to develop an EM&V overview, which provides details on evaluation studies. Study progress is reported quarterly via Gantt Charts. The Gantt Chart below is an example reflecting the **status of 2013-2015 studies**. As the Evaluation Plan evolves and new studies are initiated in 2016-2018, progress will be tracked in a similar format and provided with the quarterly updates.



B APPENDIX C: BASELINE WORKING GROUP

A working group was formed to establish a clearer determination of when, and how, baseline values are updated. To this end, the working group is developing a memo to guide this process. A finalized version of the memo will be included in subsequent versions of the Strategic Evaluation Plan.

A brief summary of this effort is as follows:

- To help in this process the PAs have prepared a flow chart that can be used by both program planners and evaluators to help determine if values other than federal or state codes should be applied as the baseline value for program measures.
- There are then three scenarios that could lead to baselines other than code: early replacement, intermediate efficiencies, and lack of code compliance.
    - It's important to note that these are not mutually exclusive; a measure may fall into multiple categories and thus have multiple baselines, and thus require a weighted baseline that would account for two or more of these scenarios.
- The memo is not intended to provide detailed specifics regarding the exact research activities and criteria that are to be used to determine non-baseline code: it does not provide specific survey or interview questions, research activities, or algorithms. Rather, it is intended to provide general guidance and direction for how baselines should be determined.
- The specific research activities and criteria, as well as other potential inputs (e.g., remaining useful life for early replacement measures, the revised incremental costs to reflect the changing baselines), should be determined as part of both the planning and EM&V processes.

T. **Evaluation Study Summaries**

APPENDIX T

Evaluation Study Summaries

Study 1: Massachusetts Residential Lighting Cross-Sector Sales Research

Type of Study: Market Assessment
Evaluation Conducted by: NMR Group
Date Evaluation Conducted: 3/24/2015

Study Objective and Summary of Results:

The objective of this research was to review evaluations conducted in other jurisdictions that estimate cross sector sales, i.e., the proportion of residential program lighting purchases that are installed in commercial rather than residential applications. Based on this review, the evaluation team recommended a "placeholder" value for cross sector sales to be used in Massachusetts (MA). This value is intended to be useful for the Program Administrators (PAs) for near-term planning.

Core Initiatives to which the Results of the Study Apply:

- Residential Lighting (electric) (Electric Only)

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

The evaluation team recommends using a placeholder value of 7% to be applied to the Massachusetts upstream lighting program sales to reflect the proportion of residential program lighting used in commercial settings.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affected Program Results:

If adopted, the estimate of 7% cross-sector sales would shift that percentage of savings from the residential to the commercial sector, including making adjustments for different hours of use in that sector.

Overview of Study Method:

The evaluation team performed secondary research into applicable studies conducted in other jurisdictions. The evaluation team reviewed 23 evaluation reports conducted in 10 states, each of which touched on the topic of cross-sector sales. The evaluation team considered not only the degree of cross-sector sales found in other studies (expressed as the percent commercial allocation), but also the extent to which those results could be applied to MA. The evaluation team assessed applicability to MA according to a variety of factors, including the program size and design, incentive type, bulb types supported, regional differences, and the time period and approach of the evaluation. The evaluation team prioritized those studies they expected would be most relevant in determining a placeholder for percent commercial allocation in MA.

The evaluation team also considered the various biases brought about by the different means of assessing cross-sector sales, and the implications of such biases for the eventual commercial allocation estimates.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 1.

Study 2: Multistage Lighting Net-to-Gross Assessment: Overall Report

Type of Study: Impact Evaluation
Evaluation Conducted by: DNV GL
Date Evaluation Conducted: 8/25/2015

Study Objective and Summary of Results:

The purpose of this study was to describe various approaches to estimating net-to-gross (NTG) ratios for residential lighting energy efficiency programs. In addition the study explains the process used to develop and finalize NTG estimates, both retrospectively for 2014, and prospectively for 2016-2018. A group consisting of the Massachusetts PAs, Energy Efficiency Advisory Council (EEAC) consultants, and evaluation consultants reviewed the CFL and LED NTG and net-of-freeridership estimates derived for 2013 and/or 2014. In addition the group reviewed on-going evaluation research regarding current and projected future lighting prices. Considering this information and using a consensus-building process the group ultimately came to consensus on the recommended NTG estimates.

The report draws on NTG, net-of-freeridership, and other relevant information from the following evaluation studies or tasks:

- Multistage Lighting NTG Demand elasticity modeling;
- Multistage Lighting NTG, Saturation Stagnation, and Incremental Cost point-of-sale data analysis;
- Multistage Lighting NTG, Lighting Market Assessment, and Incremental Cost supplier interviews;
- Multistage Lighting NTG Lighting Market Assessment on-site saturation in Massachusetts, Georgia, Kansas and New York; and
- Incremental Cost web-based pricing modeling.

The study provides the following key findings:

- Each method of estimating NTG has relative strengths and weaknesses, such that any single method may not yield a reliable estimate of net savings. The purpose of applying multiple methods was to avoid overreliance on any single method and counterbalance the weaknesses of any individual methods.
- Drawing on the expertise of a team of researchers limits the biases in any individual's assessment of the strengths and weaknesses of various approaches.
- A consensus-building process that takes into account various NTG estimates and other relevant information reduces the bias inherent in the one-method/one evaluator approach.
- The study identified consensus values for retrospective and prospective NTG ratios for various products, as outlined in the recommendations below.

Core Initiatives to which the Results of the Study Apply:

- Residential Lighting (electric) (Electric Only)
- Residential New Construction (Electric Only)

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

The evaluators recommend using the following NTG values in estimating program impacts.

Table 1. Consensus Retrospective and Prospective NTG Estimates

Product	Retrospective	Prospective		
	2014	**2016**	**2017**	**2018**
Non-Hard to Reach (HTR) Standard CFLs	53%	54%	53%	53%
HTR Standard CFLs	93%	93%	92%	91%
Non-HTR LEDs	-*	90%	80%	70%
HTR LEDs	102%	100%	99%	98%
All LEDs*	95%	93%	85%	78%
CFL Fixtures	NA	96%	96%	96%
LED Fixtures	NA	98%	93%	89%

* Non-HTR LEDs were not on the initial estimate template that was circulated because the PAs did not target LEDs to one market or the other in 2014. The evaluation team believes the best value to use for LEDs in 2014 is the overall "All LEDs" estimate. Moving forward, if the PAs decide to target some LEDs to HTR channels, then the differentiated results will become appropriate.

The evaluation team recommends that PAs closely monitor the market, and periodically revisit and if necessary revise the 2016-2018 NTG estimates. If these NTG estimates change substantially, the evaluation team recommends that policy makers allow PAs to apply the new NTG estimates to develop revised savings targets for the 2016-2018 period.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affected Program Results:

The prospective NTG ratios will be used for program planning purposes for the 2016 to 2018 program cycle.

Overview of Study Method:

The study used a consensus-building process among PAs, EEAC members, and evaluation team members to integrate NTG and net-of-freeridership estimates from previous research into finalized NTG values. The first step was for each party taking part in the discussions to review the estimates provided by each prior research approach. The second step was to reach agreement on appropriate overall NTG values by bulb type for 2014, which the group achieved by considering feedback on the differing research approaches and values, and reviewing saturation trends and EISA's schedule for phasing out inefficient lighting. The third step, once the group had agreed on the finalized retrospective NTG estimates for 2014, was to use those values as well as preliminary information from the incremental cost study (specifically anticipated price and market-share trends, converted to anticipated incremental costs and NTG ratios) and suppliers' future price predictions to provide insight and develop recommended prospective (that is, forward-looking) NTG estimates for the 2016-2018 program cycle as required by the Massachusetts DPU. Formal voting on a finalized value was not necessary, as the group was able to reach agreement on those values through a series of discussions.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 2.

Study 3: Lighting Market Assessment and Saturation Stagnation Overall Report

Type of Study: Market Assessment
Evaluation Conducted by: NMR Group
Date Evaluation Conducted: 8/25/2015

Study Objective and Summary of Results:

This report summarizes results from multiple studies that explored market reactions to energy efficiency lighting program interventions, including: 1) the 2014 lighting market assessment study, 2) the 2015 lighting consumer survey study and market assessment, 3) the 2014 lighting saturation stagnation study, 4) the 2014 comparison area research from Kansas and Georgia, and 5) the 2015 comparison area research from New York. The objective of these studies was to continue to monitor the Massachusetts lighting market for the Massachusetts PAs and the EEAC and to explore factors that drive energy-efficient socket saturation in Massachusetts and other states across the nation. The research also examined what circumstances might have explained the apparent stagnation in energy efficient lighting saturation that occurred in Massachusetts and other some states from 2009 to 2013. Together, the three studies characterized the overall residential lighting market, yielding critical information on the market and the PAs' intervention in it.

The study provides the following key findings:

- **Increased LED penetration and saturation in Massachusetts.** Penetration of LEDs—the percentage of homes using at least one LED—increased from 7% in 2012 to 33% in 2015, while the percentage of sockets filled with LEDs has grown 500% during the same time period (from 1% of sockets in 2012 to 6% in 2015).
- **Nearly ubiquitous CFL penetration and increased saturation, especially among low-income households.** Nearly all households in Massachusetts use at least one CFL (96%), a value that has held steady since 2012, while socket saturation increased from 28% in 2013 to 32% in 2015. Socket saturation of CFLs stood at 42% in low-income households compared to 28% for non-low-income households.
- **Program support has increased CFL sales.** Analysis of point-of-sale LightTracker data reveals that the removal of standard CFL incentives in New York in 2012 and California in 2013 are associated with decreases in CFL share, despite previously positive trends. In contrast, Massachusetts continued program incentives and saw its CFL market share increase during this time period.
- **Average wattage decreased per bulb for all bulbs between 2013 and 2015.** Results from an on-site panel of households visited multiple times revealed that participating households changed 1,554 sockets between 2013 and 2015, with the primary movement being from incandescent bulbs to CFLs and LEDs. As a result, average wattage of bulbs installed in homes decreased from 47.9W to 27.3W (delta Watts of 20.6).

Core Initiatives to which the Results of the Study Apply:

- Residential Lighting (electric) (Electric Only)

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: The PAs should continue to provide incentives and educate consumers about LEDs in the next program cycle. At the same time, the PAs should monitor any new information that becomes available from future evaluations or other sources regarding delta Watts, measure life, price trends, and incremental costs, and be ready to shift LED strategy if providing incentives ceases to be cost effective.

Recommendation 2: The PAs and EEAC consultants should continue to fund regular on-site saturation studies—including the continued annual panel study—at least through the early 2020s in order to track the impact of Energy Independence and Security Act (EISA), changes in LED pricing and availability, and possible changes in effectiveness of incentives for standard and specialty CFLs and LEDs. Additionally, the PAs should work with the residential evaluation team to develop a methodology for identifying the diameter and length of fluorescent tubes in use in homes. Fluorescent bulbs are subject to increased efficiency standards through the Energy Policy Act (EPAct) of 2005, as implemented through the DOE General Service Fluorescent Lamp (GSFL) Rulemaking. The timing and depth of new on-site visits could potentially deviate from those performed annually by the evaluation team since 2009 given the expense involved, but the evaluation team believes that annual visits are ideal for a panel study and for new on-site visits.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affected Program Results:

Many of these indicators provide the information that will ultimately contribute to revisions of program savings estimates while others contribute to a broader assessment of the market as EISA implementation moves forward.

Overview of Study Method:

The evaluation team completed six tasks for the Market Assessment and Saturation Stagnation studies that contributed to the findings reported in this document. A brief summary of each of those tasks is included below.

Consumer Surveys

The evaluation team conducted internet and telephone consumer surveys in Massachusetts, and telephone surveys in comparison areas in eastern Kansas and in Georgia in 2014. In 2015, the evaluation team conducted internet and telephone consumer surveys in Massachusetts and telephone surveys in upstate New York. In both years, the surveys assessed issues such as awareness and familiarity with various bulb types, knowledge of the lighting market, and satisfaction with CFLs and LEDs.

On-site Saturation and Panel Study Visits

In 2014, the evaluation team visited homes that had been identified through the consumer surveys in Massachusetts, Georgia, and eastern Kansas. In addition, the evaluation team continued an on-site panel study of homes that were first visited as part of an on-site saturation and hours-of-use study in 2013. The evaluation team returned to these homes to understand how their bulb saturation had changed over the past year and to see what types of bulbs they used to replace ones that burned out or were removed. In 2015 the evaluation team conducted on-site visits in Massachusetts and New York, and continued the on-site panel study of homes.

Shelf Stocking Study

The evaluation team worked with the implementation contractor to perform a shelf-stocking study in the fall of 2013. The study included currently participating and formerly participating stores. The study involved collecting data on the amount of shelf-space devoted to different types of light bulbs (CFL, LEDs, halogen, incandescent, and other bulb types), the number of bulb packages, and the number of bulbs of each type. The effort also examined the prices of bulbs and estimated the price differential between program-supported and non-supported standard and specialty CFLs and A-line and reflector LEDS.

Supplier Interviews

The evaluation team conducted supplier interviews in 2014 to learn how partner manufacturers, high-level buyers, and store managers familiar with lighting viewed the current lighting market and the program's impact on it. The study also looked to get insights from these partners on their view of the future of the lighting market. Specifically, the evaluation team performed in-depth interviews with manufacturers and buyers as well as computer-assisted telephone surveys with store or lighting-department managers. The interviews and surveys addressed a wide range of topics such as the impact of the EISA on sales of various bulb types, the impact of program activity on sales of various bulb types, expectations for future sales and price trends, the effectiveness of program strategies to increase sales among hard-to-reach customers, and satisfaction with various elements of the program.

Saturation Trend Comparison

In an effort to understand trends in saturation in Massachusetts, the evaluation team compared program and evaluation design and results between Massachusetts and comparison areas in New York and California. The evaluation team reviewed program reports and saturation data from New York and California and in-depth interviews with individuals associated with investor-owned utility lighting programs in California or who worked for the California Public Utilities Commission.

Point-of-Sale Data Analysis

The evaluation team examined data obtained from LightTracker Inc. to assess trends in light bulb sales, prices, and market share for the 44 states in the database. The evaluation team created statistical models to explain the effect of program activity on market share, controlling for other demographic and economic factors.

Application of Results: Retroactively and Prospectively

A copy of the complete study can be found in Appendix U, Study 3.

Study 4: Baseline Sensitivity Analysis 2016-2018

Type of Study: Impact Evaluation
Evaluation Conducted by: NMR Group
Date Evaluation Conducted: 7/30/2015

Study Objective and Summary of Results:

The objective of this evaluation was to develop a market adoption model to simulate the changing baseline for the lighting program based on recent market assessment work conducted by the residential evaluation team. This version of the market adoption model compared three scenarios for the 2016 to 2018 lighting market:

1. Energy Independence and Security Act (EISA) is strictly enforced with a hard stop on sales of non-compliant bulbs in 2020 (not considered likely at this time);
2. EISA continues with a long sale-through period of non-compliant bulbs (current situation and most likely scenario); and
3. EISA is repealed due to a political shift (not considered likely at this time).

This version of the market adoption model also incorporates updates from tasks completed for other lighting studies, including:

- Saturation Stagnation, Multistage NTG estimation, and Incremental Cost point-of-sale data analysis
- Lighting Market Assessment on-site saturation
- Lighting Market Assessment consumer surveys
- Lighting Market Assessment and Incremental Cost supplier interviews

Core Initiatives to which the Results of the Study Apply:

- Residential Lighting (electric) (Electric Only)
- Residential Multi-Family Retrofit (Electric Only)
- Residential Home Energy Services (Electric & Gas)
- Residential New Construction (Electric & Gas)
- Low-Income Single Family (Electric Only)
- Low-Income Multi-Family (Electric Only)

Evaluation Recommendations:

No formal recommendations were made in this evaluation.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

N/A (no formal recommendations were made in this evaluation)

How the Study Affected Program Results:

The evaluation yielded gross savings estimates of delta watts based on different scenarios of the residential lighting market in 2016 to 2018. These scenarios have informed program planning for the same time period. The basis for the delta watts for most deemed lighting measures flow from the work done in this model. The gross savings for lighting decline each year as the program gets closer to 2020.

Overview of Study Method:

The evaluation team constructed three predictions of what the lighting market might look like in 2016 – 2018 in the absence of any further program intervention. In each of the scenarios, the market shifts towards more efficient light bulbs, but the size of that shift and the mix of bulb types (halogens, CFLs, and LEDs) varies. Also, the model assumes a somewhat less aggressive increase in CFLs and more aggressive increase in LEDs compared to earlier versions of the model. The model continues to predict a decrease in gross savings attributable to lighting year over year.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 4.

Study 5: Lighting Interactive Effects Study Preliminary Results

Type of Study: Impact Evaluation
Evaluation Conducted by: Navigant Consulting
Date Evaluation Conducted: 4/6/2015

Study Objective and Summary of Results:

The goal of this study was to determine the heating, ventilation, and air conditioning (HVAC) impacts of energy efficient lighting retrofits, using interactive effects (IE) factors. This analysis will allow the Massachusetts PAs and EEAC consultants to better understand and report the true impact of energy efficient lighting installations in the upstream program.

The study provides the following preliminary key findings:

Table 2: Average IE Factor in Massachusetts

Factor	Average IE Factor
Heating Fuel IE Factor (Btu/kWh)	2,237

Core Initiatives to which the Results of the Study Apply:

- Residential Lighting (electric) (Electric & Gas)

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: Since the inputs were heavily biased towards single family homes and included only single family participants in the Home Energy Services (HES) program, the evaluation team recommends reassessing the preliminary results by incorporating multi-family building types using recent data developed during the low income multi-family billing analysis and HVAC saturations and building types from the Residential Customer Profiling study.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affected Program Results:

Results confirmed that lighting retrofits impact HVAC use, as measured by interactive effects factors. Energy efficient bulbs give off less heat than inefficient bulbs, resulting in more use of heating systems in the winter and less use of air conditioning in the summer once lighting retrofits are complete.

Overview of Study Method:

In order to best estimate the HVAC interactive effects attributable to lighting retrofits, the evaluation team developed simulation models based on building characteristics compiled from three sources:

1. The HES dataset containing audit data from 2010-2014;
2. Existing High Efficiency Heating Equipment (HEHE) models used in a recent program study; and
3. The HES Realization Rate analysis completed in 2013.

The team built and calibrated four models using the National Renewable Energy Laboratory's Building Energy Optimization (BEopt) software[1] (EnergyPlus engine). The models were based on heating type and number of building stories using billing data for statewide HES participants from 2010-2013. The evaluation team calibrated the models using customized inputs reflecting the HES participants. In order to calculate a single statewide average, the evaluation team chose Worcester as the centralized location to reflect both coastal and inland weather patterns. Models were calibrated to within 2% of the targets helping to ensure an accurate reflection of an average home in Massachusetts. The team also used efficient lighting load shapes developed for the Market Adoption model. The baseline was modeled as a simple 20% increase in lighting consumption. Load shapes were extracted and analyzed to determine the specific IE Factors.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 5.

[1] BEopt Version 2.4.0.1 Beta available at https://beopt.nrel.gov/. Last visited October 15, 2015.

Study 6: Program Assessment Tube TV Recycling

Type of Study: Market Assessment
Evaluation Conducted by: Navigant Consulting
Date Evaluation Conducted: 3/24/2015

Study Objective and Summary of Results:

The purpose of this study was to assess the feasibility of expanding the MassSave Appliance Rebate program to offer rebates for recycling operable but old, inefficient tube televisions (CRT-TVs).

The study provides the following key findings:

- The evaluation team found that 20% of TVs assessed were CRT-TVs (targets for replacement), with the remaining 80% consisting of LCD/LED, plasma, or rear projection TVs (all considered efficient).
- The savings associated with replacement of primary CRT-TVs are estimated at 200kWh/yr while savings for secondary and other CRT-TVs are estimated at 70kWh/yr.
- About 12% of all TVs studied qualify for the recycling program as it stands. An additional 6% of TVs identified as older flat screen TVs and potentially valuable targets for recycling. Under the proposed recycling program, the average savings associated with replacement would be 33kWh/yr/house, a figure that would rise to 56kWh/yr/house if older primary flat screen TVs were also included.
- Typical CRT recycling costs are currently around $0.10/lb for fully intact TVs. A large scale recycling program such as the one proposed here is estimated to cost about $12 per (statistically larger) primary CRT-TV and about $8 per smaller secondary CRT-TV with older LCD/LED TVs costing about $10 to recycle.

While our team observed a reasonably high saturation of CRT-TVs, our research indicated that the remaining CRT-TVs were underutilized, small, and being naturally replaced by users.

Initiatives to which the Results of the Study Apply:

- Residential Consumer Products/Appliances (Electric Only)

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

- Based on TV sales data and current TV breakdown, natural turnover appears to be replacing CRT-TVs with new efficient models. Therefore, the evaluation team recommends not expanding the existing recycling program to CRT-TVs. Alternatively, PAs could consider recycling all TVs (including LCD/LED TVs) older than 2010.
- Consider a follow up study to measure natural TV replacement in the Massachusetts market.
- Future studies should be conducted in 4-6 years to measure whether CRT-TVs are indeed being replaced naturally.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

The PAs will adopt recommendation to not expand the existing recycling program.

How the Study Affected Program Results:

The study did not affect the program results.

Overview of Study Method:
The evaluation team collected television data from 150 Massachusetts homes in conjunction with the lighting market assessment study. Out of 150 houses, the team identified 370 TVs, measuring the size and recording the technology type of each unit. The evaluation team also collected additional self-reported usage information such as the average hours of daily use, estimated purchase date, and the willingness of the customer to replace the unit if offered with free removal for secondary TVs and a $50 voucher for primary TVs.

Application of Results: Retroactively and Prospectively

A copy of the complete study can be found in Appendix U, Study 6.

Study 7: Cool Smart Incremental Cost Study

Type of Study: Market Assessment
Evaluation Conducted by: Navigant Consulting
Date Evaluation Conducted: 7/31/2015

Study Objective and Summary of Results:

This incremental cost study estimated how manufacturing production costs and purchase prices of residential air conditioning (AC) and heat pump (HP) equipment change as equipment efficiency increases.

The study provides the following key findings:

- Higher efficiency AC and HP units often include bundled features that do not improve efficiency, such as louvered cases, sound dampening, and specialty thermostats.
- The study provides incremental costs required to achieve a given efficiency above a specified baseline defined in terms of the efficiency metrics of seasonal energy efficiency ratio (SEER), energy efficiency ratio (EER), and heating seasonal performance factor (HSPF).
- For a system combination of AC and air handler, the minimum incremental costs of improving from a 13.0 SEER baseline to 16.0 SEER and 18.0 SEER are $325 and $1,725, respectively.
- For a system combination of HP and air handler, the minimum incremental costs of improving efficiency from a 14.0 SEER baseline to 16.0 SEER and 18.0 SEER are $431 and $1,808, respectively.
- The study also provides incremental costs for a variety of other efficiency levels and system combinations.

Core Initiatives to which the Results of the Study Apply:

- Residential Heating and Cooling (Electric Only)

Evaluation Recommendations:

No formal recommendations were made in this evaluation.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

Although this study did not make any formal recommendations, the PAs are using the study's incremental cost results to update its evaluation of the cost effectiveness of the Cool Smart program.

How the Study Affected Program Results:

This study does not affect the energy or load savings estimated in this Plan for HVAC. However, it informs future program planning by providing the PAs a better understanding of the incremental costs consumers incur to increase the efficiency of their HVAC units.

Overview of Study Method:

The residential evaluation team examined Cool Smart tracking data provided by the Massachusetts PAs to determine the characteristics (manufacturer, equipment class, capacity, and efficiency rating) of units that are most frequently rebated through the Cool Smart program.

Based on analysis of tracking data, the evaluation team selected HVAC units for teardown, inspection, and cost modeling. The output of these cost models includes an estimated manufacturing production cost and retail purchase price for each unit modeled. The evaluation team adjusted the manufacturing cost models to exclude features that are not efficiency related. The evaluation team used weighted average markups to estimate the retail purchase price of each unit.

The evaluation team adapted the cost model to estimate the costs and prices of units that were not physically torn down or inspected in this analysis. To model these units and systems, the evaluation team conducted "catalog teardowns" by applying scaling factors to the teardown data and simulating teardowns using catalog information provided by manufacturers. In total, the evaluation team used catalog teardowns to model the costs of an additional 79 units which were used to estimate manufacturing production costs and price points for more than 450 unique system combinations.

The evaluation team plotted the resulting cost estimates in a series of cost-efficiency plots. On each of these plots, the evaluation team mapped the "efficiency frontier," which is defined here as the minimum incremental price (required to achieve a given efficiency for the systems that were modeled. The evaluation team mapped the efficiency frontier by identifying and recording the lowest cost system at each increment of efficiency gain.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 7.

Study 8: Home Energy Service Initiative and HEAT Loan Delivery Assessment

Type of Study: Process Evaluation
Evaluation Conducted by: The Cadmus Group
Date Evaluation Conducted: 7/31/2015

Study Objective and Summary of Results:

The purpose of the Home Energy Services (HES) initiative delivery and HEAT Loan assessments was to:

- Determining the relative strengths and weaknesses of the two HES delivery channels for the program: lead vendor and Home Performance Contractor (HPC).
- Assess the current overlap in the HES, High Efficiency Heating Equipment (HEHE), Cool Smart, and HEAT Loan programs.

The study provides the following key findings:

- HPCs and lead vendors offer complementary approaches, each with their own benefits and drawbacks. Providing services through both channels is likely helping to expand the reach of the HES initiative.
- HPC customers have lower rates of cross-program participation than lead vendor customers, which may be a result of lack of HPC understanding regarding program offerings and less proactive promotion of non-HES initiative offerings.
- The majority of customers find that the Energy Specialist’s recommendations for making energy-efficient upgrades in their homes are easy to understand; a smaller majority feels certain about how to navigate Mass Save offerings and incentives.
- Customers who participated through the lead vendor delivery channel indicated higher overall satisfaction with the HES initiative and found that the lead vendor recommendations were easier to understand; however, all customers reported being at least somewhat satisfied with the initiative regardless of delivery channel.
- The HEAT Loan has been successful in promoting deeper and broader savings, acting as a motivating factor for a select group of customers and a business tool for contractors.

Core Initiatives to which the Results of the Study Apply:

- Residential Home Energy Services (Electric & Gas)
- Residential Heating and Cooling (Electric & Gas)
- Other (specify below) (Electric & Gas)

Other: HEAT Loan

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: To encourage HPCs to further promote non-HES Mass Save offerings, consider exploring approaches for holding all HPCs accountable for cross-promoting programs and providing additional clarity to HPCs about non-HES program offerings.

Recommendation 2: Consider the following options for assisting HES customers in navigating the Mass Save offerings and incentives available to them: 1) Conduct additional research with customers to test their receptivity to a customized web portal, 2) Explore approaches for optimizing assessment delivery to more effectively disseminate information, encourage cross-program participation, and increase close rates, and 3) Streamline program materials by identifying needs for summary additional program materials and improving clarity and salience in program materials provided to customers in advance of home energy assessments.

Recommendation 3: Explore opportunities to further promote the HEAT Loan outside of the HES program.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affected Program Results:

This study is not being applied directly to the estimated savings projected in this Plan. However, it informs program design and planning by providing strategic recommendations, including opportunities for achieving greater and deeper savings, improving program performance and effectiveness, and improving customer experiences.

Overview of Study Method:

The evaluation team calculated 20 key performance indicators by delivery channel. The evaluation team conducted in depth interviews with PA Program managers, lead vendors, HPCs, HEHE contractors, and HEAT Loan lenders. The evaluation team conducted surveys of program participants, non-participants, and HEAT Loan lenders. The evaluation team used survey data to undertake an Analytic Hierarchy Process analysis to understand the interplay of the HES initiative and the HEAT Loan.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 8.

Study 9: Residential Customer Profile Study

Type of Study: Market Characterization
Evaluation Conducted by: The Cadmus Group
Date Evaluation Conducted: 10/2/2015

Study Objective and Summary of Results:

The Residential Customer Profile Study (RCPS) was launched in 2014, using program data from calendar year 2013. The RCPS is intended to be an ongoing project to provide stakeholders with a state-wide view of Residential and Low-Income efficiency program participation, gross savings, and incentive spending across all Massachusetts PAs. This study provides the first geographic analysis of the Residential and Low-Income program impacts across all PAs as well as insight into patterns of participation across multiple initiatives.

The study provides the following key findings:

- This study found that in 2013, a total of 15,386 premises participated in two or more core initiatives (excluding Behavior / Feedback), representing 7.7% of the total of 200,523 premises that opted to participate in any initiative.
- Of all premises participating in multiple initiatives in 2013, the Home Energy Services initiative is the most common single point of entry to the residential efficiency program, representing 35% of all lead initiatives for the premises that participated in multiple initiatives.
- In 2013, a total of 6% of premises served by electric PAs participated in an electric efficiency initiative and 5% of premises served by gas PAs participated in a gas initiative (not including Behavioral / Feedback). In total, 7% of all PA premises in Massachusetts participated in a program in 2013.

Core Initiatives to which the Results of the Study Apply:

- Residential Consumer Products (Electric & Gas)
- Residential Lighting (electric) (Electric Only)
- Residential Heating and Cooling (Electric Only)
- Residential Behavior/Feedback (Electric & Gas)
- Residential Home Energy Services (Electric & Gas)
- Residential Multi-Family Retrofit (Electric & Gas)
- Residential New Construction (Electric & Gas)
- Low-Income Single Family (Electric & Gas)
- Low-Income Multi-Family (Electric & Gas)

Evaluation Recommendations:

- No formal recommendations were made in this evaluation.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

N/A (no formal recommendations were made in this evaluation)

How the Study Affected Program Results:

This study is not being applied directly to the estimated savings projected in this Plan. However, it informs program design and planning by providing a preliminary geographic-based view of Residential and Low-Income efficiency program participation, gross savings, and incentive spending across all Massachusetts PAs. The PAs would benefit from analysis on additional years of data beyond the 2013 benchmark to identify trends over time and investigate influences of different factors on the geospatial patterns observed in participation, savings, and incentive payments impacts as mapped.

Overview of Study Method:

The residential evaluation team collected data for this project through an analysis of billing records, program tracking records, and publicly available census and demographic data sets. Customer address records in billing and tracking data files were then normalized using a third-party software platform to revise them to US Postal Service standard address format.

The team developed a custom database and first loaded each PA's customer data records to establish a foundation of unique service premises. Program tracking records were joined to the specific premises established using customer billing records. Specific measure gross savings for each initiative were adopted from program tracking records or drawn from the Benefit-Cost Ratio (BCR) model files provided by PAs according to guidance they gave specific to certain initiatives and measures. In this way, total savings were established for each participating premises in an efficiency program.

Since the Upstream Lighting Initiative and Behavioral/Feedback initiative do not track savings at the premises level, the evaluation team used modelling techniques to include these impacts in the statewide views.

Participation, savings, and incentive spending data were aggregated for all initiatives and programs at the premises level as well as the census block group level in the database. The team produced maps illustrating the geospatial distribution of program impacts. For each fuel and program, the Team presented high-level demographic data for program participants versus non-participants.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 9.

Study 10: Multifamily Impact Findings Memo

Type of Study: Impact Evaluation
Evaluation Conducted by: DNV GL
Date Evaluation Conducted: 10/5/2015

Study Objective and Summary of Results:

This study was designed to assess the impacts of the Multifamily Program's residential channel in terms of electric and natural gas savings. This impact analysis seeks to estimate gross and net energy savings associated with the program.

The study provides the following key findings:

- This study was not successful in developing savings estimates for this program. There were two key factors that contributed to this outcome. First, trying to perform the analysis at the account or premise level was determined to be a flawed approach. Second, the level of savings at the account/premise level made it difficult to discern the effect of the treatment from the data.
- The key finding of this work was that billing analysis for programs of this nature should be performed at the facility level where issues of attrition can be better handled and representation of program treatment better understood.

Core Initiatives to which the Results of the Study Apply:

- Residential Multi-Family Retrofit (Electric & Gas)

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: The residential evaluation team recommended that the placeholder results from the study not be used by the Massachusetts PAs due to concerns with data sufficiency, sample representation and broader concerns stemming from analysis performed at the premise level.

Recommendation 2: The evaluation team further recommended that a new analysis at the facility level be performed for National Grid, where facility level activity is understood to be reliably tracked in a way that allows the aggregation of consumption and tracking data for each treated building.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affected Program Results:

The PAs have decided to adopt an assumed realization rate in the absence of results from this study. The team is currently in the process of performing a new billing analysis at the facility level for National Grid.

Overview of Study Method:

This study performed a two-stage, premise-level, difference-of-differences modelling approach for energy consumption analysis using a panel dataset combining consumption, weather, and participation and other premise and customer-specific characteristics. This approach was designed to estimate gross energy savings and relies on a comparison group consisting of past and/or future participants to control for non-program related change. The results of this study were reviewed with a working group of PAs and EEAC consultants and it was decided that the results were not reliable enough for use and that a new effort to perform the analysis at a facility level was needed. This new effort is being undertaken at this time.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 10.

Study 11: Ductless Mini-Split Heat Pump (DMSHP) Final Heating Season Results

Type of Study: Impact Evaluation
Evaluation Conducted by: Navigant Consulting
Date Evaluation Conducted: 10/12/2015

Study Objective and Summary of Results:

As part of a large impact metering study, the Massachusetts PAs asked the residential evaluation team to determine heating season savings and full load hours associated with DMSHPs installed through the Cool Smart program.

The study provides the following key findings:

- Participants have an average of 447 heating equivalent full load hours (EFLH).
- Typical heating season savings for DMSHPs were 210 kWh.

Core Initiatives to which the Results of the Study Apply

- Residential Heating and Cooling (Electric Only)

Evaluation Recommendations:

Evaluators have made no final recommendations at this time, except to adopt a lower heating FLH value.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs adopted the recommendation for planning and are continuing to study the savings in a follow up study.

How the Study Affected Program Results:

Overall, the study results showed much lower heating FLH than earlier planning estimates.

As shown in the separate DMSHP baseline memo, the most common heating baseline for DMSHPs was a code-minimum DMSHP. Starting in 2016, all DMSHP units sold in the United States must meet a minimum heating season performance factor (HSPF) of 8.2, an increase from the current standard of 7.7 HSPF. The evaluation team calculated the FLH consistent with a HSPF-based savings calculation and savings compared to an 8.2 HSPF baseline, shown in Table 1 below.

Table 3. Draft Heating Season Full Load Hours and Savings

Stated Purchase Intent	Full Load Hours	Estimated Annual Savings – 8.2 HSPF Baseline (kWh)	Percent of Total
Purchased for Cooling	220	103	31%
Purchased for Heating	841	395	4%
Purchased for Heating and Cooling	531	250	65%
Average	**447**	**210**	**N/A**

Overview of Study Method:

The evaluation team metered approximately 150 participating systems during the winter of 2014-2015 and extrapolated their usage to a typical weather year. Some of the metered inputs included power of the DMSHP outdoor compressor, runtime of the air handling fan, temperature and humidity of the outdoor unit and temperature and humidity of the indoor spaces. These inputs, along with manufactures curves, were used to calculate the FLHs and total kWhs of energy used. Combining these results and the baseline memo referenced above, the PAs were able to estimate the total heating energy savings as shown in Table 1. Some of the winter weather season had to be removed due to abnormal snow amounts in February and March. In all cases, the systems included in the analysis had at least eight weeks of metered data including operation during cold weather and more mild weather that spanned the operating range of the equipment. As a follow up, the PAs have decided to leave the meters in for another winter to hopefully encounter a more typical winter and verify the results presented above.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 11.

Study 12: Ductless Mini-Split Heat Pump (DMSHP) Baseline Determination

Type of Study: Impact Evaluation
Evaluation Conducted by: Navigant Consulting
Date Evaluation Conducted: 10/22/2015

Study Objective and Summary of Results:

As part of a large impact metering study, the Massachusetts PAs asked the residential evaluation team to determine the appropriate baseline for installed ductless mini-split heat pumps (DMSHP) promoted through the electric PAs' Cool Smart program. The results of the study will be used to estimate gross energy efficiency impacts of the DMSHP component of the program. The study provides the following key findings:

- The program design implies that the baseline should be code.
- The influence of the program on customer decisions to install any kind of DMSHP is unclear at this time. A small portion of customers stated that they would have left the space unconditioned if not for the DMSHP measure. These responses were interpreted 1 of 2 ways; 1) the customer would have installed either a standard DMSAC or DMSHP or 2) would have installed no heating and/or cooling in the absence of the DMSHP incentive. In the case that assumes no fuel switching in the baseline, this has very little influence on the resulting baseline mix and resulted in a standard DMSHP baseline ranging from 90% to 94% of installations.
- The evaluation team has developed baselines for a case where fuel switching is allowed and one where it is not in case fuel switching is allowed in the future.

Core Initiatives to which the Results of the Study Apply

- Residential Heating and Cooling (Electric Only)

Evaluation Recommendations:

The evaluation team has made no formal recommendations at this time, except to present a possible baseline mix consistent with the draft scenarios presented.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

N/A (no formal recommendations were made in this evaluation)

How the Study Affected Program Results:

The study found that the most appropriate baseline assuming a no fuel-switching scenario was a standard efficiency DMSHP. The current code for a DMSHP is a SEER 14, HSPF 8.2 and should be used in future years as the DMSHP baseline. The study also presented results for a scenario in which fuel switching is allowed, in the event that it is needed for a future change to the program.

Overview of Study Method:

The determination of appropriate baselines is based on information gathered from program participants during on-site visits to install meters that measure the energy usage of the DMSHPs and other heating and cooling equipment. The baseline determination depends on:

1) The actual displaced equipment found in each home;
2) Customer intentions – whether customers purchased the DMSHP[2] for its cooling capability, its heating capability, or both; and
3) Stated alternative actions to purchasing the DMSHP, relative to the customer's purchase intentions.

These considerations helped determine what the customer would have chosen absent of the DMSHP incentive and thus the most appropriate baseline. The total number of participants included in this sample was 116. The results were presented in four different ways. Two iterations were based on a no-fuel switching and a fuel switching scenario. The other two scenarios were based on a small portion of customers stating that they would have left the space unconditioned if not for the DMSHP measure. These responses were interpreted 1 of 2 ways; option 1) the customer would have installed either a standard DMSAC or DMSHP or option 2) would have installed no heating and/or cooling in the absence of the DMSHP incentive. The current program design and incentive levels were determined based on a no-fuel savings case. In the no fuel savings case, 90% (option 2) to 94% (option 1) of the installation, depending on the scenario, were determined to have a DMSHP as the baseline, 6% (both option 1 and option 2) were determined to have the existing equipment baseline and between 0% (option 1) and 4% (option 2) were determined to have no heating system as the baseline. Due to the overwhelming majority having a DMSHP as the baseline, it was determined to use the DMSHP baseline at this time.

Application of Results: Prospectively

2 DMSHP is referenced as singular – recognizing that in many homes these are systems that may have multiple condenser units and/or head units in a single home.

A copy of the complete study can be found in Appendix U, Study 12.

Study 13: Massachusetts Low-Income Multifamily Initiative Impact Evaluation

Type of Study: Impact Evaluation
Evaluation Conducted by: The Cadmus Group
Date Evaluation Conducted: 10/5/2015

Study Objective and Summary of Results:

The purpose of this study was to verify the energy impacts and improve the transparency and consistency of the estimated savings in the Massachusetts Low-Income Multifamily (LIMF) Initiative. This was the first impact evaluation of the LIMF Initiative, and combined engineering analysis and tracking data review, billing analysis, direct measurement, and on-site verification.

The study provides the following key findings:

- The residential evaluation team produced evaluated statewide deemed savings values for all non-custom measures implemented in the initiative to improve transparency, consistency, and accuracy across the PA initiatives.
- Through billing analysis of 217 facilities, the evaluation team estimated an average savings of 126 therms per dwelling unit or 21% of pre-retrofit natural gas consumption.
- Compared to the initiative ex ante estimates, the billing analysis results represent an average statewide realization rate of 80%, indicating that the initiative is achieving 80% of the reported natural gas savings.
- The majority of projects that received natural gas efficiency measures to reduce heating consumption also received efficient lighting measures, which increase heating loads because they produce less waste heat. Separating out the lighting interactive effects on the heating load increases the realization rate to 83% - 89%.
- The evaluation team estimated a statewide realization rate of 97% for common area lighting measures, verifying that auditors are accurately estimating annual energy savings.
- Through inspection of showerheads and faucets within 20 apartment units, the evaluation team confirmed that all showerheads were below the 2.5-gallon-per-minute maximum threshold and most faucet aerators were below the 1.5-gallon-per-minute threshold.
- Through documentation of the cooling type at all 56 projects in the common area lighting sample, the evaluation team estimated that 89% of facilities use window air-conditioning as the primary cooling equipment.
- Finally, through literature review and examination of the primary data collected in this study, the evaluation team estimated deemed values for secondary impacts such as water savings from faucet aerators, showerheads, and clothes washers.

Core Initiatives to which the Results of the Study Apply:

- Low-Income Multi-Family (Electric & Gas)

Evaluation Recommendations:

No formal recommendations were made in this evaluation.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

N/A (no formal recommendations were made in this evaluation)

How the Study Affected Program Results:

The results of this evaluation serve to increase the projected energy savings from some measures while decreasing them for others. The evaluated savings for all of the natural gas measures are lower than the reported savings. The evaluated savings for common area lighting are slightly higher than the reported savings for National Grid (101%), and slightly lower for Eversource (96%) and statewide (97%).

The evaluated deemed savings values for the following electrical measures are greater than the values previously reported in the Massachusetts Technical Reference Manual:

- LED Bulb
- Showerhead
- TLC Kit (Eversource and CLC only)

The evaluated deemed savings values for the following electrical measures are lower than the values previously reported in the Massachusetts Technical Reference Manual:

- Torchiere
- CFL Bulb
- Window AC Replacement
- Refrigerator
- 2nd Refrigerator Removal
- Freezer Replacement
- Clothes Washer
- Heat Pump Water Heaters (50 Gallon)
- Faucet Aerator

Overview of Study Method:

For measures not requiring primary data collection, the evaluation team used existing literature and engineering analysis to determine the best method for estimating savings. The evaluation team also conducted a billing analysis to estimate savings using a combination of regression models. The evaluation team metered lighting hours of use for a variety of common area space types to determine realization rates relative to ex ante energy savings. The evaluation team also conducted on-site visits to verify installed equipment and operating parameters. Finally, the evaluation team explored project benefits beyond primary fuel conservation by reviewing the estimation of water savings and the impact of weatherization measures on cooling season energy consumption.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 13.

Study 14: Comprehensive Review of Non-Residential Training and Education Programs, with a Focus on Building Operator Certification

Type of Study: Process Evaluation
Evaluation Conducted by: Research Into Action
Date Evaluation Conducted: 6/19/2015

Study Objective and Summary of Results:

The purpose of this study was to: 1) assess reasons for low rates of Building Operator Certification (BOC) in Massachusetts, with the eventual goal of identifying how to increase the number and share of PA customers who achieve BOC credentials with the assistance of PA training subsidies; 2) develop a better understanding of the factors that influence BOC savings; and 3) provide updated values for the MA TRM for BOC.

The study provides the following key findings:

- The primary motive for many MA BOC students is learning the subject matter, not obtaining the certification; emerging work demands are a key barrier to obtaining certification.
- Reducing the burden on applying for subsidies may be the best way to increase the number of subsidy applications.
- Multiple studies, varying in assessment approach and methodological rigor, have produced varying estimates of the per-student energy savings from BOC.
- Training multiple BOC operators at a site likely produces incremental increases in energy savings for that site.
- Level 2 BOC certificants may generate more savings than Level 1 certificants, but there is insufficient information with which to attribute the incremental savings to the differences in certification level and/or other differences between Level 1 and Level 2 students.
- PAs across the country claim energy savings for BOC training and/or certification for a minimum of one year after certification to a maximum of five years following expiration of certification.
- BOC energy savings may vary by building end-use, with schools possibly providing the lowest savings and government-owned buildings the highest.
- A variety of energy efficiency education and training programs besides BOC exist that have demonstrated the potential to generate energy savings by building operators, managers, and occupants.

Core Initiatives to which the Results of the Study Apply:

- C&I Retrofit: Existing Building (Electric & Gas)

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: The Massachusetts PAs should employ multiple channels to promote BOC and the subsidies.

Recommendation 2: The PAs should craft BOC messaging that conveys the value proposition of certification and maintenance of certification to high-level managers.

Recommendation 3: The PAs should encourage high-level managers who take the training to also send their operators with day-to-day O&M responsibilities.

Recommendation 4: The PAs should promote BOC to participants of other energy efficiency programs.

Recommendation 5: The PAs should claim savings for each subsidized customer for eight years from the initial year of certification – that is, for the year of certification plus seven additional years.

Recommendation 6: The PAs should *not* claim additional savings for an individual's Level 2 certification beyond those claimed for Level 1 certification.

Recommendation 7: The PAs should claim two-thirds of the recommended per-operator savings for a second subsidized operator at a given workplace.

Recommendation 8: The PAs should consider designing and implementing additional adult efficiency education/ training programs.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affected Program Results:

This study is not being applied directly to the savings estimated in this Plan. However, it informs future program planning for those PAs planning to offer BOCs by providing a series of recommendations for improving the BOC rate among the MA PAs' customers and how the associated savings should be claimed.

Overview of Study Method:

The evaluation team members carried out the following research activities:

- Analyzed indicators of BOC market penetration to compare penetration in Massachusetts with the rest of the country.

- Interviewed:
    - 14 BOC program managers and one contractor for the PAs in Massachusetts and elsewhere.
    - Two contacts for a regional BOC implementer.
    - 24 Massachusetts BOC participants.
- Reviewed 11 studies reporting BOC savings estimates.
- Reviewed 16 non-BOC adult energy efficiency (EE) education and training programs offered by PAs, private organizations, and governmental entities to identify other opportunities to promote and support energy efficiency.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 14.

Study 15: Comprehensive Review of Behavior and Education Programs

Type of Study: Process Evaluation
Evaluation Conducted by: Navigant Consulting
Date Evaluation Conducted: 6/30/2015

Study Objective and Summary of Results:

The purpose of this study was to provide a comprehensive review of behavior and education (K-12) programs for the Massachusetts PAs and the EEAC.

The study provides the following key findings related to behavior-based programs:

- There is a wide array of residential behavior programs that leverage various combinations of behavioral strategies. Most have not been tested at scale.
- Home Energy Report and Feedback programs are the most widely tested though many questions remain regarding program design and implementation.
- Many utilities serving small markets implement Home Energy Report programs, though several have needed to adopt strategies to improve cost-effectiveness, such as: more careful selection of vendors, entering partnerships to achieve economies of scale, reconsidering evaluation methods and requirements for claiming savings, and possibly supporting a measure life of more than one year.
- Behavioral programs identified as being particularly effective in small markets have a high level of customer engagement (often involving in-person/community interaction).
- There are several classes of commercial behavior programs. These programs typically rely on employee engagement, social interactions, competitions, feedback and benchmarking.
- Recent trends in
  - Residential behavior programs include enhanced customer access and engagement, interaction with end-uses, and a multi-pronged approach.
  - Commercial behavior programs include use of competitions, workplace engagement and business energy reports.

The study provides the following key findings related to K-12 education programs:

- A diverse landscape of educational programs leverages various combinations of behavioral strategies, similar to those seen in other behavior-based programs.
- In addition to traditional kit-based K-12 programs, a large number of school-wide and classroom-based education programs utilize behavioral strategies to reduce student energy use at school and at home.
- Most non-kit behavior-based energy efficiency programs currently employ savings calculation methodologies in line with industry current practice, rather than randomized control trials (RCTs) or regression-based methods. Many utilities are able to claim savings based on these methods. There are many

examples of non-kit programs working with utilities to develop more rigorous methods for evaluating savings, including the use of RCTs.

- Recent trends in
    - K-12 programs include alternatives to traditional kit-based programs, using a multi-pronged approach, and leveraging feedback technologies.
    - Savings methodologies in K-12 programs include partnerships with utilities, use of Advanced Metering Infrastructure, and use of RCT and Matching methods.

Core Initiatives to which the Results of the Study Apply:

• Residential Behavior/Feedback	(Electric & Gas)
• C&I Retrofit: Small Business	(Electric & Gas)
• Other (specify below) – K-12 Education Facilities	(Electric & Gas)

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: Test alternative residential behavior-based program offerings. Programs relying on web portals and smartphone applications can provide lower cost opportunities with comparable savings to the HER program. However, these programs may provide less opportunity for wide-scale implementation as not all customers have computers or smartphones.

Recommendation 2: Consider conducting an opportunity assessment of existing program offerings to identify opportunities for employing behavioral strategies, such as commitments and framing, to further enhance program participation. Although the Home Energy Services and low-income programs already have behavioral and education components, additional integration opportunities may remain.

Recommendation 3: Further explore opportunities for addressing barriers faced by PAs serving small markets in delivering behavior-based programs, particularly around partnership, evaluation methods and requirements for claiming savings, and assumptions regarding measure life.

Recommendation 4: Consider testing a workplace engagement program to initiate experience with small and medium commercial behavior programs.

Recommendation 5: Consider implementing kit-based education programs. Involve appropriate stakeholders in design and implementation to ensure behavioral savings can be quantified and claimed. Typically, savings are determined using TRM values for kit measures, applying measure-specific installation rates.

Recommendation 6: Monitor the outcome of K-12 programs promoting school-wide energy-saving through culture change in similar jurisdictions with periodic, targeted reviews of key programs cited in this research.

Recommendation 7: Consider the possibility of path-breaking, targeted research around behavior-based programs in higher education. Due to the number of college and university students per capita, Massachusetts may reap higher benefits from such efforts relative to other states. Many of the behavioral strategies and K-12 program models have application in a higher education setting.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affected Program Results:

This study is not being applied directly to the savings estimated in this Plan.

Overview of Study Method:

Navigant relied on interviews and a secondary literature review to conduct the review of behavior and education programs. Given that most of the current and ground-breaking developments are not yet published, the informational interviews provided access to the most recent information on trends to develop a better understanding of the evolving landscape of behavior and education programs. The review of secondary literature sources complimented and enhanced the primary research findings.

Navigant conducted in-depth interviews and informational interviews with over twenty thought-leaders including researchers, PAs, program implementers, policy makers and more. In addition, the team reviewed conference proceedings, evaluation reports, whitepapers, academic research, utility websites, vendor websites, regulatory filings and more to conduct the secondary literature review.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 15.

Study 16: Massachusetts Behavioral Programs Process Evaluation

Type of Study: Process Evaluation
Evaluation Conducted by: Navigant Consulting and Illume Advising
Date Evaluation Conducted: 7/31/2015

Study Objective and Summary of Results:

The purpose of this study was to collect process feedback of and insights into the long-standing behavior programs in Massachusetts. Due to the large number of programs and PA cohorts, the evaluation team examined the survey results by fuel treatment type (electric, gas, combined dual-fuel, and cross PA).

The study provides the following key findings:

- Overall, customers remain satisfied with the Home Energy Reports (HER) and the frequency of treatment. Across fuel groups, 74% to 80% of customers indicated that they want the reports to be sent at "about the same" frequency as they are now.
- The survey results also suggest that the HER programs are enhancing customer satisfaction among electric treatment groups, who are statistically more satisfied than control groups with the energy efficiency services received from their PA (mean scores of 3.58 vs. 3.42 respectively, on a five-point scale where five is very satisfied). There is a clear lift in energy-saving actions among treatment customers above their control counterparts and findings, most of which are independent of other programs. Several measures experiencing "lift" (statistically significant difference in treatment actions over control) have long measure lives, such as 25 years for insulation (building envelope category) and 15 years for energy efficient furnaces (heating/cooling category).[3] Notably, the reports also appear to support the maintenance of conservation-based behaviors[4].
- Most energy saving actions appear to be independent of other programs (i.e. received no financial incentives), though gas customers showed greater cross-program participation.
- Further, the data suggest that customers who are treated with one fuel, such as electric, are taking action in other fuels (such as gas, water).

Core Initiatives to which the Results of the Study Apply:

- Residential Behavior/Feedback (Electric & Gas)

[3] Massachusetts Technical Reference Manual, 2013-2015 planning period.
[4] As a part of the survey, the evaluation team asked customers whether they regularly took specific behaviors in the past year. For behaviors that did not start or increase in frequency in the previous year, customers began these behaviors in previous years and are still maintaining them.

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: While the savings associated with other programs cannot be double-counted across the portfolio, the net benefit of cross-program promotion and participation is positive. The PAs and EEAC should consider mechanisms to balance the "costs" of cross-program effects to avoid undue burden on the HER program where cross-program savings are substantial. Options for consideration include prorating these benefit adjustments to all programs, or conducting joint benefit-cost tests across the affected energy-efficiency and behavior-based programs.

Recommendation 2: Overall, feedback from cross PA customers is positive and similar to most other fuel groups. Therefore, PAs should continue with the current treatment for these customers without concern of negative customer satisfaction side effects.

Recommendation 3: The PAs should consider conducting more comprehensive exploratory research, such as in-home ethnography, to identify the potential for home automation solutions to target plug load. Across the interviews, this was the most commonly cited end use where customers were interested in additional support and solutions. Further, customers admit that actions like unplugging appliances and switching off power strips are too burdensome to take on a regular basis. It is important to note that this research is currently underway in in Massachusetts and follow-up research has been proposed for 2016.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affected Program Results:

This study is not being applied directly to the savings estimated in this Plan.

Overview of Study Method:

The evaluation consisted of the following major activities:

1. Telephone survey with treatment (~2100) and control group customers (~2100) across electric, gas, and dual fuel customers in Eversource and National Grid's territory. The surveys measured actions taken in the past year and satisfaction with the HES report.

2. In-depth interviews with 24 treatment customers to explore their interactions with the reports and energy saving behaviors in more depth.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 16.

Study 17: 2014-2015 Commercial and Industrial Natural Gas Programs Free-ridership and Spillover Study

Type of Study: Impact Evaluation
Evaluation Conducted by: Tetra Tech
Date Evaluation Conducted: 8/10/2015

Study Objective and Summary of Results:

The purpose of this study was to quantify the net impacts of the 2014-2015 C&I natural gas energy efficiency programs by estimating free-ridership, participant "like" spillover and non-participant "like" spillover. A secondary objective of the study was to assess how free-ridership varies between Green Communities and non-Green Communities.

The study provides the following key findings:

- The study produced free-ridership, participant spillover and non-participant spillover rates for each PA by program and end use.
- Overall, the statewide net-to-gross rates (NTGRs) for this study (87 percent) were similar to the 2011 gas study (90 percent), but significantly higher than the 2010 gas study (79 percent). In addition, NTGRs varied dramatically by measure type both between evaluation years and among PAs for a given year. Two factors driving this variability that the evaluation team was able to observe were: 1) the categorization of measures into measure types varied between PAs and over time, and 2) some end uses and PAs had a small number of participants that make the estimates more volatile.
- Custom measures had a higher overall NTGR (88 percent) than prescriptive measures (76 percent).
- End-uses with the highest NTGRs in 2014-2015 included steam traps (114 percent), water saving measures (102 percent), water heating (97 percent), and other (92 percent). End-uses with the lowest NTGRs were food service (56 percent), thermostats (70 percent), and comprehensive (74 percent).
- The overall statewide NTGRs for municipal buildings within a Green Community (91 percent) are less than to those for municipal buildings within non-Green Communities (110 percent).

Core Initiatives to which the Results of the Study Apply:

- C&I New Construction: New Buildings & Major Renovations (Gas Only)
- C&I New Construction: Initial Purchase & End of Useful Life (Gas Only)
- C&I Retrofit: Existing Building (Gas Only)
- C&I Retrofit: Small Business (Gas Only)
- C&I Retrofit: C&I Multi-Family (Gas Only)

Evaluation Recommendations:

Results from this study are used by the PAs in setting prospective NTGRs in their three-year plans. When results are based on more than 10 survey records, the PAs should use PA-specific results. When sample sizes are not sufficient (10 completed surveys or less), PAs should use statewide figures. The report contains the recommended NTGR values for filing purposes.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs plan to adopt the recommendations.

How the Study Affected Program Results:

The updated NTGRs will be applied to the PAs' savings estimates for C&I gas measures for 2016 through 2019. The change in net savings varies by PA, program, measure, and/or end use.

Overview of Study Method:

The methodology used for this study follows the standardized methodology developed in 2010 and 2011 for the Massachusetts PAs for use in situations where end-users are able to report on program impacts via self-report methods. [5]

As recommended in that report, the current study: 1) implemented two waves of the free ridership survey so that participants were contacted as soon as possible after the project was completed, and 2) implemented the spillover survey with 2013 program participants in order to allow more time for spillover to have occurred. The study also included interviews with design professionals and equipment vendors involved in the 2014-15 installations.

With separate populations surveyed for the free-ridership and spillover studies, net-to-gross results incorporate savings from each study. For that reason, a particular measure type may have free-ridership, spillover, or both reflected in its net-to-gross estimate.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 17.

[5] "Cross-Cutting C&I Free-Ridership and Spillover Methodology Study Final Report", prepared for the Massachusetts Program Administrators by Tetra Tech, KEMA, and NMR, May 20, 2011.

Study 18: Efficient Neighborhoods+ Incremental Cost Assessment

Type of Study: Impact Evaluation
Evaluation Conducted by: Opinion Dynamics
Date Evaluation Conducted: 7/8/2015

Study Objective and Summary of Results:

The purpose of this study was to estimate the incremental costs incurred by the Massachusetts PAs to design and implement the first round of the Efficient Neighborhoods+SM initiative.

The study provides the following key findings, despite uncertainties in the incremental cost estimates:

- Considerable per-participant and per-unit of energy costs for the initiative. Across all PAs combined, the incremental costs are $470 per EN+ participant, $0.13 per annual kWh saved, and $5.86 per annual therm saved. To put these costs in perspective, the cost per annual kWh saved by the Residential program portfolio in Q4 2014 was $0.40, while the cost per annual therm saved during the same time frame was $6.17.[6]
- Economies of scale might diminish incremental costs as an initiative expands. Comparison of per-participant costs across communities revealed that as the number of targeted customers increased, per-participant costs decreased. This is not surprising because larger communities should have a larger absolute number of participants yet some of the costs either remain fixed as the number of targeted customers increases (such as planning and design costs, marketing and collateral development) or increase only incrementally (distribution of marketing and collateral to a larger group of customers).
- As part of the initiative, PAs spent a considerable amount of incremental dollars to achieve savings for fuels other than gas and electric. More specifically, over $39,000 was paid in incremental incentives for savings from other fuels. This amounts to 57% of all incremental incentive dollars paid and 9% of overall incremental costs.

Core Initiatives to which the Results of the Study Apply:

- Other (specify below) (Electric & Gas)
  Pilot programs and community-based initiatives

[6] http://ma-eeac.org/wordpress/wp-content/uploads/MA-EEAC-Consultant-Team-2016-18-Three-Year-Goals-Framework-Memo.pdf

Evaluation Recommendations:

The following considerations were made by the evaluators conducting this study.

Consideration 1: PAs should consider deploying cost tracking mechanisms as part of future efforts to allow for a more accurate estimation of incremental costs. Incremental cost data were difficult to obtain and were often based on rough estimates. Incremental incentive data were not clearly tracked and required a considerable amount of time to parse out. Incremental administrative cost data were also not tracked and therefore based on rough estimates from data provided for more than one community. Many of these difficulties were due to internal and external staffing changes and required the evaluation team to make assumptions when preparing the data.

Consideration 2: The results suggest that scaling up EN+ by either targeting more customers in a single community or engaging multiple communities will result in lower incremental costs per participant. The results, however do not account for additional gains in economies of scale due to statewide implementation (e.g., spreading and amortizing design and start-up costs, systematizing and centralizing staffing, recycling marketing, etc.). Scaling the initiative, however, may not be a feasible option for smaller PAs whose service territory limits the number of customers and communities that they can engage.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

N/A (no formal recommendations were made in this evaluation)

How the Study Affected Program Results:

This study is not being applied directly to the savings estimated in this Plan.

Overview of Study Method:

For the purposes of this assessment, incremental costs include the following four cost sources:

- Incremental incentives paid for measures installed as part of the initiative
- Incremental marketing costs incurred by PAs and implementation contractors
- Incremental administrative (labor) costs incurred by PAs
- Incremental administrative (labor) costs incurred by implementation contractors

The administrative cost data are based on rough PA and implementation contractor estimates due to the amount of time elapsed since the initiative implementation. The evaluation team leveraged the incremental marketing data collected previously for the EN+ evaluation in 2014, which the evaluation team confirmed again with the PAs. The incremental cost data analysis included the following steps:

- Analysis of program tracking data to isolate incremental incentives associated with the EN+ initiative
- Conversion of incremental staff hours into costs using wage rate data from the United States Bureau of Labor Statistics (BLS)
- Allocation of incremental costs by PA and community
- Imputation of missing cost data
- Normalization of incremental costs by participation and energy savings

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 18.

Study 19: Prescriptive Gas Impact Evaluation: Steam Trap Evaluation Phase 1

Type of Study: Impact Evaluation
Evaluation Conducted by: DNV GL
Date Evaluation Conducted: 6/17/2015

Study Objective and Summary of Results:

The purpose of this study was to identify the best available methods for calculating the deemed savings for steam traps and assumptions for their measure life. The evaluation team also used the study as an opportunity to solicit general feedback on program delivery and other factors.

Since steam trap lifetime references are not well established in the literature, the evaluation team supplemented its literature review with information solicited directly from steam trap vendors/manufacturers, and investigated the existence of Massachusetts gas customer facility records that could: 1) provide historical documentation of steam trap replacement, and 2) directly support steam trap measure lifetime conclusions.

The study provides the following key findings:

- The evaluation team's review of over twenty available steam trap references including technical reports, energy efficiency evaluations, manufacturer publications, energy efficiency program resource manuals, and other savings documentation, suggests that a measure life of six years is more appropriate. The evaluation team's literature review found that all source materials except for the Massachusetts and Rhode Island Technical Resource Manuals utilized a lifetime assumption of five to six years for steam trap measures and was based largely on Delphi method of manufacturer interviews. Analysis of data for Massachusetts gas customer facilities that had annual steam trap surveys conducted on an ongoing basis also provided support for a lifetime assumption of six years.
- The literature review also showed that there are several analytic methods to calculate the energy savings achieved from the repair or replacement of failed steam traps. Massachusetts appears to have the only efficiency program that uses two calculation methods that have been effectively "calibrated" to both provide consistent savings values. Meetings conducted with steam trap vendors and the PAs' subcontractors suggest that adoption or refinement of a small number of common assumptions would further increase the accuracy and consistency between the two existing tools.
- Gas customers, vendors, and manufacturers indicated that gas savings through steam trap repair and replacement can be increased through both broader participation and heightened customer awareness.

Core Initiatives to which the Results of the Study Apply:

- C&I Retrofit: Existing Building (Gas Only)

- C&I Retrofit: Small Business (Gas Only)

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: Continue providing two steam trap programs, prescriptive and custom, to accommodate the wide variation in steam pressures and sizes, types, and number of steam traps; facility size; processes by which steam traps are repaired; and applicable savings methods and values.

Recommendation 2: Increase measure lifetime from three to six years based on the evaluation team's literature review and analysis of MA gas customer survey data.

Recommendation 3: Convene a steam trap stakeholder group – composed of PA staff members directly involved with steam traps, program implementation subcontractors, and steam trap repair/replacement vendors—to identify common assumptions/inputs to use in the savings algorithm, with the goal of improving program accuracy and consistency at the state-wide level. Any changes recommended by the stakeholder group would ultimately need to be verified and approved by the individual PAs.

Recommendation 4: Develop a new prescriptive steam trap deemed savings value using the savings algorithm developed in Phase 2 (per the recommendation above).

Recommendation 5: Leverage the steam trap stakeholder group to identify approaches to increase program participation and savings.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are adopting the study's recommended measure life of six years. The PAs are considering the other recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affected Program Results:

The study produced a finding that increases the steam trap measure life in this 3-Year Plan (six years) in comparison to prior program years (three years).

Overview of Study Method:

DNV GL conducted five major tasks:

- Conduct in-depth industry and literature research on steam traps focusing on the methods employed for calculating their deemed savings and the assumptions on their measure life
- Conduct and provide a summary of meetings with vendors/manufacturers most active with repair/replacement of steam traps in Massachusetts
- Collect and analyze actual Massachusetts gas customer facility data to determine measure life
- Provide a technical discussion of steam trap savings calculations currently in use in the industry and other efficiency programs
- Provide recommendations for the best approach for adjusting the current steam trap prescriptive program deemed savings value

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 19.

Study 20: Prescriptive Programmable Thermostats

Type of Study: Impact Evaluation
Evaluation Conducted by: DNV GL
Date Evaluation Conducted: 9/14/2015

Study Objective and Summary of Results:

The purpose of this study was to identify a deemed savings value for programmable thermostats (PTs) used only for gas-fired heating at C&I facilities.

The study provides the following key findings:

- Based on survey results and billing analysis, a savings of 5.3 therms per year per programmable thermostat, with a standard error of 3.8 therms, was initially estimated. This initial estimate was much lower than that specified in the TRM (77 therms per year savings per thermostat) based on a residential study from RLW Analytics (2007), "Validating the Impact of Programmable Thermostats." After adjusting the billing analysis, the evaluation team produced a revised savings estimate of 130.9 therms per year per programmable thermostat, with a standard error of 108.2 therms.
- However, due to technical concerns raised about the appropriateness of the billing analysis modifications as well as the large standard errors, and the insufficient time with which to discuss them and properly vet any new results, the evaluation team reduced the deemed savings to 32 therms per year per programmable thermostats for the time being, to be consistent with the current residential PT savings value. The evaluation team, PAs, and EEAC consultants agreed that additional billing analysis, including 2014 billing data, would be beneficial to the evaluation. Therefore, DNV GL will work with the PAs to set up an additional billing analysis to help gain more clarity on these results.

Core Initiatives to which the Results of the Study Apply:

- C&I Retrofit: Existing Building (Gas Only)
- C&I Retrofit: Small Business (Gas Only)

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: Perform analysis on the 2014 program data, which is currently underway. Knowing the details of PT measure growth or waning, the quantity of PTs installed, program savings, and the delivery method that was employed for each project will provide guidance to identify the optimal next steps.

Recommendation 2: Undertake a second participant survey that is focused on the 2014 program participants to identify and examine important consistencies, variances, and changes between the 2013 and 2014 program years, as well as to clarify the use of PTs, the pre-installed condition, and the savings.

Recommendation 3: Conduct a billing analysis using data from both the 2013 and 2014 program years to increase the precision of the savings estimates results from a future billing analysis.

Recommendation 4: Consider modifications to the billing analysis that would better account for exogenous change in the participant population such as including a matched sample of small businesses, and collecting some additional business-level information in the survey (e.g., hours worked by or paid to employees).

Recommendation 5: Given the inherent difficulties of billing analyses, continue to investigate methods to better quantify the savings achieved by PT installations, such as pre/post PT installation metering.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs have adopted the deemed savings value of 32 therms per year per programmable thermostats for the time being, until the analysis of the 2014 program (and if initiated, 2014 billing) data is complete.

The PAs are considering the other recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affected Program Results:

The study produced an interim savings value that decreases the prescriptive programmable thermostat savings projected in this 3-Year plan in comparison to prior program years.

Overview of Study Method:

DNV GL conducted three major tasks as part of this study:

- Participant survey: C&I customers that received incentives in 2013 for prescriptive PT's were surveyed to understand their PT use/program delivery method, pre-existing condition, interactive effects, and suitability to participate in a billing analysis.
- Site visits: The evaluation team conducted in-person site visits at 37 selected survey participants' facilities in order to collect more in-depth information and to

verify that information from the survey responses was accurate. The site visits were also used to further screen facilities to determine whether a billing analysis of that facility would likely provide conclusive or inconclusive PT savings results.

- Billing analysis: The evaluation team performed a billing analysis with the goal of identifying a deemed savings value with sufficient confidence to integrate in the Massachusetts TRM. In contrast to the conventional billing analysis that is performed over a large population, the analytical approach focused on a sample of 91 accounts that were identified as “suitable for a billing analysis” by the survey and site visits, and by the availability of sufficient billing data in the pre- and post-program periods.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 20.

Study 21: Impact Evaluation of PY2013 Custom Gas Installations

Type of Study: Impact Evaluation
Evaluation Conducted by: DNV GL
Date Evaluation Conducted: 10/7/2015

Study Objective and Summary of Results:

The primary mission of the study was to determine program realization rates. There was also a secondary objective to further test the efficacy of using a novel process, called "desk review benchmarking" (DRB), which uses structured desk reviews to identify significant changes to program processes.

The study provides the following key findings:

- The study produced statewide results for realization rates that are reliable (±9.5% precision) at 80% confidence. In addition, the precision level for Eversource (±14.2%), National Grid (±19.0%), and Columbia Gas (±21.0) are sufficient to warrant application of their individual PA realization rates.
- The results of the DRB test were not strong enough to warrant its adoption as the primary determinant of impact evaluation timing.

Core Initiatives to which the Results of the Study Apply:

- C&I Retrofit: Existing Building (Gas Only)
- C&I New Construction: New Buildings & Major Renovations (Gas Only)
- C&I New Construction: Initial Purchase & End of Useful Life (Gas Only)
- C&I Retrofit: C&I Multi-Family (Gas Only)

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: Realization rates should be utilized for the purposes of planning and reporting as follows: Eversource (91.8%), National Grid (77.9%), Columbia Gas (72.7%) and statewide (88.3%).

Recommendation 2: A single guidance document that codifies the various protocols, principles, and practices used for applying realization rates across all programs, both gas and electric, in all sectors, should be developed as a common reference and to minimize ambiguity. The November 2010 Protocol Memo presents a framework for deciding whether to apply PA-specific, state-wide, or measure specific realization rates for custom gas evaluation results. However, the rules guiding the application of realization rates are not limited to a single program.

Recommendation 3: Follow the recommendation of the "Massachusetts 2013 Prescriptive Gas Impact Evaluation Steam Trap Evaluation Phase I" to commence with a Phase II activity to standardize algorithms. A variety of steam trap tools were used by applicants, some with unsupported assumptions. Steam traps may also be moved to an upstream program delivery model; savings estimates for the upstream model should be coordinated with Phase II outcomes as well.

Recommendation 4: Further explore the role of the DRB method in impact evaluation planning, as future impact evaluations may benefit from a structured data collection of the M&V sample for ongoing measurement of program characteristics.

Recommendation 5: Comprehensive Design Analysis (CDA) natural gas tracking savings included the interactive gas penalty from electric measures. The electric measure penalties should be reported as a resource penalty to the electric program and not reported as a gas program penalty.

Recommendation 6: The application reviewers should cross-check the fraction of the natural gas bills a project is expected to save against typical savings fractions, particularly those that are high.

Recommendation 7: Confirm existing condition ventilation rates and the efficient operation of the installed equipment, given the erratic and often poor savings rates of ventilation control measures (including ventilation heat recovery, demand controlled ventilation [DCV], and ventilation related EMS measures). The additional engineering effort would not be an easy or inexpensive task. However, without further engineering, these types of measures add risk to the portfolio and could expose customers to potentially higher bills than anticipated in cases where the pre-condition did not meet code ventilation requirements. Further research into potential solutions and their impact on installed cost and cost-effectiveness is recommended.

Recommendation 8: The PAs should be diligent in gathering the technical assistance studies, spreadsheets, and models used to develop the project and include them in the electronic documentation, given that the application files are not always complete and sometimes miss significant information. Particular attention should be paid to the documentation of baseline conditions.

Recommendation 9: Consider evaluating projects consisting of only deemed measures with deemed savings as part of technology specific evaluations. In this cycle, there were a number of sites that consisted of deemed measures only using deemed savings estimates (steam trap, low-flow devices, insulation/air-sealing, and programmable thermostats). These sites were predominantly multifamily projects. While the PAs may wish to include the projects in the custom track for administrative reasons, they are most appropriately evaluated in a technology specific evaluation (i.e. a low flow device impact evaluation). These measures do not lend themselves to metering which is the mainstay of a custom evaluation.

Recommendation 10: An error ratio of 0.60 is recommended for future evaluations.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs have adopted the revised realization rates. The PAs are considering the other recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affected Program Results:

The study produced realization rates that affect program gross savings. The changes in the RR from the previous impact realization are: Eversource (increase in RR from 84% to 91.8%), National Grid (increase in RR from 68% to 77.9%), Columbia Gas (decrease in RR from 83% to 72.7%) and statewide (increase in RR from 82% to 88.3%).

Overview of Study Method:

The study determined gross realization rate through on-site M&V at a statistically selected sample of forty-six PY2013 participating sites. The DRB consisted of desk reviews of ninety-four PY2013 projects using a structured data collection process that characterized the savings estimate and other aspects of the project. The desk reviews included a billing analysis and an engineering assessment of the savings. The PY2013 reviews were compared to benchmarks established by examining PY2009, PY2010, and PY2011 M&V impact evaluation sites using the same structured review.

Application of Results: Retroactively and Prospectively

A copy of the complete study can be found in Appendix U, Study 21.

Study 22: Massachusetts Commercial New Construction Energy Code Compliance Follow-up Study

Type of Study: Market Assessment
Evaluation Conducted by: DNV GL
Date Evaluation Conducted: 7/22/2015

Study Objective and Summary of Results:

The purpose of this study was to assess compliance with the Massachusetts energy code by reviewing construction documentation and conducting field visits at 50 active construction sites throughout Massachusetts.

The study provides the following key findings:

- Energy code compliance for MA (using MA-CIEC methodology) was observed to be approximately 94%, suggesting that the state has met the ARRA requirement to achieve 90% compliance by 2017. Compliance using the DOE/PNNL methodology was 85%.
- Code compliance increases near the end of energy code cycles as the design and building communities and code officials become more familiar with the requirements and compliance approaches.
- Code determinations are most often made during the design phase of a commercial project. The primary on-site focus is executing the project as designed and documented.
- Daylighting provisions, introduced for MA in IECC 2009, are not yet being properly implemented in about 50% of the project sites.
- Increased adoption of the MA Stretch Code may have led to increased energy code compliance as designers and builders are increasingly aware of its Code requirements.

Core Initiatives to which the Results of the Study Apply:

- C&I New Construction: New Buildings & Major Renovations (Electric & Gas)

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: Adopt modified code baselines that reflect standard practices as the basis for determining energy efficiency incentives.

Recommendation 2: Promote a focus on installation quality to realize greater savings from energy efficiency.

Recommendation 3: Promote high-performance building strategies to achieve additional energy savings.

Recommendation 4: Target code training at specific provisions to achieve additional savings from improved compliance.

Recommendation 5: Streamline future code compliance studies to enable more frequent, cost-effective compliance assessments.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affected Program Results:

This study informs program design and planning by providing an assessment of current compliance with the MA energy code as well as offering recommendations to achieve greater energy savings (e.g., focus on advanced building performance strategies) and more frequent, cost-effective compliance assessments (e.g., focus on construction document review).

Overview of Study Method:

This study assessed compliance with the Massachusetts energy code by reviewing construction documentation and conducting field visits for 50 active construction sites throughout Massachusetts. The project team developed stratified, random samples for large (greater than or equal to 50,000 sq ft) and small buildings (less than 50,000 sq ft) from McGraw-Hill Construction's Dodge Global Network (Dodge Database) that were actively under construction from June 2014 through February 2015. The drawn sample included 25 large sites and 25 small sites and was expected to meet a 90/10 confidence/precision target.

For each site, the evaluators obtained a copy of the most current construction design documents and conducted a review of this documentation for energy code compliance. Following the documentation review, evaluators scheduled field visits for each site to confirm what was observed on the construction documents and fill in any gaps in information. For some of the large sites, the evaluators conducted multiple site visits to observe energy code components throughout the construction process.

Following the field visits, the evaluators developed a code compliance score for each site based on observed code provisions weighted by their relative energy impact. The evaluators evaluated each site using two different methodologies: one developed by the Department of Energy (DOE) in conjunction with the Pacific Northwest National

Laboratory (PNNL) (the DOE/PNNL methodology) and an enhanced methodology developed by the evaluation team to more accurately capture the energy impact of observed building practices (MA-CIEC methodology).

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 22.

Study 23: Massachusetts LED Spillover Analysis

Type of Study: Market Assessment
Evaluation Conducted by: DNV GL
Date Evaluation Conducted: 9/24/2015

Study Objective and Summary of Results:

The purpose of this study was to assess the potential spillover savings associated with the LED lighting programs offered by the PAs in light of recent findings from the LED Market Effects Baseline Characterization study that showed high levels of C&I customer adoption.

More specifically, this study sought to:

- Further investigate causes of the higher rate of LED adoption observed in Massachusetts C&I customers
- Estimate spillover and free-ridership associated with PA programs that support C&I LED products
- Research other key market elements, such as factors influencing the purchase of LED products, changes in supplier activities to promote LEDs, and processes by which customer decide to purchase lighting

The study provides the following key findings:

- C&I LED NTG of 1.42
- Indicators of strong LED market development:
    - The sample participants reported that the program primarily influenced the timing and quantity of their LED purchases. Eighty-two percent would have purchased LEDs for replacement without the program, highlighting the influence of the program on expediting and increasing these planned purchases
    - The majority of customers noted that the level of vendors' promotions of LED products has increased over the last two years
    - Over 70% of customers purchase LED lamps through distributors and contractors
- Indicators of strong effects of prior program participation
    - Sixty percent of participants noted that prior program experience had influenced their decision to purchase out-of-program LEDs
    - Almost all customers noted that past programs made them more comfortable and aware of the benefits associated with energy efficiency

Core Initiatives to which the Results of the Study Apply:

- C&I Retrofit: Upstream Lighting (electric) (Electric Only)

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

> **Recommendation 1:** The PAs should take steps to ensure that smaller customers are exposed to opportunities to purchase incented LED lamps through Direct Install programs and strong promotions via large home improvement stores and electronics retailers.

> **Recommendation 2:** Focus program efforts on the promotion of LED linear fixtures, which account for a very high portion (roughly 80 percent) of total commercial lighting energy consumption currently. Sales of LED linear equipment continue to be low, but significant reductions in price are forecasted over the next 5 years.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are adopting the NTG ratio of 1.42 developed in this study for upstream C&I non-linear LED lighting. The PAs are considering the other recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affected Program Results:

The study produced a NTG ratio that is higher than the overall NTG value for LED lighting products and commercial lighting that is currently being applied. The PAs are applying the updated NTG ratio to estimate the savings for Upstream C&I non-linear LED lighting projected in this Plan.

Overview of Study Method:

The DNV GL team conducted a survey of customers (99 of 144 possible respondents, for a response rate of 73%) to estimate free-ridership and spillover for LED products supported by the PAs' programs, using the methods and survey questions developed as part of the Cross-Cutting evaluation portfolio.[7] Specifically, the evaluation team surveyed on-site respondents from Wave I of the Massachusetts Commercial and Industrial Customer On-Site Assessments with verified LEDs to ensure a relatively more accurate inventory of LED holdings.

[7] Tetra Tech. 2011. *2010 Commercial and Industrial Electric Programs Free-ridership and Spillover Study.*

To estimate free-ridership and spillover for each survey respondent, the evaluation team developed in and out of program LED savings for each account using data from three distinct data sources:

- **On-site data collected in the fall of 2014.** DNV GL engineers verified that 144 sites surveyed as part of the first wave of the Massachusetts Commercial and Industrial Customer On-Site Assessment Study contained interior LED lighting products.
- **2011-14 Customer & Industrial Customer Tracking Data, including prescriptive, custom, and new construction program tracking data**
- **2012-14 Upstream Data**

For the purposes of estimating these free-ridership, participant spillover, and non-participant spillover, the evaluation team treated participants and non-participants as separate populations. Free-ridership and participant spillover were calculated as ratios of the sampled LED savings characterized as free-rider or spillover savings to total sampled LED savings (Equation 1 and Equation 2). Non-participant spillover, on the other hand, was estimated in comparison to total program LED savings from the 2011-14 tracking data in order to represent non-participant savings from the total population of C&I customers (Equation 3).

Equation 1: Free-Ridership Calculation

$$\frac{\sum(\textbf{Free Rider Rate } \boldsymbol{i} * \textbf{Site Weight } \boldsymbol{i} * \textbf{Program LED Savings } \boldsymbol{i})}{\sum(\textbf{Site Weight } \boldsymbol{i} * \textbf{Program LED Savings } \boldsymbol{i})}$$

Equation 2: Participant Spillover Calculation

$$\frac{\sum(\textbf{Participant Spillover Rate } \boldsymbol{i} * \textbf{Site Weight } \boldsymbol{i} * \textbf{Out} - \textbf{of} - \textbf{Program LED Savings } \boldsymbol{i})}{\sum(\textbf{Site Weight } \boldsymbol{i} * \textbf{Out} - \textbf{of} - \textbf{Program LED Savings } \boldsymbol{i})}$$

Equation 3: Non-Participant Spillover Calculation

$$\frac{\sum(\textbf{Non} - \textbf{Participant Spillover Rate } \boldsymbol{i} * \textbf{Site Weight } \boldsymbol{i} * \textbf{Site} - \textbf{level LED Savings } \boldsymbol{i})}{\textbf{Total } \mathbf{2011 - 2014} \textbf{ LED Program Savings}}$$

Application of Results: Prospectively

A copy of the complete study can be found in Appendix U, Study 23.

Study 24: Impact Evaluation of Prescriptive Chiller and Compressed Air Installations

Type of Study: Impact Evaluation
Evaluation Conducted by: DNV GL
Date Evaluation Conducted: 10/22/2015

Study Objective and Summary of Results:

The purpose of this study was to verify and re-estimate gross energy and demand savings through site specific inspection, monitoring and analysis. The retrospective results of this study will be used to determine the final realization rates for Prescriptive CAIR and HE Chiller energy efficiency measures installed in 2015. Realization rates for both measures were determined at the statewide level, while HE Chiller results are also provided for Eversource-NSTAR separately due to the differences in methods of tracking savings calculations. In addition to producing retrospective results, the impact evaluation provides prospective deemed savings estimates, savings algorithms and/or savings factors (such as ELFH) to be used to inform future savings estimates.

The study provides the following key findings:

- Savings from new prescriptive chillers have a retrospective energy savings realization rate of 104% at the state level. For the larger PAs, energy savings realization rates were also positive with National Grid at 127% and Eversource-NSTAR at 100%. These realization rates were driven by two factors, namely increased delta efficiency and an increase in EFLH. In addition, it appears that the TRM methodology underestimated savings while the Eversource-NSTAR tool was more accurate.
- Savings from all three prescriptive compressed air measures (air compressors, refrigerated air dryers, and zero loss condensate drains) are being realized.
    - The air compressor measure produced a retrospective energy savings realization rate of 109%. This value was driven by VSD air compressors, which performed much better (113%) than the load/unload air compressors (19%). However, it should be noted that there were only three load/unload air compressors in the sample and those may be considered as the baseline going forward. The high VSD compressor realization rates were primarily the result of higher than anticipated operating hours.
    - The study also suggests using load/unload air compressors as the baseline technology for high efficiency air compressors going forward instead of the current modulating with blowdown baseline. Compressor results are provided for both baseline scenarios.
    - The dryer measure yielded a retrospective energy savings realization rate of 257%, which was driven by both a higher average kW reduction per CFM, and higher operating hours. The largest savings increase came from

the largest dryer category (>400 CFM). This dryer category included five dryers, which were all part of compressed air systems that operated 24/7.

- The zero loss condensate drains appear to be installed as expected. Though this equipment was not monitored, evaluators verified the installation of almost all drains that were incentivized. It was recommended that no savings adjustments be made to this measure.

Core Initiatives to which the Results of the Study Apply:

- C&I New Construction: New Buildings & Major Renovations (Electric Only)
- C&I New Construction: Initial Purchase & End of Useful Life (Electric Only)

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: The retrospective realization rates for chillers produced in this study are intended to be used by all PAs for their 2015 projects. This evaluation recommends that Eversource-NSTAR utilize its own PA specific retrospective realization rates, and that all remaining PAs use the TRM user retrospective realization rates.

The new savings factors and prospective realization rates for chillers produced by this study, which are calculated based on the average operating kW of the sample of chillers, may be used to update the values from the TRM. If applied, they should not be combined with the retrospective realization rates.

Recommendation 2: Consider more research around the key finding that many chillers operate at very low part loads (i.e., not cycling, and therefore operating below the manufacturer-recommended part load values), particularly the implications for reliability, efficiency, and energy savings.

Recommendation 3: Consider a closer review of chiller project applications, ensuring that more complicated projects, like those with multiple chillers or chillers used for data center cooling, go through the custom track.

Recommendation 4: Encourage vendors to look for additional chiller savings opportunities such as changing control set points (e.g., lower condenser water temperature, higher chilled water temperature or chilled water temperature reset). These types of improvements are covered by the custom program, and may result in moving some prescriptive projects to the custom track.

Recommendation 5: Update the air compressor baseline from the current modulating with blowdown to load/unload, even though the savings calculated from these two different baselines did not vary significantly. A recent incremental cost study found that the cost of a modulating air compressor is nearly the same as a load/unload air compressor, and that the load/unload air compressor is now considered the baseline compressor. The results of this study show that the savings opportunities from going from a modulating to load/unload system are minimal except at higher storage levels for the load/unload unit.

Recommendation 6: The retrospective realization rates for air compressors produced in this study are intended to be used by all PAs for their 2015 projects.

The new prospective savings factors for air compressors and refrigerated dryers produced by this study may be used to update the values in the TRM. If applied, they should not be combined with the retrospective realization rates. Should the program switch to a load/unload baseline, the TRM should use the set of values calculated from this baseline condition.

Recommendation 7: Recommend that compressed air vendors conduct simple short term metering to better understand their operation during off-shift periods and help improve the accuracy of the annual hours of operation.

Recommendation 8: Consider a review of interval load data prior to finalizing applications, given that in many cases the actual operating hours were observed to be significantly higher, resulting in unclaimed savings. For applications with relatively low operating hours (<~4,000 hrs/yr), it may be worthwhile to perform a brief interval load data review to confirm actual plant operating hours since compressors are often a significant percentage of a facility's energy consumption and operation.

Recommendation 9: Encourage vendors to look for additional compressed air savings opportunities such as lowering the discharge pressure, and inspecting for and reducing air leaks. These types of improvements are covered by the custom program, and may result in moving some prescriptive air compressor projects to custom.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs have adopted the revised retrospective and prospective realization rates and savings factors produced in this study as well as the updated compressor baseline. The PAs are considering the other recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affected Program Results:

The study produced realization rates and savings factors that increase the estimated gross savings projected in this 3-Year plan for chillers in comparison to prior program years. It also increases the estimated savings for VSD air compressors and air dryers.

Overview of Study Method:

DNV GL conducted the following steps:

- Examined the population of prescriptive chiller and compressed air measures statewide so that the PAs can better understand their characteristics;
- Designed an efficient sampling plan for the selection of prescriptive chiller and compressed air participants for on-site visits, and to optimize to the extent possible energy savings estimate results with ±10% precision at the 90% confidence interval for all selected end uses at the statewide level;
- Developed a project work plan outlining the major approaches and foreseeable research issues of this impact evaluation effort;
- Reviewed the formulas, calculations, and factors used in the development of the tracking savings for each sampled participant to develop measure specific M&V plans;
- Performed comprehensive data collection at each sample site to support an independent analysis of adjusted gross energy and demand savings realization rates; and
- Produced comprehensive reporting of results, including analysis methods, findings and trends, final sample plans and data collection instruments used.

Application of Results: Retroactively and Prospectively

A copy of the complete study can be found in Appendix U, Study 24.

Study 25: Impact Evaluation of 2012 Custom HVAC Installations

Type of Study: Impact Evaluation
Evaluation Conducted by: DNV GL
Date Evaluation Conducted: 10/23/2015

Study Objective and Summary of Results:

The purpose of this study was to verify or re-estimate the electric energy and demand savings estimates for 69 Custom HVAC projects through site-specific inspection, monitoring, and analysis. The results of this study will be used to determine the final realization rates for Custom HVAC energy efficiency measures installed in 2015 and for 2016-2018 program planning. Realization rates were separately determined for Cape Light Compact, Eversource (NSTAR and WMECo separately), National Grid and Unitil, as well as at the statewide level.

The study provides the following key findings:

- The study produced a statewide energy realization rate of 88% that is reliable (±7.4%) at 90% confidence. In addition, the precision level for Eversource-NSTAR (±9.4%) and National Grid (±8.8) are sufficient to warrant application of their individual PA realization rates of 91% and 75%, respectively.
- The study produced statewide summer and winter on-peak and seasonal peak kW savings realization rates.
    - Summer on-peak: 88% realization rate with a precision of ±12.6% at 80% confidence.
    - Winter on-peak: 85% realization rate with a precision of ±13.1% at 80% confidence.
    - Summer seasonal: 87% realization rate with a precision of ±17.1% at 80% confidence.
    - Winter seasonal: 85% realization rate with a precision of ±16.6% at 80% confidence.
- The study produced Eversource-NSTAR summer and winter on-peak savings realization rates.
    - Summer on-peak: 94% realization rate with a precision of ±15.3% at 80% confidence.
    - Winter on-peak: 88% realization rate with a precision of ±16.1% at 80% confidence.
- The study produced National Grid summer and winter on-peak savings realization rates.
    - Summer on-peak: 70% realization rate with a precision of ±18.7% at 80% confidence.
    - Winter on-peak: 67% realization rate with a precision of ±16.7% at 80% confidence.

Core Initiatives to which the Results of the Study Apply:

- C&I New Construction: New Buildings & Major Renovations (Electric Only)
- C&I Retrofit: Existing Building (Electric Only)
- C&I Retrofit: C&I Multi-Family (Electric Only)
- C&I New Construction: Initial Purchase & End of Useful Life (Electric Only)

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommandation 1: Improve Baseline or Pre-Retrofit Documentation. Several sites did not clearly document the pre-retrofit equipment operation or the basis for the base case in their project applications. The supporting documentation and baseline assumptions provided for HVAC control measures, such as ventilation control measures, economizers, and other controls were not as comprehensive and clear as with other technologies. It is recommended that the PAs collect and document information on the actual HVAC system operations such as damper positions, outside air ventilation levels, etc. for existing equipment undergoing controls improvements.

Recommendation 2: Provide Sufficient Documentation. Comprehensive documentation, meaning working savings calculation files and thorough explanation of baseline and installed case assumptions, is essential for supporting baseline conditions and detailed calculations as well as for evaluation purposes. Missing information, such as building simulation input files and working custom savings spreadsheets, should be included in the PA files.

Recommendation 3: Clearly Document Calculations of Peak Demand Savings. It is recommended that vendors provide full and clear documentation of peak savings calculations, including how peak demand savings are estimated (e.g., source or logic of the weighted operational proportions).

Recommendation 4: Encourage More Comprehensive Commissioning and Updating of Tracking Estimates with Findings from Commissioning. Commissioning is a useful tool to help improve savings estimates for HVAC controls projects. While all PAs currently use commissioning in some capacity, there are areas where this tool can be improved. First, PAs should consider employing a commissioning process on any large or complex project and particularly those with controls measures. Additionally, PAs should continue to follow-up on projects that are commissioned to ensure that the project and savings calculation has been done in accordance with the design intent, and that any savings calculation adjustments resulting from commissioning are made to the final tracking estimates.

Recommendation 5: Conduct Pre-Installation Metering for More Retrofit Projects. Short term pre-installation metering could be used to confirm assumptions about pre-existing equipment for some retrofit projects, particularly control type projects. The evaluator may not be able to simulate pre-retrofit operating conditions; therefore metering by the implementation vendor prior to installation could improve confidence in the pre-retrofit assumptions. This would be most useful for demand control ventilation or other controls type projects.

Recommendation 6: Improve use of Post Inspection to Verify Measure Operation. Evaluators identified a number of sites in which the controls or equipment installed were not operational. Post inspections are generally occurring on all custom projects, but the effectiveness of the post inspection could be improved by observing and documenting operating conditions at the time of the inspection rather than only verifying if the measure was installed. Evaluators have observed some improvement in operational effectiveness because of post installation screening in more recent custom impact evaluations, as compared to studies from five years ago. It is recommended that the PAs continue to use more rigorous post-installation inspections to further build on the efforts made in this area.

Recommendation 7: Require Trend Data Acquisition. Stipulate in customer participation agreements that for sites receiving controls measures, either customer staff are to be trained or the controls contractor will be required to assist with subsequent EMS trending in the event the customer is chosen as an evaluation site. It would be helpful to include in the contract specifically which trends should be made available to the PA and evaluators for evaluation. The engineers developing the project scopes could specify the required trends. Consider the feasibility of configuring controls systems to allow remote access by evaluators to allow for data downloads.

Recommendation 8: Use of Desk Review Methodology. A recent MA custom gas evaluation performed desk reviews on a double sample of custom gas projects.[8] This was set up as a test to determine if a desk review process could predict changes in realization rates that would trigger an impact evaluation. The evaluators concluded that the results of the test were not strong enough to warrant adoption of this process as the primary means of determining when to conduct an impact evaluation. However, future impact evaluations, including custom HVAC, may benefit from a structured desk review of key parameters from the M&V sample for ongoing monitoring of program characteristics. An interesting option is to use the structured desk review on a rolling sample for the purpose of providing ongoing program implementation feedback and as well as a continuous indication of program change that could be reviewed as part of the annual evaluation planning. A continuous desk review process would characterize some program change indicators, including quality of engineering calculations and baselines used to estimate savings. The PAs have commissioned a study to improve evaluation planning, where the desk review role in impact evaluation can be further considered.

[8] Energy & Resource Solutions and DNV GL, Project 43 Impact Evaluation of PY2013 Custom Gas Installations, September 2015

Recommendation 9: Consider Other Evaluation Methodologies. Given that this impact evaluation of custom HVAC installations took over two years to complete, the evaluation team should investigate alternative options to evaluate large, influential measures such as custom HVAC. Ideas, including a rolling annual sample, are currently being discussed as part of a new effort to refine the gross impact evaluation framework.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs have adopted the revised realization rates produced in this study. The PAs are considering the other recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations

How the Study Affected Program Results:

The study produced realization rates that decrease the gross savings projected in the 3-Year plan in comparison to prior program years.

Overview of Study Method:

The evaluation of 2012 custom HVAC installations used an approach similar to those of previous evaluations. The primary objective of determining realization rates at the statewide and PA end-use level was accomplished by conducting on-site M&V at a statistically selected sample of 69 participant sites from the 2012 program year. This impact study consists of the following five tasks:

- Develop sample design.
- Develop site measurement and evaluation plans.
- On-site data gathering and site analysis.
- Site report writing and follow-up.
- Expansion analysis and evaluation report.

Application of Results: Retroactively and Prospectively

A copy of the complete study can be found in Appendix U, Study 25.

U. **Evaluation Studies**

V. **Technical Reference Manual**

Massachusetts
Technical Reference Manual

for Estimating Savings from Energy Efficiency Measures

2016-2018 Program Years – Plan Version

October 2015

Table of Contents

Introduction

This *Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures* ("TRM") documents for regulatory agencies, customers, and other stakeholders how the energy efficiency Program Administrators ("PAs") consistently, reliably, and transparently calculate savings from the installation of efficient equipment, collectively called "measures." This reference manual provides methods, formulas and default assumptions for estimating energy, peak demand and other resource impacts from efficiency measures.

Within this TRM, efficiency measures are organized by the sector for which the measure is eligible and by the primary energy source associated with the measure. The two sectors are Residential and Commercial & Industrial ("C&I").[1] The primary energy sources addressed in this TRM are electricity and natural gas.

Each measure is presented in its own section as a "measure characterization." The measure characterizations provide mathematical equations for determining savings (algorithms), as well as default assumptions and sources, where applicable. In addition, any descriptions of calculation methods or baselines are provided as appropriate. The parameters for calculating savings are listed in the same order for each measure.

Algorithms are provided for estimating annual energy and peak demand impacts for primary and secondary energy sources if appropriate. In addition, algorithms or calculated results may be provided for other non-energy impacts (such as water savings or operation and maintenance cost savings). Data assumptions are based on Massachusetts PA data where available. Where Massachusetts-specific data is not available, assumptions may be based on, 1) manufacturer and industry data, 2) a combination of the best available data from jurisdictions in the same region, or 3) credible and realistic factors developed using engineering judgment.

The TRM will be reviewed and updated annually to reflect changes in technology, baselines and evaluation results.

[1] In this document, the Residential and Low Income programs are represented in a single "Residential" sector due to the degree of overlap in savings assumptions for similar measures in the standard income programs.

TRM Update Process

Overview

This section describes the process for updating the TRM. The update process is synchronized with the filing of program plans and Plan Year Reports by the PAs with the DPU.

Updates to the TRM can include:

- additions of new measures,
- updates to existing TRM measures due to:
  - changes in baseline equipment or practices, affecting measure savings
  - changes in efficient equipment or practices, affecting measure savings
  - changes to deemed savings due the revised assumptions for algorithm parameter values (e.g., due to new market research or evaluation studies)
  - other similar types of changes,
- updates to impact factors (e.g., due to new impact evaluation studies),
- discontinuance of existing TRM measures, and
- updates to the glossary and other background material included in the TRM.

Each TRM is associated with a specific program year, which corresponds to the calendar year. This results in two main versions of the TRM for each program year:

- the "Plan Version" is filed with the PA program plans prior to the program year, and
- the "Report Version" includes updates to the "Plan Version" document as needed and is filed with the PA Plan Year Reports, with the final savings algorithms and factors used to report actual savings.

The TRM for each program year is updated over time as needed to both plan for future program savings and to report actual savings.

Key Stakeholders and Responsibilities

Key stakeholders and their responsibilities for the TRM updates are detailed in the following table.

Stakeholder	Responsibilities
TRM Coordinating Committee	▪ Administrative coordination of TRM activities, including: ▪ Assure collaboration and consensus by the PAs regarding TRM updates ▪ Assure updates are compiled from the PAs and incorporated into the TRM ▪ Coordinate with related program activities (e.g., evaluation and program reporting processes)
Program Administrators	▪ Provide one or two representatives each to the TRM Coordinating Committee, either by direct representation or through a proxy (e.g., GasNetworks). Both the planning and evaluation functions should be represented on the Committee. ▪ Identify needed updates to the TRM ▪ Coordinate with other PAs on all TRM updates ▪ File TRM updates with the DPU

Stakeholder	Responsibilities
Department of Energy Resources	▪ Provide one representative to the TRM Coordinating Committee ▪ Assure coordination with PA submissions of program plans and reported savings

TRM Update Cycle

The timeline below shows the main milestones of the TRM update cycle over a period of two years. The milestones for the program year ("PY") 2016-2018 TRM Plan and Report versions are described below the timeline.

OCTOBER 2015: The 2016-2018 PY – Plan Version TRM is filed with the PAs' program plans.

The 2016-2018 Program Year – Plan Version TRM is filed with the DPU jointly with the PAs' energy efficiency program plans. With regard to the program plans, the TRM is considered a "planning document" in that it provides the documentation for how the PAs *plan* to count savings for that program year. The TRM is not intended to fully document how the PAs develop their plan estimates for savings.

OCTOBER 2015 - JUNE 2017: The 2016 Program Year TRM will be updated as needed based on evaluation studies and any other updates that will affect reported savings for PY 2016.

After the 2016-2018 Program Year – Plan Version TRM has been filed, there may be updates to the TRM to reflect how savings are actually calculated for PY 2016. The most common updates to the TRM will result from new evaluation studies. Results of evaluation studies will be integrated into the working version of the TRM as the studies are completed. Other updates may include the results of working group discussions to achieve greater consistency among PA assumptions.

JANUARY 2016: PAs begin to track savings based on the 2016-2018 TRM

Beginning in January 2016, the PAs will track savings for PY 2016-2018 based on the 2016-2018 Program Year – Plan Version TRM.

JUNE 2017: The 2016 Program Year – Report Version TRM will be filed with the PY 2016 Plan Year Reports

The 2016 Program Year – Report Version TRM, including any updates relative to the Program Plan version, will be filed with the PAs' Plan Year Reports. Updates from the Plan Version may include new evaluation results or changes based on working group discussions, and will be clearly identified in the Report Version

Measure Characterization Structure

This section describes the common entries or inputs that make up each measure characterization. A formatted template follows the descriptions of each section of the measure characterization.

Source citations: The source of each assumption or default parameter value should be properly referenced in a footnote. New source citations should be added to Appendix D: Table of Referenced Documents, which serves as a cross-reference to digital versions of the referenced documents.

Measure Name

A single device or behavior may be analyzed as a range of measures depending on a variety of factors which largely translate to where it is and who is using it. Such factors include hours of use, location, and baseline (equipment replaced or behavior modified). For example, the same screw-in compact fluorescent lamp will produce different savings if installed in an emergency room waiting area than if installed in a bedside lamp.

Version Date and Revision History

This section will include information regarding the history of the measure entry including when the data for that measure is effective, and the last date that the measure is offered.

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

This section will include a plain text description of the efficient and baseline technology and the benefit(s) of its installation, as well as subfields of supporting information including:

Description: <Description of the energy efficiency measure>
Primary Energy Impact: < Natural Gas, Propane, Oil, Electric >
Secondary Energy Impact: <e.g., Natural Gas, Propane, Oil, Electric, None>
Non-Energy Impact: <e.g., Water Resource, O&M, Non-Resource, None>
Sector: <Residential, Low Income or Commercial and Industrial>
Market: <Lost Opportunity, Retrofit and/or Products and Services>
End-Use: <Per ISO-NE efficiency reporting tool – see list below>
Core Initiative: <Per PA definition>

End-Uses:

Lighting	Compressed Air	Energy Star Homes
HVAC	Behavior	Home Energy Services
Motors /Drives	Envelope	Process
Refrigeration	Custom Measures	Food Service
Hot Water		

Notes

This is an optional section for additional notes regarding anticipated changes going forward. For example, this section would not if there were upcoming statewide evaluations affecting the measure, or any plans for development of statewide tool for calculating measure savings.

Algorithms for Calculating Primary Energy Impacts

This section will describe the method for calculating the primary energy savings in appropriate units, i.e., kWh for electric energy savings or MMBtu for natural gas energy savings. The savings algorithm will be provided in a form similar to the following:

$$\Delta kWh = \Delta kW \times Hours$$

Similarly, the method for calculating electric demand savings will be provided in a form similar to the following:

$$\Delta kW = \left(Watts_{BASE} - Watts_{EE}\right)/1000$$

Below the savings algorithms, a table contains the definitions (and, in some cases, default values) of each input in the equation(s). The inputs for a particular measure may vary and will be reflected as such in this table (see example below).

ΔkWh	=	gross annual kWh savings from the measure
ΔkW	=	gross connected kW savings from the measure
Hours	=	average hours of use per year
$Watts_{BASE}$	=	baseline connected kW
$Watts_{EE}$	=	energy efficient connected kW

Baseline Efficiency

This section will include a statement of the assumed equipment/operation efficiency in the absence of program intervention. Multiple baselines will be provided as needed, e.g., for different markets. Baselines may refer to reference tables or may be presented as a table for more complex measures.

High Efficiency

This section will describe the high efficiency case from which the energy and demand savings are determined. The high efficiency case may be based on specific details of the measure installation, minimum requirements for inclusion in the program, or an energy efficiency case based on historical participation. It may refer to tables within the measure characterization or in the appendices or efficiency standards set by organizations such as ENERGY STAR® and the Consortium for Energy Efficiency.

Hours

This section will note operating hours for equipment that is either on or off, or equivalent full load hours for technologies that operate at partial loads, or reduced hours for controls. Reference tables will be used as needed to avoid repetitive entries.

Measure Life

Measure Life includes equipment life and the effects of measure persistence. Equipment life is the number of years that a measure is installed and will operate until failure. Measure persistence takes into account business turnover, early retirement of installed equipment, and other reasons measures might be removed or discontinued.

Secondary Energy Impacts

This section described any secondary energy impacts associated with the energy efficiency measure, including all assumptions and the method of calculation.

Non-Energy Impacts

This section describes any non-energy impacts associated with the energy efficiency measure, including all assumptions and the method of calculation.

Impact Factors for Calculating Adjusted Gross Savings

The section includes a table of impact factor values for adjusting gross savings. Impact factors for calculating net savings (free ridership, spillover and/or net-to-gross ratio) are Appendix B: Net to Gross Impact Factors. Further descriptions of the impacts factors and the sources on which they are based are described below the table.

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}

Abbreviated program names may be used in the above table. The mapping of full program names to abbreviated names is given below.

	Full Core Initiative Name	Abbreviation
Residential-Electric	Residential New Construction	RNC
	Residential Heating & Cooling Equipment	RHVAC
	Residential Multi-Family Retrofit	MF Retrofit
	Residential Home Energy Services	HES
	Residential Behavior/Feedback Program	Behavior/Feedback
	Residential Lighting	Res Lighting
	Residential Consumer Products	Res Products
Low Income-Electric	Low-Income Single Family Retrofit	LI Retrofit 1-4
	Low-Income Multi-Family Retrofit	LI MF Retrofit
C&I – Electric	C&I New Buildings & Major Renovations	NB
	C&I Initial Purchase & End of Useful Life	EUL
	C&I Existing Building Retrofit	Large Retrofit
	C&I Multifamily Retrofit	C&I MF Retrofit
	C&I Upstream Lighting	Upstream
	C&I Small Business	Small Retrofit
Residential – Gas	Residential New Construction	RNC
	Residential Heating & Cooling Equipment	RHVAC
	Residential Home Energy Services	HES
	Residential Multi-Family Retrofit	MF Retrofit
	Residential Behavior/Feedback	Behavior/Feedback
Low Income – Gas	Low-Income Single Family Retrofit	LI Retrofit 1-4
	Low-Income Multi-Family Retrofit	LI MF Retrofit
C&I - Gas	C&I New Buildings & Major Renovations	NB
	C&I Initial Purchase & End of Useful Life	EUL
	C&I Existing Building Retrofit	Large Retrofit
	C&I Multifamily Retrofit	C&I MF Retrofit
	C&I Small Business	Small Retrofit

Impact Factors for Calculating Adjusted Gross and Net Savings

PAs use the algorithms in the Measure Characterization sections to calculate the gross savings for energy efficiency measures. Impact factors are then applied to make various adjustments to the gross savings estimate to account for the performance of individual measures or energy efficiency programs as a whole in achieving energy reductions as assessed through evaluation studies. Impacts factors address both the technical performance of energy efficiency measures and programs, accounting for the measured energy and demand reductions realized compared to the gross estimated reductions, as well as the programs' effect on the market for energy efficient products and services.

This section describes the types of impact factors used to make such adjustments, and how those impacts are applies to gross savings estimates. Definitions of the impact factors and other terms are also provided in Appendix F: Glossary.

Types of Impact Factors

The impact factors used to adjust savings fall into one of two categories:

Impact factors used to adjust gross savings:

- In-Service Rate ("ISR")
- Realization Rate ("RR")
- Summer and Winter Peak Demand Coincidence Factors ("CF").

Impact factors used to calculate net savings:

- Free-Ridership ("FR") and Spillover ("SO") Rates
- Net-to-Gross Ratios ("NTG").

The **in-service rate** is the actual portion of efficient units that are installed. For example, efficient lamps may have an in-service rate less than 1.00 since some lamps are purchased as replacement units and are not immediately installed. The ISR is 1.00 for most measures.

The **realization rate** is used to adjust the gross savings (as calculated by the savings algorithms) based on impact evaluation studies. The realization rate is equal to the ratio of measure savings developed from an impact evaluation to the estimated measure savings derived from the savings algorithms. The realization rate does not include the effects of any other impact factors. Depending on the impact evaluation study, there may be separate realization rates for energy (kWh), peak demand (kW), or fossil fuel energy (MMBtu).

A **coincidence factor** adjusts the connected load kW savings derived from the savings algorithm. A coincidence factor represents the fraction of the connected load reduction expected to occur at the same time as a particular system peak period. The coincidence factor includes both coincidence and diversity factors combined into one number, thus there is no need for a separate diversity factor in this TRM.

Coincidence factors are provided for both the on-peak and seasonal peak periods as defined by the ISO New England for the Forward Capacity Market ("FCM"), and are calculated consistently with the FCM methodology. Electric demand reduction during the ISO New England peak periods is defined as follows:

On-Peak Definition:

- Summer On-Peak: average demand reduction from 1:00-5:00 PM on non-holiday weekdays in June July, and August
- Winter On-Peak: average demand reduction from 5:00-7:00 PM on non-holiday weekdays in December and January

Seasonal Peak Definition:

- Summer Seasonal Peak: demand reduction when the real-time system hourly load is equal to or greater than 90% of the most recent "50/50" system peak forecast for June-August
- Winter Seasonal Peak: demand reduction when the real-time system hourly load is equal to or greater than 90% of the most recent "50/50" system peak load forecast for December-January.

The values described as Coincidence Factors in the TRM are not always consistent with the strict definition of a Coincidence Factor (CF). It would be more accurate to define the Coincidence Factor as "the value that is multiplied by the Gross kW value to calculate the average kW reduction coincident with the peak periods." A coincidence factor of 1.00 may be used because the coincidence is already included in the estimate of Gross kW; this is often the case when the "Max kW Reduction" is not calculated and instead the "Gross kW" is estimated using the annual kWh reduction estimate and a loadshape model.

A **free-rider** is a customer who participates in an energy efficiency program (and gets an incentive) but who would have installed some or all of the same measure(s) on their own, with no change in timing of the installation, if the program had not been available. The **free-ridership rate** is the percentage of savings attributable to participants who would have installed the measures in the absence of program intervention.

The **spillover rate** is the percentage of savings attributable to a measure or program, but additional to the gross (tracked) savings of a program. Spillover includes the effects of 1) participants in the program who install additional energy efficient measures outside of the program as a result of participating in the program, and 2) non-participants who install or influence the installation of energy efficient measures as a result of being aware of the program. These two components are the **participant spillover** (SO_P) and **non-participant spillover** (SO_{NP}).

The **net savings** value is the final value of savings that is attributable to a measure or program. Net savings differs from gross savings because it includes the effects of the free-ridership and/or spillover rates.

The **net-to-gross** ratio is the ratio of net savings to the gross savings adjusted by any impact factors (i.e., the "adjusted" gross savings). Depending on the evaluation study, the NTG ratio may be determined from the free-ridership and spillover rates, if available, or it may be a distinct value with no separate specification of FR and SO values.

Standard Net–to–Gross Formulas

The TRM measure entries provide algorithms for calculating the gross savings for those efficiency measures. The following standard formulas show how the impact factors are applied to calculate the adjusted gross savings, which in turn are used to calculate the net savings. These are the calculations used by the PAs to track and report gross and net savings. The gross savings reported by the PAs are the unadjusted gross savings without the application of any impact factors.

Calculation of Net Annual Electric Energy Savings

$$adj\_gross\_kWh = gross\_kWh \times RR_E \times ISR$$
$$net\_kWh = adj\_gross\_kWh \times NTG$$

Calculation of Net Summer Electric Peak Demand Coincident kW Savings

$$adj\_gross\_kW_{SP} = gross\_kW \times RR_{SP} \times ISR \times CF_{SP}$$
$$net\_kW_{SP} = adj\_gross\_kW_{SP} \times NTG$$

Calculation of Net Winter Electric Peak Demand Coincident kW Savings

$$adj\_gross\_kW_{WP} = gross\_kW \times RR_{WP} \times ISR \times CF_{WP}$$
$$net\_kW_{WP} = adj\_gross\_kW_{WP} \times NTG$$

Calculation of Net Annual Natural Gas Energy Savings

$$adj\_gross\_MMBtu = gross\_MMBtu \times RR_E \times ISR$$
$$net\_MMbtu = adj\_gross\_MMBtu \times NTG$$

Depending on the evaluation study methodology:

- NTG is equal to $(1 – FR + SO_P + SO_{NP})$, or
- NTG is a single value with no distinction of FR, SO_P, SO_{NP}, and/or other factors that cannot be reliably isolated.

Where:

Gross_kWh	=	Gross Annual kWh Savings
adj_gross_kWh	=	Adjusted Gross Annual kWh Savings
net_kWh	=	Net Annual kWh Savings
$Gross\_kW_{SP}$	=	Gross Connected kW Savings (summer peak)
$adj\_gross\_kW_{SP}$	=	Adjusted Gross Connected kW Savings (summer peak)
$Gross\_kW_{WP}$	=	Gross Connected kW Savings (winter peak)
$adj\_gross\_kW_{WP}$	=	Adjusted Gross Connected kW Savings (summer peak)
net_kW_{SP}	=	Adjusted Gross Connected kW Savings (winter peak)
net_kW_{WP}	=	Net Coincident kW Savings (winter peak)
Gross_MMBtu	=	Gross Annual MMBtu Savings
adj_gross_MMBtu	=	Adjusted Gross Annual MMBtu Savings
net_MMBtu	=	Net Annual MMBtu Savings
ISR	=	In-Service Rate
CF_{SP}	=	Peak Coincidence Factor (summer peak)
CF_{WP}	=	Peak Coincidence Factor (winter peak)
RR_E	=	Realization Rate for energy (kWh, MMBtu)
RR_{SP}	=	Realization Rate for summer peak kW
RR_{WP}	=	Realization Rate for winter peak kW

NTG	=	Net-to-Gross Ratio
FR	=	Free-Ridership Factor
SO_P	=	Participant Spillover Factor
SO_{NP}	=	Non-Participant Spillover Factor

Calculations of Coincident Peak Demand kW Using "Seasonal Peak" Coincidence Factors

The formulas above for peak demand kW savings use the "on-peak" coincidence factors (CF_{SP}, CF_{WP}), which apply the "on-peak" coincidence methodology as allowed for submission to the FCM. The alternative methodology is the "seasonal peak" methodology, which uses the identical formulas, but substituting the "seasonal peak" coincidence factors for the "on-peak" coincidence factors:

CF_{SSP}	=	Peak Coincidence Factor for Summer Seasonal Peak
CF_{WSP}	=	Peak Coincidence Factor for Winter Seasonal Peak

Residential Efficiency Measures

Appliances – Clothes Dryer

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Clothes Dryers exceeding minimum qualifying efficiency standards established as ENERGY STAR with drum moisture sensors and associated moisture sensing controls achieve greater energy savings over clothes dryers that do not have moisture sensors.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: Process
Measure Type: Clothes Dryers
Core Initiative: Electric - Residential Consumer Products

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms and assumptions:

Annual kWh Savings = Annual kWh usage baseline – Annual kWh usage Energy Star
*Annual kWh usage baseline= (lbs/load) / Baseline CEF * loads/yr*
*Annual kWh usage ENERGY STAR= (lbs/load) / ENERGY STAR CEF * loads/yr*

Where:
Baseline Combined Energy Factor (CEF) (lbs/kWh) = 3.11[2]
ENERGY STAR CEF = 3.93[3]
Lbs/load = 8.45[4]
Loads/Year = 283[5]

Energy Star Dryer Savings

Measure Name	Core Initiative	ΔkWh	ΔkW[6]
Dryer (Energy Star)	Res Products	160	0.02

[2] DOE (2015). 10 CFR Part 431 March 27, 2015. *Energy Conservation Program: Energy Conservation Standards for Residential Clothes Dryers*. Table II.7. http://www.gpo.gov/fdsys/pkg/FR-2015-03-27/pdf/2015-07058.pdf
[3] Ibid.
[4] DOE (2013). 10 CFR Parts 429 and 430 August 14, 2013. *Energy Conservation Program: Test Procedures for Residential Clothes Dryers; Final Rule.* Table 11.1. http://www.gpo.gov/fdsys/pkg/FR-2013-08-14/pdf/2013-18931.pdf
[5] Ibid.
[6] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Baseline Efficiency

The baseline efficiency case is a new electric resistance dryer that meets the federal standard as of January 1, 2015 which is an Energy Factor (EF) of 3.73 for a vented standard dryer. Different testing procedures were used in setting the federal standard (DOE Test Procedure Appendix D1) and the Energy Star standard (DOE Test Procedure Appendix D2). To enable comparison a baseline CEF of 3.11 is used. This was derived from ENERGY STAR Version 1.0 Estimated Baseline which multiplies the 2015 federal standard by the average change in electric dryers' assessed CEF between Appendix D1 and Appendix D2: 3.73-(3.73*0.166).

High Efficiency

The high efficiency case is a new electric resistance dryer that meets the Energy Star standard as of January 1, 2015. The ENERGY STAR CEF (Combined Energy Factor) is 3.93. .

Measure Life

The measure life is 12 years.[7]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Dryer (Energy Star)	Res Products	All	1.00	1.00	1.00	1.00	1.00	0.90

In-Service Rates
In-service rates are set to 100% based on the assumption that all purchased units are installed.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[8]

[7] MA Common Assumptions
[8] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

Appliances – Early Retirement Clothes Washers

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The replacement and recycling of a working top-loading clothes washer with an agitator with an Energy Star rated front-loading washing machine.
Primary Energy Impact: Electric
Secondary Energy Impact: Oil, Propane, Gas
Non-Energy Impact:
Sector: Residential
Market: Retrofit
End Use: Process, Hot Water
Measure Type: Clothes Washers
Core Initiative: Electric – Residential Home Energy Services, Gas – Residential Home Energy Services

Notes

Collectively the MA PAs decided that the gas PAs will claim all the gas savings while the electric PAs claim all the other savings.

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms and assumptions:

*ΔkWh = [(Capacity * 1/IMEFbase * Ncycles) * (%CWkwhbase + %DHWkwhbase + %Dryerkwhbase)] - [(Capacity * 1/IMEFeff * Ncycles) * (%CWkwheff + %DHWkwheff + %Dryerkwheff)]*

*ΔMMBTUs = [(Capacity * 1/MEFbase * Ncycles) * ((%DHWffbase *r_eff) + %Dryerffbase] - [(Capacity * 1/MEFeff * Ncycles) * (%DHWffeff * r_eff) + %Dryergaseff]*MMBTU_convert*

Where:

Capacity	=	washer volume in ft^3. Existing top loading washer is 3.09 ft^3, new standard efficiency top loading washer is 3.38 ft^3, ENERGY STAR front loading is 3.90 ft^3
IMEF	=	Integrated Modified Energy Factor and is measured in ft^3/kWh/cycle
Ncycles	=	283 loads per year[9]
%CWkwh	=	% of total kWh energy consumption for clothes washer operation (different for baseline and efficient unit). See table below
%DHWkwh	=	% of total kWh energy consumption used for water heating (different for baseline and efficient unit). See table below. If water is heated by gas or propane this is 0%

[9] Department of Energy 10 CFR Parts 429 and 430 August 14, 2013. *Energy Conservation Program: Test Procedures for Residential Clothes Dryers; Final Rule.* Table 11.1. http://www.gpo.gov/fdsys/pkg/FR-2013-08-14/pdf/2013-18931.pdf

%Dryerkwh = % of total kWh energy consumption for dryer operation (different for baseline and efficient unit). See table below. If the dryer is gas this is 0%

%DHWff = % of total fossil fuel energy consumption used for water heating (different for baseline and efficient unit). See table below. If water is heated by electric this is 0%.

%Dryerff = % of total fossil fuel energy consumption for dryer operation (different for baseline and efficient unit). See table below. If the dryer is electric this is 0%.

r_eff = recovery energy factor used to account for the difference in recovery efficiencies of electric and gas/oil/propane hot water heaters. Electric water heaters are 100% efficient while other water heaters are 75% efficient. The ratio is 1.33 (100%/75%)

MMBTU_convert = Conversion factor from kWh to MMBTU is 0.003412

Efficiency Ratings and Percentage of Total Energy Consumption[10]

	% Energy used for			IMEF	IWF	Volume
	Washer operation	Water heating	Drying	ft^3/kWh/ cycle	gallons/ cycle/ft^3	ft^3
Existing-Top Loading CW	8%	34%	59%	0.84	9.92	3.09
New-Federal Standard Top Loading CW	5%	37%	58%	1.29	8.44	3.38
New-Energy Star Front Loading CW	8%	20%	72%	2.38	3.70	3.90

Savings from Early Retirement of Clothes Washers

Measure Name	Energy Type	ΔkWh	ΔkW	Δ MMBtu
Early Retirement CW (Retire) Elec DHW & Elec Dryer	Electric	302	0.05	0
Early Retirement CW (EE) Elec DHW & Elec Dryer	Electric	275	0.04	0
Early Retirement CW (Retire) Gas DHW & Elec Dryer	Electric/Gas	224	0.03	0.35
Early Retirement CW (EE) Gas DHW & Elec Dryer	Electric/Gas	94	0.01	0.82
Early Retirement CW (Retire) Elec DHW & Gas Dryer	Electric/Gas	118	0.02	0.63
Early Retirement CW (EE) Elec DHW & Gas Dryer	Electric/Gas	180	0.03	0.32
Early Retirement CW (Retire) Gas DHW & Gas Dryer	Electric/Gas	41	0.01	0.98
Early Retirement CW (EE) Gas DHW & Gas Dryer	Electric/Gas	-0.1	0.00	1.14
Early Retirement CW (Retire) Oil DHW & Elec Dryer	Electric/Oil	224	0.03	0.35
Early Retirement CW (EE) Oil DHW & Elec Dryer	Electric/Oil	94	0.01	0.82
Early Retirement CW (Retire) Propane DHW & Elec Dryer	Electric/Propane	224	0.03	0.35
Early Retirement CW (EE) Propane DHW & Elec Dryer	Electric/Propane	94	0.01	0.82

Baseline Efficiency

It is assumed that the existing top loading clothes washer met the 2007 federal standard which was an MEF[11] > 1.262 and WF[12] < 9.53. This is equivalent to an IMEF of 0.84 and IWH[13] of 9.92. A new standard efficiency clothes washer meets the federal standard for top loading washers effective 3/7/2015 which requires an IMEF> 1.29 and an IWF < 8.4.

[10] DOE (2012). Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Clothes Washers. http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0019-0047 Chapter 7. Energy and Water Use Determination (corrected)

[11] MEF is Modified Energy Factor and is measured in ft^3/kWh/cycle

[12] WF is Water Factor and is measured in gallons/cycle/ft^3

[13] IWF is Integrated Water Factor and is measured in gallons/cycle/ft^3

High Efficiency

The new high efficiency washer is a front loading Energy Star rated washer with a minimum IMEF > 2.38 and IWF < 3.7.

Measure Life

The effective useful life of the new clothes washer is assumed to be 12 years. The remaining useful life of the existing clothes washer is assumed to be 1/3 of the effective useful life which is 4 years.

Secondary Energy Impacts

Secondary energy impacts are described in the same section as primary energy impacts.

Non-Energy Impacts

ΔWater (gallons) = (Capacity * (IWFbase - IWFeff)) * Ncycles

Where:
Capacity = washer volume in ft^3
IWF = IWF is Integrated Water Factor and is measured in gallons/cycle/ft^3
Ncycles = 283 loads per year[14]

Benefit Type	Description	Savings
Residential Water	Early Retirement CW (Retire) Water Savings	603 Gallons/Unit
Residential Water	Early Retirement CW (EE) Water Savings	3,984 Gallons/Unit

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Early Retirement CW (Retire) Elec DHW & Elec Dryer	HES	All	1.00	1.00	1.00	1.00	1.00	0.90
Early Retirement CW (EE) Elec DHW & Elec Dryer	HES	All	1.00	1.00	1.00	1.00	1.00	0.90
Early Retirement CW (Retire) Gas DHW & Elec Dryer	HES	All	1.00	1.00	1.00	1.00	1.00	0.90
Early Retirement CW (EE) Gas DHW & Elec Dryer	HES	All	1.00	1.00	1.00	1.00	1.00	0.90
Early Retirement CW (Retire) Elec DHW & Gas Dryer	HES	All	1.00	1.00	1.00	1.00	1.00	0.90
Early Retirement CW (EE) Elec DHW & Gas Dryer	HES	All	1.00	1.00	1.00	1.00	1.00	0.90
Early Retirement CW (Retire) Gas DHW & Gas Dryer	HES	All	1.00	1.00	1.00	1.00	1.00	0.90
Early Retirement CW (EE) Gas DHW & Gas Dryer	HES	All	1.00	1.00	1.00	1.00	1.00	0.90

[14] DOE (2013). 10 CFR Parts 429 and 430 August 14, 2013. *Energy Conservation Program: Test Procedures for Residential Clothes Dryers; Final Rule.* Table 11.1. http://www.gpo.gov/fdsys/pkg/FR-2013-08-14/pdf/2013-18931.pdf

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Early Retirement CW (Retire) Oil DHW & Elec Dryer	HES	All	1.00	1.00	1.00	1.00	1.00	0.90
Early Retirement CW (EE) Oil DHW & Elec Dryer	HES	All	1.00	1.00	1.00	1.00	1.00	0.90
Early Retirement CW (Retire) Propane DHW & Elec Dryer	HES	All	1.00	1.00	1.00	1.00	1.00	0.90
Early Retirement CW (EE) Propane DHW & Elec Dryer	HES	All	1.00	1.00	1.00	1.00	1.00	0.90

In-Service Rates
In-service rates are set to 100% based on the assumption that all purchased units are installed.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[15]

[15] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

Appliances – Refrigerator (Lost Opportunity)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Rebates for purchase of ENERGY STAR® Most Efficient qualified refrigerators. The ENERGY STAR Most Efficient designation recognizes the most efficient products among those that qualify for the ENERGY STAR program.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: Process
Measure Type: Refrigerators
Core Initiative: Electric - Residential Consumer Products

Algorithms for Calculating Primary Energy Impact

Unit savings are based on the following algorithm which uses averaged inputs based on data published by the EPA[16]:

$$\Delta kWh = \Delta kWh_{BASE} - \Delta kWh_{ES}$$

Where:
Unit = Installed ENERGY STAR® Most Efficient refrigerator
ΔkWh_{BASE} = Average usage of a new refrigerator meeting federal standards, by model type
ΔkWh_{ES} = Average usage of a new refrigerator meeting ENERGY STAR® Most Efficient standards , by model type

Savings for Refrigerators

Tier	ΔkWh[17]	ΔkW[18]
Refrigerator (Most Efficient)	118	0.01

Baseline Efficiency

The baseline efficiency case is a residential refrigerator that meets the federal minimum standard for energy efficiency.

[16] https://data.energystar.gov/Active-Specifications/ENERGY-STAR-Most-Efficient-Residential-Refrigerato/hgxv-ux9b
[17] Apex Analytics (2015). 2015 Refrigerator Savings Modeling.xls.
[18] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

High Efficiency

The high efficiency case is an ENERGY STAR® Most Efficient residential refrigerator.

Hours

Not applicable.

Measure Life

The measure life is 12 years.[19]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigerator Rebate	Res Products	All	1.00	1.00	1.00	1.00	1.00	0.93

In-Service Rates
In-service rates are set to 100% based on the assumption that all purchased units are installed.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[20]

[19] Environmental Protection Agency (2014). *Savings Calculator for Energy Star Qualified Appliances.* http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
[20] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

Appliances – Refrigerator (Retrofit)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: This measure covers the replacement of an existing inefficient refrigerator with a new ENERGY STAR® rated refrigerator. ENERGY STAR certified refrigerators are 9 percent more energy efficient than models that meet the federal minimum standard for energy efficiency.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Retrofit
End Use: Process
Measure Type: Refrigerators
Core Initiative: Electric - Residential Home Energy Services

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms and averaged inputs:

$$\Delta kWh = \Delta kWh_{RETIRE} + \Delta kWh_{EE}$$
$$\Delta kW = \Delta kW_{RETIRE} + \Delta kW_{EE}$$

Where:

Unit	=	Replacement of existing refrigerator with new ENERGY STAR® Refrigerator
ΔkWh_{RETIRE}	=	Annual energy savings over remaining life of existing equipment: 661 kWh[21]
ΔkWh_{EE}	=	Annual energy savings over full life of new ES refrigerator: 53 kWh[22]
ΔkW_{RETIRE}	=	Average demand reduction over remaining life of existing equipment: 0.082 kW[23]
ΔkW_{EE}	=	Average demand reduction over full life of new ES refrigerator: 0.007 kW[24]

[21] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts. 714 kWh minus 53 kWh = 661 kWh
[22] Apex Analytics (2015). 2015 Refrigerator Savings Modeling.xls. Using data published by the EPA. https://www.energystar.gov/productfinder/product/certified-residential-refrigerators/results
[23] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[24] Ibid.

Savings for Refrigerators

Tier	ΔkWh	ΔkW[25]
Refrigerator (Savings Over Remaining Life)	661	0.08
Refrigerator (Savings Compared to Baseline)	53	0.01

Baseline Efficiency

The baseline efficiency case is an existing refrigerator for savings over the remaining life of existing equipment. The baseline efficiency case is a full-sized refrigerator that meets the federal minimum standard for energy efficiency for savings for the full life.[26]

High Efficiency

The high efficiency case is an ENERGY STAR® rated refrigerator that meets the ENERGY STAR® criteria for full-sized refrigerators, using at least 9% less energy than models meeting the minimum federal government standard.

Hours

Savings are based on 8,760 operating hours per year.

Measure Life

The effective useful life of the new refrigerator is 12 years. [27] The remaining useful life of the existing refrigerator is estimated to be 4 years[28].

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigerator	HES	All	1.00	1.00	1.00	1.00	1.00	0.93

In-Service Rates
In-service rates are 100% as it is assumed all refrigerators are in-use.

[25] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[26] Apex Analytics (2015). 2015 Refrigerator Savings Modeling.xls. Using data published by the EPA. https://www.energystar.gov/productfinder/product/certified-residential-refrigerators/results
[27] Environmental Protection Agency (2014). *Savings Calculator for Energy Star Qualified Appliances.*. http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
[28] MA Common Assumptions: RUL is 1/3 of the EUL

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[29]

[29] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

Appliances – Refrigerator Replacement

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: This measure covers the replacement of an existing inefficient refrigerator with a new refrigerator.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: Process
Measure Type: Refrigerators
Core Initiative: Electric - Low-Income Single Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[30].

Savings for Refrigerator Replacement

Measure	Core Initiative	ΔkWh	ΔkW[31]
Refrigerator Replacement	LI 1-4 Retrofit	762	0.09

Baseline Efficiency

The baseline efficiency case for both the replaced and baseline new refrigerator is an existing refrigerator. It is assumed that low-income customers would otherwise replace their refrigerators with a used inefficient unit.

High Efficiency

The high efficiency case is a new refrigerator.

Hours

Savings are based on 8,760 operating hours per year.

Measure Life

The measure life is 12 years.[32]

[30] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[31] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigerator Replacement	LI Retrofit 1-4	All	1.00	1.00	1.00	1.00	1.00	0.93

In-Service Rates
In-service rates are 100% as it is assumed all refrigerators are in-use.

Realization Rates
Realization rates are set to 100% since deemed savings are based on evaluation results.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[33]

[32] *Savings Calculator for Energy Star Qualified Appliances.* http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
[33] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

Appliances – Refrigerator Replacement

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Removal of old inefficient refrigerator or freezer with the installation of new efficient refrigerator or freezer.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: Process
Measure Type: Refrigerators
Core Initiative: Electric - Low-Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are calculated using the following algorithms and assumptions:

$$\Delta kWh = \left[\left(\left(kWh_{pre} - kWh_{ES}\right) \times \frac{RUL}{EUL}\right) + \left(\left(\frac{kWh_{std} + kWh_{used}}{2} - kWh_{ES}\right) \times \frac{EUL - RUL}{EUL}\right)\right] \times F_{occ}$$

$$\Delta kW = \Delta kWh \times kW / kWh$$

Where:

kWh_{pre}	=	Annual kWh consumption of existing equipment. Value is based on metering or AHAM database. The default value is 874 kWh.
kWh_{ES}	=	Annual kWh consumption of new ENERGY STAR qualified refrigerator or freezer. This is from the nameplate on the new unit. The default value is 358 kWh.
STD		Average annual consumption of equipment meeting federal standard: Calculated by dividing the kWh_{ES} by 0.9 (i.e., the Energy Star units are assumed to be 10% more efficient than the kWh_{std} units). The default value is 398 kWh.
kWh_{used}		Average annual consumption of used equipment. Default value is 475 kWh.[34]
RUL	=	Remaining Useful life assumed to be 6 years
EUL	=	Estimated useful life for a new refrigerator is 12 years[35]
Focc	=	Occupant adjustment factor used to adjust the energy savings according to the number of occupants in the dwelling unit. See table below. Default is 2.3 occupants per tenant unit
ΔkWh	=	330, using the default assumptions

[34] Association of Home Appliance Manufacturers (2014 Revised Feb. 2015), *Technical Support Document: Early Replacement Program*, (Value estimated based on Figure 9 on page 23)
[35] Environmental Protection Agency (2014). *Savings Calculator for Energy Star Qualified Appliances*.

kW/kWh = Average kW reduction per kWh reduction: 0.00013 kW/kWh[36]
ΔkW = 0.042, using the default assumptions

Occupant Adjustment Factor[37]

Number of Occupants	F_{occ}
0 occupants	1.00
1 occupants	1.05
1.8 occupants	1.09
2 occupants	1.10
2.3 occupants	1.11
3 occupants	1.13
4 occupants	1.15
5 occupants	1.16

Baseline Efficiency

The baseline efficiency case is an existing refrigerator for which the annual kWh may be looked up in a refrigerator database. If the manufacturer and model number are not found, the refrigerator is metered for 1.5 hours in order to determine the annual kWh.

High Efficiency

The high efficiency case is a new more efficiency refrigerator. The manufacturer and model number is looked up in a refrigerator database to determine annual kWh.

Measure Life

The measure life is 12 years[38].

Hours

Not applicable.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[36] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators. Loadshape: Res Multi Family Electric Refrigeration (REFRIGERATOR) Normal
[37] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.
[38] Environmental Protection Agency (2014). *Savings Calculator for Energy Star Qualified Appliances.* http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigerator Replacement	LI MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.86

In-Service Rates
All installations have 100% in service rate since all PA programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% since this measure has not been evaluated.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[39]

[39] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Appliances – Refrigerator Replacement

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Removal of old inefficient refrigerator or freezer with the installation of new efficient refrigerator or freezer.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: Process
Measure Type: Refrigerators
Core Initiative: Electric - Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are calculated using the following algorithms and assumptions:

$$\Delta kWh = \left[\left((kWh_{pre} - kWh_{ES})\right) \times \frac{(12-8)}{12} + \left((kWh_{std} - kWh_{ES})\right) \times \frac{8}{12}\right] \times F_{occ}$$

$$\Delta kW = \Delta kWh \times kW / kWh$$

Where:

kWh_{pre}	=	Annual kWh consumption of existing equipment. Value is based on metering or AHAM database
kWh_{std}	=	Annual kWh consumption of a refrigerator meeting federal standards. Calculated by dividing the kWh_{ES} by 0.9 (i.e., the Energy Star units are assumed to be 10% more efficient than the kWh_{std} units).
kWh_{ES}	=	Annual kWh consumption of new Energy Star qualified refrigerator or freezer. This is from the nameplate on the new unit.
Age	=	Age of the existing refrigerator is 8 years
12	=	Measure life for a new refrigerator[40]
Focc	=	Occupant adjustment factor used to adjust the energy savings according to the number of occupants in the dwelling unit. See below.
kW/kWh	=	Average kW reduction per kWh reduction: 0.00013 kW/kWh[41]

[40] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Residential Refrigerator*.
[41] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators. Loadshape: Res Multi Family Electric Refrigeration (REFRIGERATOR) Normal

Occupant Adjustment Factor[42]

Number of Occupants	F_{occ}
0 occupants	1.00
1 occupants	1.05
1.8 occupants	1.09
2 occupants	1.10
3 occupants	1.13
4 occupants	1.15
5 occupants	1.16

Baseline Efficiency

The baseline efficiency case is an existing refrigerator for which the annual kWh may be looked up in a refrigerator database. If the manufacturer and model number are not found, the refrigerator is metered for 1.5 hours in order to determine the annual kWh.

High Efficiency

The high efficiency case is a new more efficiency refrigerator. The manufacture and model number is looked up in a refrigerator database to determine annual kWh.

Measure Life

The measure life is 12 years[43].

Hours

Not applicable.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigerator	MF Retrofit	All	1.00	0.60	0.60	0.60	1.00	0.86

In-Service Rates

[42] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.
[43] Environmental Protection Agency (2014). *Savings Calculator for Energy Star Qualified Appliances.* http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx

All installations have 100% in service rate since all PA programs include verification of equipment installations.

Realization Rates
Realization rates are based on draft evaluation results.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[44]

[44] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Appliances – Freezers (Lost Opportunity)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Rebates provided for the purchase of ENERGY STAR® freezers. ENERGY STAR® qualified freezers use at least 10% less energy than new, non-qualified models and return even greater savings compared to old models.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: Process
Measure Type: Freezers
Core Initiative: Electric - Residential Consumer Products

Algorithms for Calculating Primary Energy Impact

Unit savings are based on the following algorithms which use averaged inputs based on data published by the EPA[45]:

$$\Delta kWh = \Delta kWh_{BASE} - \Delta kWh_{ES}$$

Where:
Unit = Installed ENERGY STAR® freezer
kWh_{BASE} = Average usage of a new freezer meeting federal standards
kWh_{ES} = Average usage of a new freezer meeting ENERGY STAR® standards

Savings for Freezers

Measure Name	ΔkWh[46]	ΔkW[47]
Freezer (Energy Star)	43.7	0.01

Baseline Efficiency

The baseline efficiency case is a residential freezer that meets the Federal minimum standard for energy efficiency.

[45] http://www.energystar.gov/productfinder/product/certified-residential-freezers/results
[46] Ibid.
[47] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

High Efficiency

The high efficiency case is based on an ENERGY STAR® rated freezer that uses 10% less energy than models not labeled with the ENERGY STAR® logo.

Hours

Not applicable.

Measure Life

The measure life is 12 years.[48]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Freezer (Energy Star)	Res Products	All	1.00	1.00	1.00	1.00	1.00	0. 93

In-Service Rates
In-service rates are set to 100% based on the assumption that all purchased units are installed.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[49]

[48] Environmental Protection Agency (2014) *Savings Calculator for Energy Star Qualified Appliances.* http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
[49] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

Appliances – Freezer Replacement

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: This measure covers the replacement of an existing inefficient freezer with a new energy efficient model.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: Process
Measure Type: Freezers
Core Initiative: Electric - Low-Income Single Family Retrofit, Electric - Low-Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[50].

Savings for Freezer Replacement

Measure Name	Core Initiative	ΔkWh	ΔkW[51]
Freezer Replacement	LI 1-4 Retrofit	239	0.03
Freezer Replacement	LI MF Retrofit	158	0.02

Baseline Efficiency

The baseline efficiency case for both the replaced and baseline new freezer is represented by the existing freezer. It is assumed that low-income customers would replace their freezers with a used inefficient unit.

High Efficiency

The high efficiency case is a new high efficiency freezer.

Hours

Not applicable.

[50] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[51] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Measure Life

The measure life is 12 years[52]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Freezer Replacement	LI Retrofit 1-4	All	1.00	1.00	1.00	1.00	1.00	0.93
Freezer Replacement	LI MF Retrofit	Eversource (NSTAR), Eversource (WMECO), CLC, Unitil	1.00	1.00	1.00	1.00	1.00	0.73

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% since deemed savings are based on evaluation results.

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[53]

[52] Environmental Protection Agency (2014). *Savings Calculator for Energy Star Qualified Appliances.* http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
[53] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

Appliances – Refrigerator/Freezer Recycling

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The retirement of old, inefficient secondary refrigerators and freezers. Refrigerator Recycling (Primary) - Participants who retired and replaced a primary refrigerator; Refrigerator Recycling (Secondary Replaced)- Participants who retired and replaced a secondary refrigerator; Refrigerator Recycling (Secondary Not Replaced)- Participants who retired, but did not replace, a secondary refrigerator; Refrigerator Recycling (Combined) – combination of secondary replaced and secondary not replaced

Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: Process
Measure Type: Recycling
Core Initiative: Electric - Residential Consumer Products

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed and are obtained from the referenced study[54].

Savings for Refrigerator/Freezer Recycling

Measure Name	Core Initiative	ΔkWh	ΔkW[55]
Refrigerator Recycling (Primary)	Res Products	533	0.07
Refrigerator Recycling (Secondary Replaced)	Res Products	696	0.09
Refrigerator Recycling (Secondary Not Replaced)	Res Products	835	0.10
Refrigerator Recycling (Combined)	Res Products	755	0.09
Freezer Recycling	Res Products	663	0.08

Baseline Efficiency

The baseline efficiency case is an old, inefficient secondary working refrigerator or freezer. Estimated average usage is based on combined weight of freezer energy use and refrigerator energy use.

High Efficiency

The high efficiency case assumes no replacement of secondary unit.

[54] NMR Group, Inc. (2011). Massachusetts Appliance Turn-In Program Evaluation Integrated Report Findings – FINAL. Prepared for National Grid, Eversource (NSTAR) Electric, Cape Light Compact, and Western Massachusetts Electric Company.
[55] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Hours

Refrigerator and freezer operating hours are 8,760 hours/year.

Measure Life

The measure life is 8 years.[56]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigerator Recycling (Primary)	Res Products	All	1.00	1.00	1.00	1.00	1.00	0.93
Refrigerator Recycling (Secondary Replaced)	Res Products	All	1.00	1.00	1.00	1.00	1.00	0.93
Refrigerator Recycling (Secondary Not Replaced)	Res Products	All	1.00	1.00	1.00	1.00	1.00	0.93
Refrigerator Recycling (Combined)	Res Products	All	1.00	1.00	1.00	1.00	1.00	0.93
Freezer Recycling	Res Products	All	1.00	1.00	1.00	1.00	1.00	0.93

In-Service Rates
All installations have 100% in service rate.

Realization Rates
Realization rates are set to 100% since deemed savings are based on evaluation results.

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[57]

[56] NMR Group, Inc. (2011). Massachusetts Appliance Turn-In Program Evaluation Integrated Report Findings – FINAL. Prepared for National Grid, Eversource (NSTAR) Electric, Cape Light Compact, and Western Massachusetts Electric Company.
[57] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

Appliances – Appliance Removal

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Removal of second working refrigerator or freezer.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: Process
Measure Type: Recycling
Core Initiative: Electric - Low-Income Single Family Retrofit, Low-Income Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[58].

Measure Name	ΔkWh	ΔkW[59]
Appliance Removal	874	0.11

Baseline Efficiency

The baseline efficiency case is the old, inefficient secondary working refrigerator or freezer.

High Efficiency

The high efficiency case assumes no replacement of secondary unit.

Hours

Not applicable.

Measure Life

The measure life is 5 years.[60]

[58] The Cadmus Group, Inc. (2015). Massachusetts *Low-Income Multifamily Initiative Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[59] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[60] Massachusetts Common Assumption.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Appliance Removal	LI Retrofit 1-4	All	1.00	1.00	1.00	1.00	1.00	0.93
Appliance Removal	LI MF Retrofit	CLC	1.00	1.00	1.00	1.00	1.00	0.93

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% since deemed savings are based on evaluation results.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described the Cadmus Demand Impact Model.[61]

[61] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

Building Shell – Weatherization

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of weatherization measures such as air sealing and insulation
Primary Energy Impact: Electric, Oil, Propane, Natural Gas (Residential Heat)
Secondary Energy Impact: Electric
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: Envelope
Measure Type: Insulation & Air Sealing
Core Initiative: Electric - Low-Income Single Family Retrofit, Gas - Low-Income Single Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are per home and deemed based on study results[62].

Measure Name	Core Initiative	PA Type	Energy Type	ΔkWh	ΔkW[63]	ΔMMBtu
Weatherization, Electric	LI 1-4 Retrofit	Elec	Electric	1,616	0.86	
Weatherization, Oil	LI 1-4 Retrofit	Elec	Oil			28.1
Weatherization, Other	LI 1-4 Retrofit	Elec	Propane			26.3
Weatherization	LI 1-4 Retrofit	Gas	Gas			26.3
Air Sealing, Electric	LI 1-4 Retrofit	Elec	Electric	501	0.27	
Air Sealing, Oil	LI 1-4 Retrofit	Elec	Oil			9.9
Air Sealing, Other	LI 1-4 Retrofit	Elec	Propane			10.5
Air Sealing	LI 1-4 Retrofit	Gas	Gas			10.5
Insulation, Electric	LI 1-4 Retrofit	Elec	Electric	1,115	0.60	
Insulation, Oil	LI 1-4 Retrofit	Elec	Oil			18.2
Insulation, Other	LI 1-4 Retrofit	Elec	Propane			15.8
Insulation	LI 1-4 Retrofit	Gas	Gas			15.8

Baseline Efficiency

The baseline efficiency case is any existing home shell measures.

[62] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[63] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

High Efficiency

The high efficiency case includes the installation of weatherization measures (air sealing & insulation).

Hours

Not applicable.

Measure Life

For the combined weatherization measure the measure life is 20 years.[64] For insulation the measure life is 25 years and for air sealing the measure life is 15 years.

Secondary Energy Impacts

Electric savings are achieved from reduced fan run time for heating and from reduced cooling.

Measure	Core Initiative	PA Type	ΔkWh[65]	ΔkW[66]
Weatherization, Oil	LI 1-4 Retrofit	Elec	377	0.30
Weatherization, Other	LI 1-4 Retrofit	Elec	344	0.31
Weatherization	LI 1-4 Retrofit	Gas	344	0.31

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[64] Massachusetts Common Assumption.
[65] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[66] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA Type	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Weatherization, Electric	LI 1-4 Retrofit	Elec	1.00	1.00	1.00	1.00	0.00	1.00
Weatherization, Oil	LI 1-4 Retrofit	Elec	1.00	1.00	1.00	1.00	1.00	0.44
Weatherization, Other	LI 1-4 Retrofit	Elec	1.00	1.00	1.00	1.00	1.00	0.44
Weatherization	LI 1-4 Retrofit	Gas	1.00	1.00	1.00	1.00	1.00	0.44
Air Sealing, Electric	LI 1-4 Retrofit	Elec	1.00	1.00	1.00	1.00	0.00	1.00
Air Sealing, Oil	LI 1-4 Retrofit	Elec	1.00	1.00	1.00	1.00	1.00	0.00
Air Sealing, Other	LI 1-4 Retrofit	Elec	1.00	1.00	1.00	1.00	1.00	0.00
Air Sealing	LI 1-4 Retrofit	Gas	1.00	1.00	1.00	1.00	1.00	0.00
Insulation, Electric	LI 1-4 Retrofit	Elec	1.00	1.00	1.00	1.00	0.00	1.00
Insulation, Oil	LI 1-4 Retrofit	Elec	1.00	1.00	1.00	1.00	1.00	0.44
Insulation, Other	LI 1-4 Retrofit	Elec	1.00	1.00	1.00	1.00	1.00	0.44
Insulation	LI 1-4 Retrofit	Gas	1.00	1.00	1.00	1.00	1.00	0.44

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% since deemed savings are based on evaluation results.

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[67]

[67] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

Building Shell – Air Sealing

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Air sealing installed through the Home Energy Services (MassSAVE) program. Air sealing will decrease the infiltration of outside air through cracks and leaks in the home
Primary Energy Impact: Electric, Oil, Propane, Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: Envelope
Measure Type: Air Sealing
Core Initiative: Electric - Residential Home Energy Services, Gas - Residential Home Energy Services

Algorithms for Calculating Primary Energy Impact

The Program Administrators currently use vendor calculated energy savings for these measures in the Residential Home Energy Services electric program. These savings values are calculated using vendor proprietary software where the user inputs a minimum set of technical data about the house and the software calculates building heating and cooling loads and other key parameters. The proprietary building model is based on thermal transfer, building gains, and a variable-based heating/cooling degree day/hour climate model. This provides an initial estimate of energy use that may be compared with actual billing data to adjust as needed for existing conditions. Then, specific recommendations for improvements are added and savings are calculated using measure-specific heat transfer algorithms.

Rather than using a fixed degree day approach, the building model estimates both heating degree days and cooling degree hours based on the actual characteristics and location of the house to determine the heating and cooling balance point temperatures. Savings from shell measures use standard U-value, area, and degree day algorithms. Infiltration savings use site-specific seasonal N-factors to convert measured leakage to seasonal energy impacts. HVAC savings are estimated based on changes in system and/or distribution efficiency improvements, using ASHRAE 152 as their basis. Lighting, appliance, and water heating savings are based on standard algorithms, taking into account operating conditions and pre- and post-retrofit energy consumption. Interactivity between architectural and mechanical measures is always included, to avoid overestimating savings due to incorrectly “adding” individual measure results.

The PAs calculate demand (kW) savings by applying a kW/kWh factor to the vendor-estimated electric energy savings. The kW/kWh factors are provided in the table below.

kW Factors for HES Vendor Measures

Measure	kW/kWh Factor[68]
Air Sealing (Electric)	0.00053
Air Sealing (Gas, Oil, Propane)	0.00222

Baseline Efficiency

The baseline efficiency case is the existing conditions of the participating household.

High Efficiency

The high efficiency case is a home that has air sealing performed.

Hours

Hours are project-specific.

Measure Life

The measure life is 15 years.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[68] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators. For electric measures the heating loadshape was used for non-electric the central AC loadshape was used.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA Type	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Air Sealing, Electric	HES	Elec	CLC	1.00	0.51	0.51	0.51	0.0	1.00
Air Sealing, Electric	HES	Elec	National Grid	1.00	0.60	0.60	0.60	0.0	1.00
Air Sealing, Electric	HES	Elec	Eversource (NSTAR)	1.00	0.54	0.54	0.54	0.0	1.00
Air Sealing, Electric	HES	Elec	Unitil	1.00	0.54	0.54	0.54	0.0	1.00
Air Sealing, Electric	HES	Elec	Eversource (WMECO)	1.00	1.00	1.00	1.00	0.0	1.00
Air Sealing, Oil	HES	Elec	CLC	1.00	1.00	1.00	1.00	1.0	0.00
Air Sealing, Oil	HES	Elec	National Grid	1.00	0.88	1.00	1.00	1.0	0.00
Air Sealing, Oil	HES	Elec	Eversource (NSTAR)	1.00	0.85	1.00	1.00	1.0	0.00
Air Sealing, Oil	HES	Elec	Unitil	1.00	0.85	1.00	1.00	1.0	0.00
Air Sealing, Oil	HES	Elec	Eversource (WMECO)	1.00	0.55	1.00	1.00	1.0	0.00
Air Sealing, Other	HES	Elec	CLC	1.00	0.86	1.00	1.00	1.0	0.00
Air Sealing, Other	HES	Elec	National Grid	1.00	0.88	1.00	1.00	1.0	0.00
Air Sealing, Other	HES	Elec	Eversource (NSTAR)	1.00	0.95	1.00	1.00	1.0	0.00
Air Sealing, Other	HES	Elec	Unitil	1.00	0.95	1.00	1.00	1.0	0.00
Air Sealing, Other	HES	Elec	Eversource (WMECO)	1.00	0.44	1.00	1.00	1.0	0.00
Air Sealing	HES	Gas	Berkshire	1.00	0.85	n/a	n/a	n/a	n/a
Air Sealing	HES	Gas	Columbia	1.00	0.79	n/a	n/a	n/a	n/a
Air Sealing	HES	Gas	National Grid	1.00	0.74	n/a	n/a	n/a	n/a
Air Sealing	HES	Gas	Eversource (NSTAR)	1.00	0.84	n/a	n/a	n/a	n/a
Air Sealing	HES	Gas	Liberty	1.00	1.11	n/a	n/a	n/a	n/a
Air Sealing	HES	Gas	Unitil	1.00	0.84	n/a	n/a	n/a	n/a

In-Service Rates
In-service rates are set to 100% based on the assumption that all purchased units are installed.

Realization Rates
Realization rates are based on evaluation results[69].

Coincidence Factor
Summer and winter coincidence factors are estimated using demand allocation methodology described the Cadmus Demand Impact Model.[70]

[69] The Cadmus Group (2013). *HES Realization Rate Results Memo*. June 2013
[70] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Building Shell – Air Sealing

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Air sealing will decrease the infiltration of outside air through cracks and leaks in the building.
Primary Energy Impact: Electric, Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Retrofit
End Use: Envelope
Measure Type: Air Sealing
Core Initiative: Electric - Multi-Family Retrofit, Electric - Low-Income Multi-Family Retrofit, Gas - Multi-Family Retrofit, Gas - Low-Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are calculated using the following algorithms and assumptions:

$$\Delta kWh = \frac{Vol \times \Delta ACH \times 0.018 \times HDD \times \frac{24}{\eta_{heating}}}{3413}$$

$$\Delta MMBtu = \frac{Vol \times \Delta ACH \times 0.018 \times HDD \times \frac{24}{\eta_{heating}}}{1{,}000{,}000}$$

$$\Delta kW = \Delta kWh \times kW / kWh$$

Where:

Vol	=	[ft3] This is the air volume of the treated space, calculated from the dimensions of the space, which could include the number of floors, the floor area per floor, and the floor-to-ceiling height, or the dwelling floor area and number of dwellings. The treated space can be the entire building including the common areas, or just the individual dwelling units. (Auditor Input)
ΔACH	=	[ºF-day] Infiltration reduction in Air Changes per Hour, natural infiltration basis. This will typically be a default value, but the source of the assumption should be transparent and traceable, or it could come from a blower door test. (Stipulated Value or Blower Door Test)
HDD60	=	Heating degree-days, base 60 from TMY3 weather data. See table below.
ηheating	=	[AFUE, COP, thermal efficiency(%)] Efficiency of the heating system, as determined on site (Auditor Input)
24	=	Conversion factor: 24 hours per day
0.018	=	[Btu/ft3- ºF] Air heat capacity: The specific heat of air (0.24 Btu/ºF.lb) times the density

of air (0.075 lb/ft3)
1,000,000 = Conversion factor: 1,000,000 Btu per MMBtu
3413 = Conversion factor: 3413 Btu/kWh
kW/kWh = Average kW reduction per kWh reduction: 0.00050 kW/kWh[71]

Baseline Efficiency

The baseline efficiency case is the existing building before the air sealing measure is implemented. The baseline building is characterized by the existing air changes per hour (ACHPRE) for multi-family facilities, which is measured prior to the implementation of the air sealing measure. This will typically be a default value of a baseline/pre-retrofit ACH =0.5

High Efficiency

The baseline efficiency case is the existing building after the air sealing measure is implemented. The high efficiency building is characterized by the new air changes per hour (ACH_{POST}) for multi-family facilities, which is measured after the air sealing measure is implemented. This will typically be a default value of a baseline/pre-retrofit ACH =0.4.

Hours

Heating hours are characterized by the heating degree days for the facility. The heating degree days are looked up based on the nearest weather station to the customer, as selected by the program vendor.

HDD_{60} Values by Weather Station[72]

TMY3 City	HDD	CDH
Barnstable Muni Boa	4379	1349
Beverly Muni	5329	3432
Boston Logan Int'l Arpt	4550	4329
Chicopee Falls Westo	5016	4116
Lawrence Muni	4640	3978
Marthas Vineyard	4312	1345
Nantucket Memorial AP	3988	362
New Bedford Rgnl	4434	4232
North Adams	5234	2524
Norwood Memorial	4872	4763
Otis ANGBb	4718	2588
Plymouth Municipal	4559	2138
Provincetown (AWOS)	4368	2195
Westfield Barnes Muni AP	5301	3784
Worcester Regional Arpt	5816	1753

Measure Life

The measure life is 15 years.[73]

[71] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[72] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.
[73] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA Type	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Air Sealing	MF Retrofit	Elec	All	1.00	0.60	0.60	0.60	0.01	1.00
Air Sealing	MF Retrofit	Gas	All	1.00	0.60	n/a	n/a	n/a	n/a
Air Sealing	LI MF Retrofit	Elec	All	1.00	1.00	1.00	1.00	0.01	1.00
Air Sealing	LI MF Retrofit	Gas	National Grid	1.00	0.75	n/a	n/a	n/a	n/a
Air Sealing	LI MF Retrofit	Gas	Liberty	1.00	0.80	n/a	n/a	n/a	n/a
Air Sealing	LI MF Retrofit	Gas	Berkshire	1.00	0.80	n/a	n/a	n/a	n/a
Air Sealing	LI MF Retrofit	Gas	Eversource	1.00	1.05	n/a	n/a	n/a	n/a
Air Sealing	LI MF Retrofit	Gas	Columbia	1.00	0.96	n/a	n/a	n/a	n/a
Air Sealing	LI MF Retrofit	Gas	Unitil	1.00	0.96	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since all PA programs include verification of equipment installations.

Realization Rates
MF Retrofit realization rates are based on MA Common Assumptions.
LI MF Retrofit realization rates are based on evaluation results.[74]

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[75]

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[74] The Cadmus Group, Inc. (2015). *Massachusetts Low-Income Multifamily Initiative* Impact *Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[75] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Building Shell – Insulation

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Shell insulation installed through the Home Energy Services (MassSAVE) program.
Primary Energy Impact: Electric, Oil, Propane, Natural Gas (Residential Heat)
Secondary Energy Impact: Electric
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: Envelope
Measure Type: Air Sealing
Core Initiative: Electric - Residential Home Energy Services, Gas - Residential Home Energy Services

Algorithms for Calculating Primary Energy Impact

The Program Administrators currently use vendor calculated energy savings for these measures in the Residential Home Energy Services electric program. These savings values are calculated using vendor proprietary software where the user inputs a minimum set of technical data about the house and the software calculates building heating and cooling loads and other key parameters. The proprietary building model is based on thermal transfer, building gains, and a variable-based heating/cooling degree day/hour climate model. This provides an initial estimate of energy use that may be compared with actual billing data to adjust as needed for existing conditions. Then, specific recommendations for improvements are added and savings are calculated using measure-specific heat transfer algorithms.

Rather than using a fixed degree day approach, the building model estimates both heating degree days and cooling degree hours based on the actual characteristics and location of the house to determine the heating and cooling balance point temperatures. Savings from shell measures use standard U-value, area, and degree day algorithms. Infiltration savings use site-specific seasonal N-factors to convert measured leakage to seasonal energy impacts. HVAC savings are estimated based on changes in system and/or distribution efficiency improvements, using ASHRAE 152 as their basis. Lighting, appliance, and water heating savings are based on standard algorithms, taking into account operating conditions and pre- and post-retrofit energy consumption. Interactivity between architectural and mechanical measures is always included, to avoid overestimating savings due to incorrectly “adding” individual measure results.

The PAs calculate demand (kW) savings by applying a kW/kWh factor to the vendor-estimated electric energy savings. The kW/kWh factors are provided in the table below.

kW Factors for HES Vendor Measures

Measure	kW/kWh Factor[76]
Insulation (Electric)	0.00053
Insulation (Gas, Oil, Other FF)	0.00071

Baseline Efficiency

The baseline efficiency case is the existing conditions of the participating household.

High Efficiency

The high efficiency case is a home with added insulation.

Hours

Hours are project-specific.

Measure Life

The measure life is 25 years.

Secondary Energy Impacts

Electric savings are from reduced furnace fan runtime and reduced cooling due to installed insulation. The kWh savings values are deemed based on study results[77].

Measure Name	ΔkWh	ΔkW[78]
Insulation, Gas	209	0.15
Insulation, Oil	224	0.16
Insulation, Other	209	0.15

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[76] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators. For electric measures the heating loadshape was used for non-electric the central AC loadshape was used.
[77] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[78] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA Type	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Insulation, Electric	HES	Elec	CLC	1.00	0.51	0.51	0.51	0.0	1.00
Insulation, Electric	HES	Elec	National Grid	1.00	0.60	0.60	0.60	0.0	1.00
Insulation, Electric	HES	Elec	Eversource (NSTAR)	1.00	0.54	0.54	0.54	0.0	1.00
Insulation, Electric	HES	Elec	Unitil	1.00	0.54	0.54	0.54	0.0	1.00
Insulation, Electric	HES	Elec	Eversource (WMECO)	1.00	1.00	1.00	1.00	0.0	1.00
Insulation, Oil	HES	Elec	CLC	1.00	1.00	1.00	1.00	1.0	0.44
Insulation, Oil	HES	Elec	National Grid	1.00	0.88	1.00	1.00	1.0	0.44
Insulation, Oil	HES	Elec	Eversource (NSTAR)	1.00	0.85	1.00	1.00	1.0	0.44
Insulation, Oil	HES	Elec	Unitil	1.00	0.85	1.00	1.00	1.0	0.44
Insulation, Oil	HES	Elec	Eversource (WMECO)	1.00	0.55	1.00	1.00	1.0	0.44
Insulation, Other	HES	Elec	CLC	1.00	0.86	1.00	1.00	1.0	0.51
Insulation, Other	HES	Elec	National Grid	1.00	0.88	1.00	1.00	1.0	0.51
Insulation, Other	HES	Elec	Eversource (NSTAR)	1.00	0.95	1.00	1.00	1.0	0.51
Insulation, Other	HES	Elec	Unitil	1.00	0.85	1.00	1.00	1.0	0.51
Insulation, Other	HES	Elec	Eversource (WMECO)	1.00	0.44	1.00	1.00	1.0	0.51
Insulation	HES	Gas	Berkshire	1.00	0.85	1.00	1.00	1.0	0.51
Insulation	HES	Gas	Columbia	1.00	0.79	1.00	1.00	1.0	0.51
Insulation	HES	Gas	National Grid	1.00	0.74	1.00	1.00	1.0	0.51
Insulation	HES	Gas	Eversource (NSTAR)	1.00	0.84	1.00	1.00	1.0	0.51
Insulation	HES	Gas	Liberty	1.00	1.11	1.00	1.00	1.0	0.51
Insulation	HES	Gas	Unitil	1.00	0.84	1.00	1.00	1.0	0.51

In-Service Rates
In-service rates are set to 100% based on the assumption that all purchased units are installed.

Realization Rates
Realization rates are based on evaluation results[79].

Coincidence Factor
Summer and winter coincidence factors are estimated using demand allocation methodology described the Cadmus Demand Impact Model.[80]

[79] The Cadmus Group (2013). *HES Realization Rate Results Memo*. June 2013
[80] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Building Shell – Insulation

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Insulation upgrades are applied in existing multifamily facilities.
Primary Energy Impact: Electric, Gas
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Retrofit
End Use: Envelope
Measure Type: Insulation
Core Initiative: Electric - Multi-Family Retrofit, Electric - Low-Income Multi-Family Retrofit, Gas - Multi-Family Retrofit, Gas - Low-Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

$$MMBTu_{annual} = \frac{\left(\frac{1}{R_{exist}} - \frac{1}{R_{new}}\right) \times HDD \times 24 \times Area}{1{,}000{,}000 \times \eta_{heat}}$$

$kWh_{annual} = MMBTu_{annual}\ x\ 293.1$

$kW = kWh_{annual}\ x\ kW/kWh_{heating}$

Where:

R_{exist}	=	Existing effective R-value (R-ExistingInsulation + R-Assembly), ft^2-°F/Btuh
R_{new}	=	New total effective R-value (R-ProposedMeasure + R-ExistingInsulation + R-Assembly), ft^2-°F/Btuh
Area	=	Square footage of insulated area
η_{heat}	=	Efficiency of the heating system (AFUE or COP)
293.1	=	Conversion constant (1MMBtu = 293.1 kWh)
24	=	Conversion for hours per day
HDD	=	Heating Degree Days; dependent on location, see table below
1,000,000	=	Conversion from Btu to MMBtu
kW/kWh heating	=	Average annual kW reduction per kWh reduction: 0.00050 kW/kWh[81]

[81] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Baseline Efficiency

The baseline efficiency case is characterized by the total R-value of the existing attic, basement or sidewall (R_{exisit}). This is calculated as the R-value of the existing insulation, estimated by the program contractor, plus the R-value of the ceiling, floor, or wall (for all projects: $R_{CEILING}$ = 3.36; R_{FLOOR} = 6.16; R_{WALL} = 6.65)[82].

High Efficiency

The high efficiency case is characterized by the total R-value of the attic after the installation of additional attic, basement or sidewall insulation. This is calculated as the sum of the existing R-value (R_{exisit}) plus the R-value of the added insulation.

Hours

Heating hours are characterized by the heating degree days for the facility. The heating degree days are looked up based on the nearest weather station to the customer, as selected by the program vendor.

HDD_{60} Values by Weather Station[83]

TMY3 City	HDD	CDH
Barnstable Muni Boa	4379	1349
Beverly Muni	5329	3432
Boston Logan Int'l Arpt	4550	4329
Chicopee Falls Westo	5016	4116
Lawrence Muni	4640	3978
Martha’s Vineyard	4312	1345
Nantucket Memorial AP	3988	362
New Bedford Rgnl	4434	4232
North Adams	5234	2524
Norwood Memorial	4872	4763
Otis ANGBb	4718	2588
Plymouth Municipal	4559	2138
Provincetown (AWOS)	4368	2195
Westfield Barnes Muni AP	5301	3784
Worcester Regional Arpt	5816	1753

Measure Life

The measure life is 25 years.[84]

Secondary Energy Impacts

If Facility has central cooling then also calculate air conditioning savings:

[82] Assumptions from National Grid program vendor.
[83] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis.* Prepared for Massachusetts Program Administrators.
[84] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.

$$kWh_{annual} = \frac{\left(\frac{1}{R_{exist}} - \frac{1}{R_{new}}\right) \times CDH \times DUA \times Area}{1{,}000\ Btu/kBtu \times \eta_{cool}} \times 293.1$$

$kW = kWh_{annual}\ x\ kW/kWh_{cooling}$

Where:

R_{exist}	=	Existing effective R-value (R-ExistingInsulation + R-Assembly), ft^2-°F/Btuh
R_{new}	=	New total effective R-value (R-ProposedMeasure + R-ExistingInsulation + R-Assembly), ft^2-°F/Btuh
DUA	=	Discretionary Use Adjustment to account for the fact that people do not always operate their air conditioning system when the outside temperature is greater than 75°F = 0.75[85]
Area	=	Square footage of insulated area
η_{cool}	=	Efficiency of Air Conditioning equipment (SEER or EER)
293.1	=	Conversion constant (1MMBtu = 293.1 kWh)
24	=	Conversion for hours per day
CDH	=	Cooling Degree Hours; dependent on location, see table below
kW/kWh cooling	=	Average annual kW reduction per kWh reduction: 0.00222 kW/kWh[86]

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA Type	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Insulation	MF Retrofit	Elec	All	1.00	0.60	0.60	0.60	0.00	1.00
Insulation	MF Retrofit	Gas	All	1.00	0.60	n/a	n/a	n/a	n/a
Insulation	LI MF Retrofit	Elec	National Grid	1.00	1.00	1.00	1.00	0.00	1.00
Insulation	LI MF Retrofit	Gas	National Grid	1.00	0.75	n/a	n/a	n/a	n/a
Insulation	LI MF Retrofit	Gas	Liberty	1.00	0.80	n/a	n/a	n/a	n/a
Insulation	LI MF Retrofit	Gas	Berkshire	1.00	0.80	n/a	n/a	n/a	n/a
Insulation	LI MF Retrofit	Gas	Columbia	1.00	.96	n/a	n/a	n/a	n/a
Insulation	LI MF Retrofit	Gas	Unitil	1.00	0.96	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since all PA programs include verification of equipment installations.

[85] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.
[86] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators. Loadshape: Res Multi Family Electric Cooling (UNIT_CENTRAL_AC) Normal

Realization Rates

- MF Retrofit realization rates are based on MA Common Assumptions.
- LI MF Retrofit realization rates are based on evaluation results.[87]

Coincidence Factors

Summer and winter coincidence factors are estimated using demand allocation methodology described the Cadmus Demand Impact Model.[88]

[87] The Cadmus Group, Inc. (2015). *Massachusetts Low-Income Multifamily Initiative* Impact *Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.

[88] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

HVAC – Central Air Conditioning

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The installation of high efficiency Central AC systems.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Measure Type: Cooling
Core Initiative: Electric - Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms and assumptions:

$$\Delta kWh = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}} \right) \times Hours$$

$$\Delta kW = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}} \right)$$

Where:
Tons = Cooling capacity of AC equipment
$SEER_{BASE}$ = Seasonal Energy Efficiency Ratio of baseline AC equipment
$SEER_{EE}$ = Seasonal Energy Efficiency Ratio of new efficient AC equipment.
EER_{BASE} = Energy Efficiency Ratio of base AC equipment
EER_{EE} = Energy Efficiency Ratio of new efficient AC equipment.
Hours = Equivalent full load hours

Savings for Residential Central Air Conditioners[89]

Measure Name	Average Size (tons)	SEER	EER	ΔkW	ΔkWh
Central Air SEER 16.0 EER 13	2.6	16	13	0.55	198.8

Baseline Efficiency

The baseline efficiency case is a 2.6 ton central air-conditioning system with SEER = 13 and EER = 11 for replace on failure and SEER = 10 and EER = 8.5 for early retirement.

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[89] Savings have been adjusted to reflect the mix of replace on failure and early replacement. Percentage of early retirement is from The Cadmus Group (2013). *2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing*. Prepared for the Electric and Gas Program Administrators of Massachusetts. The calculation of the adjustment can be found in MA PAs (2015). 2016-2018 Cool Smart Savings Workbook

High Efficiency

The high efficiency case is an ENERGY STAR® qualified Central AC system.

Hours

The equivalent full load cooling hours are 360 hours per year.[90]

Measure Life

The measure life is 16 years. [91]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Central Air SEER 16.0 EER 13	RHVAC	All	1.00	1.00	1.00	1.00	0.25	0.00

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on evaluation study results.[92]

[90] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-5, Table 4-3.
[91] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1. Lifetime has been adjusted to reflect the mix of replace on failure and early replacement based on: The Cadmus Group (2013). *2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing*. Prepared for the Electric and Gas Program Administrators of Massachusetts. The calculation of the adjustment can be found in MA PAs (2015). 2016-2018 Cool Smart Savings Workbook
[92] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12 Table 4-9.

HVAC – Down Size ½ Ton

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Reduction in system size consistent with manual J calculations.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Measure Type: Cooling
Core Initiative: Electric - Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on results of DOE2 modeling:

Units	=	Completed job
ΔkW/Ton	=	Average demand reduction per ton: 0.30 kW[93]
ΔkWh/Ton	=	Average annual energy reduction per ton: 203 kWh[94]

Baseline Efficiency

The baseline efficiency case is a system that is not sized in accordance with manual J calculation.

High Efficiency

The high efficiency case is a system that is sized in accordance with manual J calculation.

Hours

Not applicable.

Measure Life

The measure life is 18 years.[95]

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[93] RLW Analytics (2002). *Market Research for the Rhode Island, Massachusetts, and Connecticut Residential HVAC Market*. Prepared for National Grid, Northeast Utilities, NSTAR, Fitchburg Gas and Electric Light Company and United Illuminating; Page 3, Table 2
[94] ibid.
[95] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.

Secondary-Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Down Size ½ Ton	RHVAC	All	1.00	1.00	1.00	1.00	0.25	0.00

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on evaluation study results[96].

[96] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12 Table 4-9.

HVAC – Early Retirement of Central Air Conditioning

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Early replacement of Central Air Conditioning
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: HVAC
Measure Type: Cooling
Core Initiative: Electric - Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms and assumptions:

$$\Delta kWh = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left[\left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}} \right) \times Hours_C + \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}} \right) \times Hours_H \right]$$

$$\Delta kW = \max(\Delta kW_{COOL}, \Delta kW_{HEAT})$$

$$\Delta kW_{COOL} = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}} \right)$$

Where:

Unit	=	Replacement of existing inefficient system with new efficient system
Tons	=	Capacity of AC equipment: Current default is 2.6 tons
$SEER_{BASE}$	=	Seasonal efficiency of baseline AC equipment
$SEER_{EE}$	=	Seasonal efficiency of new efficient AC equipment
EER_{BASE}	=	Peak efficiency of base AC equipment
EER_{EE}	=	Peak efficiency of new efficient AC equipment
$Hours_C$	=	EFLH for cooling

Savings for Early Retirement Air Conditioners[97]

Measure Name	EER_{BASE}	$SEER_{BASE}$	EER_{EE}	$SEER_{EE}$	ΔkW_C	ΔkW_H	ΔkWh
Early Retirement Central Air (Retire)	8.5	10	11	13	0.83	0.00	259
Early Retirement Central Air (EE) SEER 16	11	13	13	16	0.44	0.00	162

Baseline Efficiency

The baseline efficiency case is assumed to be a typical 10-12 year-old central air-conditioning unit with SEER 10, EER 8.5

High Efficiency

For the retirement savings over the remaining life of existing AC unit, the efficient case is a SEER 13, EER 11 unit. For the high efficiency savings over lifetime of the new unit, the efficient case is a new high efficiency SEER 16, EER 13 unit.

Hours

The equivalent full load hours are 360 hours per year for cooling.[98]

Measure Life

The remaining life for the existing unit is 6 years[99], and the measure life of new equipment is 18 years[100]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Early Retirement Central Air (Retire)	RHVAC	All	1.00	1.00	1.00	1.00	0.25	0.00
Early Retirement Central Air (EE)	RHVAC	All	1.00	1.00	1.00	1.00	0.25	0.00

[97] The calculation of the adjustment can be found in MA PAs (2015). 2016-2018 Cool Smart Savings Workbook.
[98] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-5, Table 4-3.
[99] Massachusetts Common Assumption: RUL is 1/3 of the EUL.
[100] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on evaluation study results[101] and Massachusetts Common Assumptions. [102]

[101] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12 Table 4-9.
[102] The coincidence factors included in the BC model do not match the coincidence factors that are in the TRM because the B/C model only allows for a single max kW reduction to be entered for each measure and the TRM provides separate summer and winter kW reductions for some measures. An adjustment was made to the coincidence factors in the BC model in order to get the model to calculate the correct summer and winter kW reductions.

HVAC – Window AC Replacement (Retrofit)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Replacement of existing inefficient room air conditioners with more efficient models. This is only offered as a measure when an AC timer would not reduce usage during the peak period.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: HVAC
Measure Type: Cooling
Core Initiative: Electric - Low-Income Single Family Retrofit, Electric - Low-Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results for all programs and PAs except for National Grid's Low Income Multi-Family initiative[103].

Measure Name	Core Initiative	PA	ΔkWh	ΔkW
Window AC Replacement	LI Retrofit 1-4	All	113	0.32
Window AC Replacement	LI MF Retrofit	Eversource, Unitil, CLC	113	0.32

For National Grid's Low Income Multi-Family initiative unit savings are calculated using the following algorithms and assumptions:

$$\Delta kWh = (Capacity_{existing} / EER_{existing} - Capacity_{new}/EER_{new}) * hours/1000$$
$$\Delta kW = (Capacity_{exisitng}/EER_{existing} - Capacity_{new}/EER_{new}) /1000$$

Where:

$Capacity_{exisitng}$ = size of existing unit in BTUs/hour
$Capacity_{new}$ = size of new unit in BTUs/hour
$EER_{exisitng}$ = Energy Efficiency Ratio of base AC equipment
EER_{new} = Energy Efficiency Ratio of new efficient AC equipment
Hours = Equivalent full load hours= 200[104]

[103] The Cadmus Group, Inc. (2015). *Massachusetts Low-Income Multifamily Initiative Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[104] RLW Analytics (2008). *Coincidence Factor Study: Residential Room Air Conditioners*. Prepared for Northeast Energy Efficiency Partnerships' New England Evaluation and State Program Working Group; Page 32, Table 22 - found by averaging the EFLH values for MA states (Boston and Worcester): (228+172)/2 = 200.

Baseline Efficiency

The baseline efficiency case is the existing air conditioning unit.

High Efficiency

The high efficiency case is the high efficiency room air conditioning unit.

Hours

Not applicable.

Measure Life

The measure life is 9 years.[105]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Window AC Replacement	LI Retrofit 1-4	All	1.00	1.00	1.00	1.00	1.00	0.00
Window AC Replacement	LI MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.00

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% since deemed savings are based on evaluation results.

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[106]

[105] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Room Air Conditioner.* Interactive Excel Spreadsheet found at www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerRoomAC.xls.
[106] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

HVAC – Air Source Heat Pump

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The installation of high efficiency Air Source Heat Pumps.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Measure Type: Heat Pumps
Core Initiative: Electric - Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms and assumptions:

$$\Delta kWh = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left[\left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}} \right) \times Hours_C + \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}} \right) \times Hours_H \right]$$

$$\Delta kW = \max(\Delta kW_{COOL}, \Delta kW_{HEAT})$$

$$\Delta kW_{COOL} = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}} \right)$$

$$\Delta kW_H = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}} \right)$$

Where:

Unit	=	Installation of heat pump system
Tons	=	Capacity of HP equipment
$SEER_{BASE}$	=	Seasonal efficiency of baseline HP equipment
$SEER_{EE}$	=	Seasonal efficiency of new efficient HP equipment.
EER_{BASE}	=	Peak efficiency of base HP equipment
EER_{EE}	=	Peak efficiency of new efficient HP equipment.
$HSPF_{BASE}$	=	Heating efficiency of baseline HP equipment
$HSPF_{EE}$	=	Heating efficiency of new efficient HP equipment.
$Hours_C$	=	EFLH for cooling
$Hours_H$	=	EFLH for heating

Savings for Residential Air-Source Heat Pumps[107]

Measure Name	Size (tons)	SEER	EER	HSPF	ΔkW_C	ΔkW_H	ΔkWh
Heat Pump SEER 16.0 HSPF 8.5	2.8	16	13.5	8.5	0.31	0.19	450.3
Heat Pump SEER 18.0 HSPF 9.6	2.8	18	13.8	9.6	0.36	0.65	1,077.8

Baseline Efficiency

The baseline efficiency case is a 2.8 ton air-source heat pump with SEER = 14, EER = 12.2 and HSPF = 8.2 for replace on failure and SEER =10, EER= 8.5 and HSPF = 7.0 for early retirement.

High Efficiency

The high efficiency case is an ENERGY STAR® qualified Air Source Heat Pump.

Hours

Equivalent full load hours are 1200 hours/year for heating[108] and 360 hours/year for cooling.[109]

Measure Life

Measure	Measure Life[110]
Heat Pump SEER 16.0 HSPF 8.5	14
Heat Pump SEER 18.0 HSPF 9.6	16

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Heat Pump SEER 16.0 HSPF 8.5	RHVAC	All	1.00	1.00	1.00	1.00	0.29	0.31

[107] Savings have been adjusted to reflect the mix of replace on failure and early replacement. Percentage of early retirement is from The Cadmus Group (2013). *2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing*. Prepared for the Electric and Gas Program Administrators of Massachusetts. The calculation of the adjustment can be found in MA PAs (2015). 2016-2018 Cool Smart Savings Workbook.
[108] Massachusetts Common Assumption.
[109] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for Eversource (NSTAR), National Grid, Connecticut Light & Power and United Illuminating; Page 4-5, Table 4-3.
[110] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1. Lifetime has been adjusted to reflect the mix of replace on failure and early replacement based on: The Cadmus Group (2013). *2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing*. Prepared for the Electric and Gas Program Administrators of Massachusetts. The calculation of the adjustment can be found in MA PAs (2015). 2016-2018 Cool Smart Savings Workbook

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Heat Pump SEER 18.0 HSPF 9.6	RHVAC	All	1.00	1.00	1.00	1.00	0.17	0.54

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on evaluation study results and Massachusetts Common Assumptions.[111]

[111] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for Eversource (NSTAR), National Grid, Connecticut Light & Power and United Illuminating; Page 4-12 Table 4-9. Coincidence factors have been adjusted to reflect the mix of replace on failure and early replacement based on: The Cadmus Group (2013). *2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing*. Prepared for the Electric and Gas Program Administrators of Massachusetts. The calculation of the adjustment can be found in MA PAs (2015). 2016-2018 Cool Smart Savings Workbook

HVAC – Ductless MiniSplit Heat Pump

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The installation of a more efficient Ductless Mini Split HP system.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Measure Type: Heat Pumps
Core Initiative: Electric - Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms and assumptions:

$$\Delta kWh_{HP} = Tons \times \frac{12\ kBtu/hr}{Ton}\left[\left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}\right) \times Hours_C + \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}}\right) \times Hours_H\right]$$

$$\Delta kW_{COOL} = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)$$

$$\Delta kW_{HEAT} = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}}\right)$$

Where:

Unit	=	Installation of high efficiency ductless Mini Split System
ΔkWh_{HP}	=	Reduction in annual kWh consumption of HP equipment
ΔkW_{HP}	=	Reduction in electric demand of HP equipment
Tons	=	Capacity of HP equipment
$SEER_{BASE}$	=	Seasonal efficiency of baseline HP equipment
$SEER_{EE}$	=	Seasonal efficiency of new efficient HP equipment
EER_{BASE}	=	Peak efficiency of base HP equipment[112]
EER_{EE}	=	Peak efficiency of new efficient HP equipment
$HSPF_{BASE}$	=	Heating efficiency of baseline HP equipment
$HSPF_{EE}$	=	Heating efficiency of new efficient HP equipment
$Hours_C$	=	EFLH for cooling
$Hours_H$	=	EFLH for heating

[112] AHRI (Air Conditioning, Heating, and Refrigeration Institute) (2011). Average EER of current in-market equipment with from website at http://www.ahridirectory.org/ahridirectory/pages/home.aspx. Under Directory of Certified Product Performance>Residential>Variable Speed Mini-Split and Multi-Split Heat Pumps. Specified Model Status = Active, Indoor Type = Mini-Splits, and SEER Min and Max of 13 for 2013 and 2014 and Min and Max of 14 for 2015.

Savings for Residential Ductless MiniSplit Heat Pumps[113]

Measure Name	Average Size (tons)	Average SEER	Average EER	Average HSPF	ΔkW_C	ΔkW_H	ΔkWh
Mini Split HP SEER 18.0 HSPF 9	1.36	20.5	13.3	9.9	0.11	0.34	286
Mini Split HP SEER 20.0 HSPF 11	0.98	24.2	13.8	12.0	0.11	0.45	330

Baseline Efficiency

The baseline efficiency case is a non- ENERGY STAR® rated ductless mini split heat pump with SEER 14, EER 10 and HSPF 8.2.

High Efficiency

The high efficiency case is an ENERGY STAR® qualified Ductless Mini Split System. The 2014 rebated average size and efficiency by measure is shown in the table above. The program qualifications are SEER 18.0 and HSPF 9.0 and SEER 20 and HSPF 11. 0.

Hours

The equivalent full load hours are 447 hours/year for heating[114] and 360 hours/year for cooling.[115]

Measure Life

The measure life is 18 years.[116]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[113] The calculation of the adjustment can be found in MA PAs (2015). 2016-2018 Cool Smart Savings Workbook.
[114] The Cadmus Group (2015). *Ductless Mini-Split Heat Pump (DMSHP) Final Heating Season Results*. Prepared for The Electric and Gas Program Administrators of Massachusetts.
[115] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for Eversource (NSTAR), National Grid, Connecticut Light & Power and United Illuminating; Page 4-5, Table 4-3.
[116] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Mini Split HP SEER 18.0 HSPF 9	RHVAC	All	1.00	1.00	1.00	1.00	0.08	0.50
Mini Split HP SEER 20.0 HSPF 11	RHVAC	All	1.00	1.00	1.00	1.00	0.06	0.50

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on evaluation study results and Massachusetts Common Assumptions.[117]

[117] The coincidence factors included in the BC model do not match the coincidence factors that are in the TRM because the B/C model only allows for a single max kW reduction to be entered for each measure and the TRM provides separate summer and winter kW reductions for some measures. An adjustment was made to the coincidence factors in the BC model in order to get the model to calculate the correct summer and winter kW reductions.

HVAC – Early Retirement of Heat Pump Unit

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Early replacement of Heat Pump Units
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: HVAC
Measure Type: Heat Pumps
Core Initiative: Electric - Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms and assumptions:

$$\Delta kWh = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left[\left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}} \right) \times Hours_C + \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}} \right) \times Hours_H \right]$$

$$\Delta kW = \max\left(\Delta kW_{COOL}, \Delta kW_{HEAT}\right)$$

$$\Delta kW_{COOL} = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}} \right)$$

$$\Delta kW_{HEAT} = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}} \right)$$

Where:

Unit	=	Replacement of existing inefficient system with new efficient system
Tons	=	Capacity of AC/HP equipment: Current default is 2.8 tons
$SEER_{BASE}$	=	Seasonal efficiency of baseline AC equipment
$SEER_{EE}$	=	Seasonal efficiency of new efficient AC equipment
EER_{BASE}	=	Peak efficiency of base AC equipment
EER_{EE}	=	Peak efficiency of new efficient AC equipment
$HSPF_{BASE}$	=	Heating efficiency of baseline HP equipment
$HSPF_{EE}$	=	Heating efficiency of new efficient HP equipment
$Hours_C$	=	EFLH for cooling
$Hours_H$	=	EFLH for heating

Savings for Early Retirement Heat Pumps[118]

Measure Name	EER_{BASE}	$SEER_{BASE}$	$HSPF_{BASE}$	EER_{EE}	$SEER_{EE}$	$HSPF_{EE}$	ΔkW_C	ΔkW_H	ΔkWh
Early Retirement Heat Pump (Retire)	8.5	10	7.0	12.2	14	8.2	1.20	0.7	1189
Early Retirement Heat Pump (EE) SEER 16	12.2	14	8.2	13.5	16	8.5	0.27	0.145	282
Early Retirement Heat Pump (EE) SEER 18	12.2	14	8.2	13.8	18	9.6	0.32	0.598	909

Baseline Efficiency

The baseline efficiency case for the retire portion is assumed to be a typical 10-12 year-old heat pump unit with SEER 10, EER 8.5, HSPF 7.0. The baseline efficiency case for EE portion is a standard efficiency SEER 14, EER 12.2, HSPF 8.2.

High Efficiency

For the retirement savings over the remaining life of existing AC unit, the efficient case is a SEER 14, EER 12.2, HSPF 8.2 unit. For the high efficiency savings over lifetime of the new unit, the efficient case is either a new high efficiency SEER 16, EER 13.5, 8.5 HSPF unit or a new high efficiency SEER 18, EER 13.8, 9.6 HSPF unit.

Hours

The equivalent full load hours are 1,200 hours per year for heating[119] and 360 hours per year for cooling.[120]

Measure Life

The remaining life for the existing unit is 6 years[121], and the measure life of new equipment is 18 years[122]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[118] The calculation of the adjustment can be found in MA PAs (2015). 2016-2018 Cool Smart Savings Workbook.
[119] Massachusetts Common Assumption.
[120] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for Eversource (NSTAR), National Grid, Connecticut Light & Power and United Illuminating; Page 4-5, Table 4-3.
[121] Massachusetts Common Assumption: Assume the RUL is 1/3 of the EUL.
[122] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Early Retirement Heat Pump (Retire)	RHVAC	All	1.00	1.00	1.00	1.00	0.25	0.293
Early Retirement Heat Pump (EE) SEER 16	RHVAC	All	1.00	1.00	1.00	1.00	0.25	0.273
Early Retirement Heat Pump (EE) SEER 18	RHVAC	All	1.00	1.00	1.00	1.00	0.134	0.50

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on evaluation study results[123] and Massachusetts Common Assumptions. [124]

[123] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12 Table 4-9.
[124] The coincidence factors included in the BC model do not match the coincidence factors that are in the TRM because the B/C model only allows for a single max kW reduction to be entered for each measure and the TRM provides separate summer and winter kW reductions for some measures. An adjustment was made to the coincidence factors in the BC model in order to get the model to calculate the correct summer and winter kW reductions.

HVAC – Central AC Quality Installation Verification (QIV)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The verification of proper charge and airflow during installation of new Central AC system.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Measure Type: HVAC O&M
Core Initiative: Electric - Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms and assumptions:

$$\Delta kWh = Tons \times \frac{12\ kBtu/hr}{Ton} \times \frac{1}{SEER} \times Hours \times 5\%$$

$$\Delta kW = Tons \times \frac{12\ kBtu/hr}{Ton} \times \frac{1}{EER} \times 5\%$$

Where:

Units	=	Completed QIV
Tons	=	Cooling capacity of AC equipment: Current default is 2.6 tons
SEER	=	Seasonal efficiency of AC equipment: Default = 16
EER	=	Peak efficiency of AC equipment: Default = 13.0
Hours	=	Equivalent full load hours
5%	=	Average percent demand reduction: 5.0%[125]

Savings for Central Air QIV[126]

Measure Name	ΔkWh	ΔkW
Central Air QIV	35	0.12

Baseline Efficiency

The baseline efficiency case is a cooling system with SEER = 16 and EER = 13.0 whose installation is inconsistent with manufacturer specifications.

[125] Massachusetts Common Assumption.
[126] The calculation can be found in MA PAs (2015). 2016-2018 Cool Smart Savings Workbook.

High Efficiency

The high efficiency case is the same cooling system whose installation is consistent with manufacturer specifications.

Hours

Equivalent full load cooling hours are 360 hours per year.[127]

Measure Life

The measure life is 18 years.[128]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Central Air QIV	RHVAC	All	1.00	1.00	1.00	1.00	0.25	0.00

In-Service Rates
All installations have 100% in service rate.

Realization Rates
Realization rates are set to 100% based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on evaluation study results[129].

[127] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-5, Table 4-3.
[128] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.
[129] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12 Table 4-9.

HVAC – Heat Pump Quality Installation Verification (QIV)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The verification of proper charge and airflow during installation of new Heat Pump systems.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Measure Type: HVAC O&M
Core Initiative: Electric - Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms and assumptions:

$$\Delta kWh = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{SEER} \times Hours_C + \frac{1}{HSPF} \times Hours_H \right) \times 5\%$$

$$\Delta kW = \max(\Delta kW_{COOL}, \Delta kW_{HEAT})$$

$$\Delta kW_{COOL} = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{EER} \right) \times 5\%$$

$$\Delta kW_{HEAT} = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{HSPF} \right) \times 5\%$$

Where:

Unit	=	Completed QIV
Tons	=	Cooling capacity of HP equipment: Current default is 2.8 tons
SEER	=	Seasonal cooling efficiency of HP equipment
EER	=	Peak cooling efficiency of HP equipment
HSPF	=	Heating efficiency of HP equipment
$Hours_C$	=	EFLH for cooling
$Hours_H$	=	EFLH for heating
5%	=	Average demand reduction: 5%[130]

[130] Massachusetts Common Assumption.

Savings for Heat Pump QIV[131]

Measure Name	ΔkWh	ΔkW
Heat Pump QIV	275	0.20

Baseline Efficiency

The baseline efficiency case is a heating and cooling system with SEER = 16, EER = 13.5 and HSPF = 8.5) whose installation is inconsistent with manufacturer specifications.

High Efficiency

The high efficiency case is the same heating and cooling system whose installation is consistent with manufacturer specifications.

Hours

The equivalent full load heating hours are 1,200 hours per year and the equivalent full load cooling hours are 360 hours per year.[132]

Measure Life

The measure life is 18 years.[133]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Heat Pump QIV	RHVAC	All	1.00	1.00	1.00	1.00	0.157	0.50

In-Service Rates
All installations have 100% in service rate.

Realization Rates
Realization rates are set to 100% based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on Massachusetts Common Assumptions.

[131] The calculation can be found in MA PAs (2015). 2016-2018 Cool Smart Savings Workbook.
[132] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-5, Table 4-3.
[133] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.

HVAC – Mini Split Heat Pump Quality Installation Verification (QIV)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The verification of proper charge and airflow during installation of new Ductless Heat Pump systems.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Measure Type: HVAC O&M
Core Initiative: Electric - Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms and assumptions:

$$\Delta kWh = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{SEER} \times Hours_C + \frac{1}{HSPF} \times Hours_H \right) \times 5\%$$

$$\Delta kW = \max(\Delta kW_{COOL}, \Delta kW_{HEAT})$$

$$\Delta kW_{COOL} = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{EER} \right) \times 5\%$$

$$\Delta kW_{HEAT} = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{HSPF} \right) \times 5\%$$

Where:
Unit = Completed QIV
Tons = Cooling capacity of HP equipment: Current default is 1.36 tons
SEER = Seasonal cooling efficiency of HP equipment
EER = Peak cooling efficiency of HP equipment
HSPF = Heating efficiency of HP equipment
$Hours_C$ = EFLH for cooling
$Hours_H$ = EFLH for heating
5% = Average demand reduction: 5%[134]

Savings for Mini Split Heat Pump QIV[135]

Measure Name	ΔkWh	ΔkW
Mini Split Heat Pump QIV	51	0.08

[134] Massachusetts Common Assumption.
[135] The calculation can be found in MA PAs (2015). 2016-2018 Cool Smart Savings Workbook.

Baseline Efficiency

The baseline efficiency case is a ductless mini-split system with SEER = 18and HSPF = 8.5) whose installation is inconsistent with manufacturer specifications.

High Efficiency

The high efficiency case is the same heating and cooling system whose installation is consistent with manufacturer specifications.

Hours

The equivalent full load heating hours are 447[136] hours per year and the equivalent full load cooling hours are 360 hours per year.[137]

Measure Life

The measure life is 18 years.[138]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Mini Split Heat Pump QIV	RHVAC	All	1.00	1.00	1.00	1.00	0.186	0.50

In-Service Rates
All installations have 100% in service rate.

Realization Rates
Realization rates are set to 100% based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on Massachusetts Common Assumptions.

[136] The Cadmus Group (2015). *Ductless Mini-Split Heat Pump (DMSHP) Final Heating Season Results*. Prepared for The Electric and Gas Program Administrators of Massachusetts
[137] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for Eversource (NSTAR), National Grid, Connecticut Light & Power and United Illuminating; Page 4-5, Table 4-3.
[138] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.

HVAC – Heat Pump Digital Check-up/Tune-up

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Tune-up of an existing heat pump system.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Measure Type: HVAC O&M
Core Initiative: Electric - Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms and assumptions:

$$\Delta kWh = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{SEER} \times Hours_C + \frac{1}{HSPF} \times Hours_H \right) \times 5\%$$

$$\Delta kW = \max(\Delta kW_{COOL}, \Delta kW_{HEAT})$$

$$\Delta kW_{COOL} = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{EER} \right) \times 5\%$$

$$\Delta kW_{HEAT} = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{HSPF} \right) \times 5\%$$

Where:

Unit	=	Completed tune-up
Tons	=	Cooling capacity of HP equipment: Current default is 2.8 tons
SEER	=	Seasonal cooling efficiency of HP equipment
EER	=	Peak cooling efficiency of HP equipment
HSPF	=	Heating efficiency of HP equipment
$Hours_C$	=	EFLH for cooling
$Hours_H$	=	EFLH for heating
5%	=	Average demand reduction: 5%[139]

Savings for Heat Pump Digital Check-up/Tune-Up[140]

Measure Name	ΔkWh	ΔkW
Heat Pump Digital Check-up/Tune-Up	312	0.24

[139] Massachusetts Common Assumption.
[140] The calculation can be found in MA PAs (2015). 2016-2018 Cool Smart Savings Workbook.

Baseline Efficiency

The baseline efficiency case is a system baseline heating and cooling system (SEER = 13 and HSPF = 7.7) that does not operating according to manufacturer specifications.

High Efficiency

The high efficiency case is the same heating and cooling system that does operate according to manufacturer specifications.

Hours

The equivalent full load hours are 1200 hours per year for heating[141] and 360 hours per year for cooling.[142]

Measure Life

The measure life is 5 years[143]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Heat Pump Digital Check-up/Tune-Up	RHVAC	All	1.00	1.00	1.00	1.00	0.21	0.50

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on evaluation study results and Massachusetts Common Assumptions.[144]

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[141] Massachusetts Common Assumption.
[142] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-5, Table 4-3.
[143] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.
[144] The coincidence factors included in the BC model do not match the coincidence factors that are in the TRM because the B/C model only allows for a single max kW reduction to be entered for each measure and the TRM provides separate summer and winter kW reductions for some measures. An adjustment was made to the coincidence factors in the BC model in order to get the model to calculate the correct summer and winter kW reductions.

HVAC – Duct Sealing

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: A 66% reduction in duct leakage from 15% to 5% of supplied CFM.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Measure Type: Ducting
Core Initiative: Electric - Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on results of DOE2 modeling where unit equals a completed job[145].

Savings for Duct Sealing

Measure Name	ΔkWh	ΔkW[146]
Duct Sealing	212	0.30

Baseline Efficiency

The baseline efficiency case is assumes a 15% leakage.

High Efficiency

The high efficiency case is a system with duct leakage reduced by 66% to 5% leakage.

Hours

Not applicable.

Measure Life

The measure life is 20 years.[147]

[145] RLW Analytics (2002). *Market Research for the Rhode Island, Massachusetts, and Connecticut Residential HVAC Market*. Prepared for National Grid, Northeast Utilities, NSTAR, Fitchburg Gas and Electric Light Company and United Illuminating; Page 3, Table 2.
[146] **Ibid**
[147] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Duct Sealing	RHVAC	All	1.00	1.00	1.00	1.00	0.25	0.00

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on evaluation study results[148].

[148] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12 Table 4-9.

HVAC – Quality Installation with Duct Modification

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: 50% reduction in duct leakage from 20% to 10%. This measure may also include duct modifications.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Measure Type: Ducting
Core Initiative: Electric - Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on results of DOE2 modeling where unit is equal to a completed job[149].

Savings for Quality Installation with Duct Modification

Measure Name	ΔkWh	ΔkW[150]
QI w/ Duct modifications	513	0.85

Baseline Efficiency

The baseline efficiency case is a system with an installation that is inconsistent with manufacturer specifications and may include leaky ducts.

High Efficiency

The high efficiency case is a system with an installation that is consistent with manufacturer specifications and may have reduced duct leakage.

Hours

Not applicable.

Measure Life

The measure life is 18 years.[151]

[149] RLW Analytics (2002). *Market Research for the Rhode Island, Massachusetts, and Connecticut Residential HVAC Market*. Prepared for National Grid, Northeast Utilities, NSTAR, Fitchburg Gas and Electric Light Company and United Illuminating; Page 3, Table 2.
[150] Ibid.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
QI w/ Duct modifications	RHVAC	All	1.00	1.00	1.00	1.00	0.25	0.00

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on evaluation study results[152].

[151] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.
[152] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12 Table 4-9.

HVAC – Duct Sealing

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: For existing ductwork in non-conditioned spaces, seal ductwork. This could include sealing leaky fixed ductwork with mastic or aerosol.
Primary Energy Impact: Natural Gas (Residential Heat), Oil, Propane, Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Retrofit
End Use: HVAC
Measure Type: Ducting
Core Initiative: Electric - Low-Income Single Family Retrofit, Gas - Low-Income Single Family Retrofit, Electric – Residential Home Energy Services, Gas – Residential Home Energy Services

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results. [153, 154]

Measure Name	Core Initiative	Energy Type	ΔMMBtu	ΔkWh	ΔkW[155]
Duct Sealing	HES	Gas	3.6		
Duct Sealing	HES	Propane	3.6		
Duct Sealing	HES	Oil	4.1		
Duct Sealing	HES	Electric		428	0.23
Duct Sealing	LI 1-4 Retrofit	Gas	3.3		
Duct Seal, Other	LI 1-4 Retrofit	Propane	3.3		
Duct Seal, Oil	LI 1-4 Retrofit	Oil	3.3		

Baseline Efficiency

The baseline efficiency case is existing, non-sealed (leaky) ductwork in unconditioned spaces (e.g. attic or basement)

High Efficiency

The high efficiency condition is air sealed ductwork in unconditioned spaces.

[153] The Cadmus Group (2012). *Massachusetts Low Income Single Family Program Impact Evaluation*. Prepared for The Electric and Gas Program Administrators of Massachusetts.
[154] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[155] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators

Hours

Not applicable.

Measure Life

The measure life is 20 years.[156]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	Energy Type	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Duct Seal, Gas; Duct Sealing	HES	Gas	All	1.00	1.00	n/a	n/a	n/a	n/a
Duct Seal, Other	HES	Propane	All	1.00	1.00	n/a	n/a	n/a	n/a
Duct Seal, Oil	HES	Oil	All	1.00	1.00	n/a	n/a	n/a	n/a
Duct Seal, Electric	HES	Electric	All	1.00	1.00	1.00	1.00	0.59	1.00
Duct Sealing	LI 1-4 Retrofit	Gas	All	1.00	1.00	n/a	n/a	n/a	n/a
Duct Seal, Other	LI 1-4 Retrofit	Propane	All	1.00	1.00	n/a	n/a	n/a	n/a
Duct Seal, Oil	LI 1-4 Retrofit	Oil	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described the Cadmus Demand Impact Model.[157]

[156] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.
[157] Ibid

HVAC – Duct Sealing

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Ducts are sealed by reconnecting disconnected duct joints and sealing gaps or seams with mastic and fiber-mesh tape as appropriate
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Retrofit
End Use: HVAC
Measure Type: Ducting
Core Initiative: Gas – Residential Multi-Family Retrofit, Gas – Low Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta MMBtu = AnnualHeatingConsumption \times \%SAVE \times \frac{1}{1{,}000{,}000}$$

Where:
AnnualHeatingConsumption = The total annual heating consumption for the facility (Btu)
%SAVE = Average reduction in energy consumption.
1/1,000,000 = Conversion from Btu to MMBtu

Savings Factors for Multifamily Duct Sealing

Measure Type	%SAVE[158]
Surface Area < 50 SQFT	7%
Surface Area > 50 SQFT and < 200 SQFT	3%
Surface Area > 200 SQFT	1%

Baseline Efficiency

The baseline efficiency case is the existing facility or equipment prior to the implementation of duct sealing.

High Efficiency

The baseline efficiency case is the existing facility or equipment after the implementation of duct sealing.

[158] Savings assumptions from National Grid program vendor.

Hours

Not applicable.

Measure Life

The measure life is 20 years.[159]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Duct Sealing	MF Retrofit	National Grid	1.00	1.00	n/a	n/a	n/a	n/a
Duct Sealing	LI MF Retrofit	National Grid	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since all PA programs include verification of equipment installations.

Realization Rates
The energy realization rate is 100% based on no evaluations.

Coincidence Factors
There are no electric savings for this measure.

[159] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.

HVAC – Duct Insulation

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: For existing ductwork in non-conditioned spaces, insulate ductwork.
Primary Energy Impact: Natural Gas (Residential Heat), Oil, Propane, Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Retrofit
End Use: HVAC
Measure Type: Ducting
Core Initiative: Electric - Low-Income Single Family Retrofit, Gas - Low-Income Single Family Retrofit, Electric – Residential Home Energy Services, Gas – Residential Home Energy Services

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results.[160, 161]

Measure Name	Core Initiative	Energy Type	ΔMMBtu	ΔkWh	ΔkW[162]
Duct Insulation, Gas; Duct Insulation	HES	Gas	6.8		
Duct Insulation, Other	HES	Propane	6.8		
Duct Insulation, Oil	HES	Oil	7.7		
Duct Insulation, Electric	HES	Electric		1,613	0.90
Duct Insulation	LI 1-4 Retrofit	Gas	5.5		
Duct Insulation, Other	LI 1-4 Retrofit	Propane	5.5		
Duct Insulation, Oil	LI 1-4 Retrofit	Oil	4.3		

Baseline Efficiency

The baseline efficiency case is existing, non-sealed (leaky) ductwork in unconditioned spaces (e.g. attic or basement)

High Efficiency

The high efficiency condition is air sealed ductwork in unconditioned spaces.

[160] The Cadmus Group (2012). *Massachusetts Low Income Single Family Program Impact Evaluation*. Prepared for The Electric and Gas Program Administrators of Massachusetts.
[161] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[162] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators

Hours

Not applicable.

Measure Life

The measure life is 20 years.[163]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	Energy Type	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Duct Insulation, Gas; Duct Insulation	HES	Gas	All	1.00	1.00	n/a	n/a	n/a	n/a
Duct Insulation, Other	HES	Propane	All	1.00	1.00	n/a	n/a	n/a	n/a
Duct Insulation, Oil	HES	Oil	All	1.00	1.00	n/a	n/a	n/a	n/a
Duct Insulation, Electric	HES	Electric	All	1.00	1.00	1.00	1.00	0.59	1.00
Duct Insulation	LI 1-4 Retrofit	Gas	All	1.00	1.00	n/a	n/a	n/a	n/a
Duct Insulation, Other	LI 1-4 Retrofit	Propane	All	1.00	1.00	n/a	n/a	n/a	n/a
Duct Insulation, Oil	LI 1-4 Retrofit	Oil	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described the Cadmus Demand Impact Model.[164]

[163] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.
[164] Ibid

HVAC – Furnace Fan Motors (electrically efficient fan motors)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of high efficiency motors on residential furnace fans, including electronically commutated variable speed air supply motors.
Primary Energy Impact: Electric
Secondary Energy Impact: Natural Gas (Residential Heat)
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Measure Type: Motors
Core Initiative: Electric - Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[165].

Savings for Furnace Fan Motors

Measure Name	ΔkWh	ΔkW[166]
Furnace ECM	168	0.12

Baseline Efficiency

The baseline efficiency case is the installation of a furnace with a standard efficiency steady state motor.

High Efficiency

The high efficiency case is the installation of a furnace with an electronically commutated motor.

Hours

Not applicable.

[165] The Cadmus Group, Inc. (2012). *Brushless Fan Motors Impact Evaluation*. Prepared for: The Electric and Gas Program Administrators of Massachusetts. The savings values for the BFM come from Page 1, Table 1 of the BFM impact evaluation filed with the Annual Report. While this report was only to provide savings for the BFM --the original savings used by the PA's 600 kWh and .116 kW were used for both the BFM and electrically efficient fan motors. When the BFM study was almost complete we asked the evaluation team if it were possible to come up with savings for the electrically efficient fan motors motor; they calculated the 168 kWh using data from the BFM onsites, after several discussions the evaluation team determined the electrically efficient fan motors motor was a different measure than the BFM so the calculations were not 100% accurate. They note that while the 600 kWh was too high, the 168 may be on the low side but could not confirm without an evaluation of the electrically efficient fan motors. PA's determined while we did not have an evaluation for the 168 it was probably a more realistic number than the 600.
[166] Ibid

Measure Life

The measure life for the electrically efficient fan motors is assumed to be the same as the furnace it is installed on which is 18 years.[167]

Secondary Energy Impacts

A heating penalty results due to reduced heat loss of the efficient furnace motor.

Measure	Core Initiative	PA Type	Energy Type	ΔMMBtu/Unit[168]
Furnace ECM	RHVAC	Elec	Natural Gas (Residential Heat)	-0.716

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Furnace ECM	RHVAC	All	1.00	1.00	1.00	1.00	0. 00	0.16

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based evaluation results[169].

[167] Environmental Protection Agency (2009). Life Cycle Cost Estimate for ENERGY STAR Furnace.
[168] The Cadmus Group, Inc. (2012). *Brushless Fan Motors Impact Evaluation*. Prepared for: The Electric and Gas Program Administrators of Massachusetts
[169] Ibid.

HVAC – Pipe Wrap

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Insulation upgrades to existing heating system pipes
Energy Impact: Oil, Propane, Gas
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Retrofit
End Use: HVAC
Measure Type: Insulation
Core Initiative: Electric - Residential Home Energy Services, Gas - Residential Home Energy Services, Gas - Multi-Family Retrofit, Gas – Low Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results [170,171]. For HES unit is a household with pipe wrap installed on heating pipes. For Multifamily programs, units are in linear feet of insulation installed.

Measure Name	Core Initiative	Energy Type	ΔMMBtu/Unit
Pipe Wrap (Heating), Gas; Pipe Wrap (Heating)	HES	Gas	1.3
Pipe Wrap (Heating), Oil	HES	Oil	1.4
Pipe Wrap (Heating), Other	HES	Propane	1.3
Pipe Wrap (Heating)	MF Retrofit	Oil	0.16
Pipe Wrap (Heating)	MF Retrofit	Propane	0.16
Pipe Wrap (Heating)	MF Retrofit	Gas	0.16
Pipe Wrap (Heating)	LI MF Retrofit	Oil	0.16
Pipe Wrap (Heating)	LI MF Retrofit	Gas	0.16

Baseline Efficiency

The baseline efficiency case is the existing equipment prior to the implementation of additional insulation.

High Efficiency

The high efficiency case includes pipe insulation.

[170] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[171] Savings assumptions for Multifamily programs are from National Grid program vendor.

Hours

Not applicable.

Measure Life

The measure life is 15 years.[172]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Pipe Wrap (Heating)	HES	All	1.00	1.00	n/a	n/a	n/a	n/a
Pipe Wrap (Heating)	MF Retrofit	All	1.00	0.60	n/a	n/a	n/a	n/a
Pipe Wrap (Heating)	LI MF Retrofit	National Grid	1.00	0.75	n/a	n/a	n/a	n/a
Pipe Wrap (Heating)	LI MF Retrofit	Eversource	1.00	1.05	n/a	n/a	n/a	n/a
Pipe Wrap (Heating)	LI MF Retrofit	Columbia	1.00	0.96	n/a	n/a	n/a	n/a
Pipe Wrap (Heating)	LI MF Retrofit	Unitil	1.00	0.96	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
For HES the realization rate is set to 100% since deemed savings are based on evaluation results. For LI MF Retrofit the realization rates are based on evaluation results.[173] For MF Retrofit the realization rates are based on draft evaluation results.

Coincidence Factors
Coincidence factors are set to zero since there are no electric savings for this measure.

[172] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.
[173] The Cadmus Group (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation. Prepared for the Massachusetts Electric and Gas Program Administrators

HVAC – Programmable Thermostats

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a programmable thermostat, which gives the ability to adjust heating or air-conditioning operating times according to a pre-set schedule.
Primary Energy Impact: Electric, Oil, Propane, Natural Gas (Residential Heat)
Secondary Energy Impact: Electric
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Retrofit
End Use: HVAC
Measure Type: Controls
Core Initiative: Electric - Residential Home Energy Services, Gas - Residential Home Energy Services, Gas - Residential Heating & Cooling Equipment, Electric - Low-Income Single Family Retrofit, Gas - Residential Multi-Family Retrofit, Gas - Low-Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results. [174,175,176,177]

Savings for Programmable Thermostats

Measure Name	Core Initiative	PA Type	Energy Type	ΔkWh	ΔkW[178]	ΔMMBtu
Programmable Thermostat, Electric	HES	Elec	Electric	330	0.18	
Programmable Thermostat, Oil	HES	Elec	Oil			3.4
Programmable Thermostat, Gas; Programmable Thermostat	HES	Both	Gas			3.2
Programmable Thermostat, Other	HES	Elec	Propane			3.2
Programmable Thermostat	RHVAC	Gas	Gas			3.2
Programmable Thermostat, Electric	LI Retrofit 1-4	Elec	Electric	330	0.18	
Programmable Thermostat, Other	LI Retrofit 1-4	Elec	Propane			3.1
Programmable Thermostat, Oil	LI Retrofit 1-4	Elec	Oil			3.1
Programmable Thermostat, Electric Resistance, No AC	MF Retrofit	Elec	Electric	257	0.13	

174 The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
175 The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
176 The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis. Page 18-2* Prepared for Massachusetts Program Administrators
177 The Cadmus Group (2015). *Massachusetts Low-Income Multifamily Initiative Impact Evaluation.* Prepared for the Massachusetts Electric and Gas Program Administrators.
178 Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Measure Name	Core Initiative	PA Type	Energy Type	ΔkWh	ΔkW[178]	ΔMMBtu
Programmable Thermostat, Electric Resistance, With AC	MF Retrofit	Elec	Electric	281	0.13	
Programmable Thermostat, AC Only	MF Retrofit	Elec	Electric	25	0.06	
Programmable Thermostat, Heat Pump	MF Retrofit	Elec	Electric	241	0.10	
Programmable Thermostat, Oil	MF Retrofit, LI MF Retrofit	Elec	Oil			2.3
Programmable Thermostat	MF Retrofit, LI MF Retrofit	Gas	Gas			2.3
Programmable Thermostat, Electric	LI MF Retrofit	Elec	Electric	257	0.13	

Baseline Efficiency

The baseline efficiency case is an HVAC system without a programmable thermostat.

High Efficiency

The high efficiency case is an HVAC system that has a programmable thermostat installed.

Hours

Not applicable.

Measure Life

The measure life is 15 years.[179] For Multifamily Retrofit the measure persistence was estimated to be 69%[180] so the effective measure life is 10 years (15 years * 69%).

Secondary Energy Impacts

For Gas - Residential Multi-Family Retrofit:

If facility has central cooling then also calculate air conditioning savings.

$$\Delta kWh = kWh_{cool} \times \%savings$$

Where:

kWh_{cool} = Average kWh consumption of the air conditioning system: 397 kWh[181]

%savings = Energy savings percent from installation of programmable thermostats, deemed at 6.2%.[182]

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[179] Environmental Protection Agency (2010). *Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat*..

[180] The Cadmus Group, Inc. (2012). *Massachusetts 2011Residential Retrofit Multifamily Program Analysis*. Prepared for the Massachusetts Program Administrators

[181] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.

[182] Ibid.

Programmable Thermostat Cooling Savings

Measure Name	kWh Savings	ΔkW[183]
Programmable Thermostat (also controls elec cooling)	25	0.05

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	Energy Type	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Programmable Thermostat	HES	Electric	All	1.00	1.00	1.00	1.00	0.00	1.00
Programmable Thermostat	HES	Oil	All	1.00	1.00	n/a	n/a	n/a	n/a
Programmable Thermostat	HES	Gas	All	1.00	1.00	n/a	n/a	n/a	n/a
Programmable Thermostat	HES	Propane	All	1.00	1.00	n/a	n/a	n/a	n/a
Programmable Thermostat	RHVAC	Gas	All	1.00	1.00	n/a	n/a	n/a	n/a
Programmable Thermostat	LI Retrofit 1-4	Electric	All	1.00	1.00	1.00	1.00	0.00	1.00
Programmable Thermostat	LI Retrofit 1-4	Propane	All	1.00	1.00	n/a	n/a	n/a	n/a
Programmable Thermostat	LI Retrofit 1-4	Oil	All	1.00	1.00	n/a	n/a	n/a	n/a
Programmable Thermostat	LI MF Retrofit	Gas	National Grid	1.00	0.75	n/a	n/a	n/a	n/a
Programmable Thermostat	LI MF Retrofit	Gas	Eversource	1.00	1.05	n/a	n/a	n/a	n/a
Programmable Thermostat	LI MF Retrofit	Gas	Columbia	1.00	0.96	n/a	n/a	n/a	n/a
Programmable Thermostat	LI MF Retrofit	Gas	Unitil	1.00	0.96	n/a	n/a	n/a	n/a
Programmable Thermostat	MF Retrofit	Gas	All	1.00	0.60	n/a	n/a	n/a	n/a
Programmable Thermostat, Electric Resistance, No AC	MF Retrofit	Electric	All	1.00	0.60	0.60	0.60	0.01	1.00
Programmable Thermostat, Electric Resistance, w/AC	MF Retrofit	Electric	All	1.00	0.60	0.60	0.60	0.41	1.00
Programmable Thermostat, AC Only	MF Retrofit	Electric	All	1.00	0.60	0.60	0.60	1.00	0.00
Programmable Thermostat, Heat Pump	MF Retrofit	Electric	All	1.00	0.60	0.60	0.60	0.81	1.00
Programmable Thermostat, Oil	MF Retrofit	Elec	All	1.00	1.00	n/a	n/a	n/a	n/a
Programmable Thermostat, Oil	LI MF Retrofit	Elec	All	1.00	1.00	n/a	n/a	n/a	n/a

[183] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

In-Service Rates

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates

- For HES, HVAC, and LI Retrofit 1-4 realization rates are set to 100% since deemed savings are based on evaluation results.
- For LI MF Retrofit the realization rates are based on evaluation results.[184]
- For MF Retrofit the realization rates are based on MA Common Assumptions.

Coincidence Factors

Summer and winter coincidence factors are estimated using demand allocation methodology described the Cadmus Demand Impact Model.[185]

[184] The Cadmus Group (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation. Prepared for the Massachusetts Electric and Gas Program Administrators

[185] Ibid

HVAC – Wi-Fi Thermostats

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: A communicating thermostat which allows remote set point adjustment and control via remote application. System requires an outdoor air temperature algorithm in the control logic to operate heating and cooling systems
Primary Energy Impact: Natural Gas (Residential Heat), Oil, Propane, Electric
Secondary Energy Impact: Electric
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: HVAC
Measure Type: Controls
Core Initiative: Electric - Residential Home Energy Services, Gas - Residential Home Energy Services, Gas - Residential Heating & Cooling Equipment, Electric - Low-Income Single Family Retrofit, Gas - Low-Income Single Family Retrofit, Gas - Residential Multi-Family Retrofit, Gas - Low-Income Multi-Family Retrofit, Electric - Residential Multi-Family Retrofit, Electric - Low-Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[186].

Savings for Wi-Fi Thermostats

Measure Name	Core Initiative	PA Type	Energy Type	ΔkWh	ΔkW[187]	ΔMMBtu
Wi-Fi Thermostat (controls gas heat only); Wi-Fi Thermostat	RHVAC, HES, LI 1-4 Retrofit	Gas	Gas			6.6
Wi-Fi Thermostat (controls elec cooling & gas heat); Wi-Fi Thermostat (also controls elec cooling)	RHVAC, HES, LI 1-4 Retrofit	Gas	Gas	104	0.23	6.6
Wi-Fi Thermostat, Electric (AC Only)	HES, LI 1-4 Retrofit	Elec	Electric	104	0.23	
Wi-Fi Thermostat, Gas	HES, LI 1-4 Retrofit	Elec	Gas			6.6
Wi-Fi Thermostat, Gas with AC	HES, LI 1-4 Retrofit	Elec	Gas	104	0.23	6.6
Wi-Fi Thermostat, Oil	HES, LI 1-4 Retrofit	Elec	Oil			6.6
Wi-Fi Thermostat, Oil with AC	HES, LI 1-4 Retrofit	Elec	Oil	104	0.23	6.6
Wi-Fi Thermostat, Other	HES, LI 1-4 Retrofit	Elec	Propane			6.6
Wi-Fi Thermostat, Other with AC	HES, LI 1-4 Retrofit	Elec	Propane	104	0.23	6.6

[186] The Cadmus Group (2011). Memo: Wi-fi Programmable Thermostat Billing Analysis. Prepared for Keith Miller and Whitney Domigan, National Grid
[187] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Measure Name	Core Initiative	PA Type	Energy Type	ΔkWh	ΔkW[187]	ΔMMBtu
Wi-Fi Thermostat (controls gas heat only); Wi-Fi Thermostat	RHVAC, HES, LI 1-4 Retrofit	Gas	Gas			6.6
Wi-Fi Thermostat (controls elec cooling & gas heat); Wi-Fi Thermostat (also controls elec cooling)	RHVAC, HES, LI 1-4 Retrofit	Gas	Gas	104	0.23	6.6
Wi-Fi Thermostat, Electric (AC Only)	MF Retrofit, LI MF Retrofit	Elec	Electric	74.8	0.155	
Wi-Fi Thermostat, Oil	MF Retrofit, LI MF Retrofit	Elec	Oil			4.7
Wi-Fi Thermostat (controls gas heat only)	MF Retrofit, LI MF Retrofit	Gas	Gas			4.7
Wi-Fi Thermostat (controls elec cooling & gas heat)	MF Retrofit, LI MF Retrofit	Gas	Gas	74.8	0.155	4.7

Baseline Efficiency

The baseline efficiency case is an HVAC system with either a manual or a programmable thermostat.

High Efficiency

The high efficiency case is an HVAC system that has a Wi-Fi thermostat installed.

Hours

Not applicable.

Measure Life

The measure life is 15 years.[188]

Secondary Energy Impacts

When the thermostat also controls the cooling system the electric savings are 104 kWh[189] and 0.231 kW[190] in Single-Family and 74.8 kWh and 0.155 kW in Multi-Family.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[188] Assumed to have the same lifetime as a regular programmable thermostat. Environmental Protection Agency (2010). *Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat*.
[189] Electric savings based on staff analysis with savings assumptions from Cadmus.
[190] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Wi-Fi Thermostat (controls gas heat only); Wi-Fi Thermostat	RHVAC, HES, LI 1-4 Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Wi-Fi Thermostat (controls elec cooling & gas heat); Wi-Fi Thermostat (also controls elec cooling)	RHVAC, HES, LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.00
Wi-Fi Thermostat, Electric (AC Only)	HES, LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.00
Wi-Fi Thermostat, Gas	HES, LI 1-4 Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Wi-Fi Thermostat, Gas with AC	HES, LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.00
Wi-Fi Thermostat, Oil	HES, LI 1-4 Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Wi-Fi Thermostat, Oil with AC	HES, LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.00
Wi-Fi Thermostat, Other	HES, LI 1-4 Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Wi-Fi Thermostat, Other with AC	HES, LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.00
Wi-Fi Thermostat, Electric (AC Only)	MF Retrofit, LI MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.00
Wi-Fi Thermostat, Oil	MF Retrofit, LI MF Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Wi-Fi Thermostat (controls gas heat only)	LI MF Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Wi-Fi Thermostat (controls gas heat only)	MF Retrofit	All	1.00	0.60	n/a	n/a	n/a	n/a
Wi-Fi Thermostat (controls elec cooling & gas heat)	LI MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.00
Wi-Fi Thermostat (controls elec cooling & gas heat)	MF Retrofit	All	1.00	0.60	1.00	1.00	1.00	0.00

In-Service Rates
All PAs assume 100% in service rate.

Realization Rates
Realization rates are set to 100% since deemed savings are based on evaluation results. For MF Retrofit the realization rate is based on draft evaluation results.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described the Cadmus Demand Impact Model.[191]

[191] Ibid

HVAC – Boiler Reset Control

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Boiler Reset Controls are devices that automatically control boiler water temperature based on outdoor or return water temperature using a software program.
Primary Energy Impact: Oil, Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Retrofit
End Use: HVAC
Measure Type: Controls
Core Initiative: Electric - Residential Home Energy Services, Gas - Residential Heating & Cooling Equipment, Electric - Low-Income Single Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results. [192,193]

Savings for Boiler Reset Controls

Measure Name	Core Initiative	Energy Type	ΔMMBtu/Unit
Boiler Reset Control, Oil	HES	Oil	4.7
Boiler Reset Control, Other	HES	Propane	4.5
Boiler Reset Control	RHVAC	Gas	4.5
Boiler Reset Controls, Oil	LI Retrofit 1-4	Oil	4.4

Baseline Efficiency

The baseline efficiency case is a boiler without reset controls.

High Efficiency

The high efficiency case is a boiler with reset controls.

Hours

Not applicable.

[192] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[193] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.

Measure Life

The measure life is 15 years.[194]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	PA Type	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Boiler Reset Controls	HES	All	Elec	1.00	1.00	n/a	n/a	n/a	n/a
Boiler Reset Controls	RHVAC	All	Gas	1.00	1.00	n/a	n/a	n/a	n/a
Boiler Reset Controls	LI Retrofit 1-4	All	Elec	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

[194] ACEEE (2006). Emerging Technologies Report: Advanced Boiler Controls. Prepared for ACEEE.

HVAC – Heat Recovery Ventilator

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Heat Recovery Ventilators (HRV) can help make mechanical ventilation more cost effective by reclaiming energy from exhaust airflows.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: Electric
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Measure Type: Ventilation
Core Initiative: Gas - Residential Heating & Cooling Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[195].

Savings for Heat Recovery Ventilator

Measure Name	ΔMMBtu/Unit
Heat Recovery Ventilator	7.7

Baseline Efficiency

The baseline efficiency case is an ASHRAE 62.2-compliant exhaust fan system with no heat recovery.

High Efficiency

The high efficiency case is an exhaust fan system with heat recovery.

Hours

Not applicable.

Measure Life

The measure life is 20 years.[196]

Secondary Energy Impacts

An electric penalty results due to the electricity consumed by the system fans.

[195] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks.
[196] Ibid.

Measure	**Energy Type**	**ΔkWh/Unit**[197]	**ΔkW/Unit**[198]
Heat Recovery Ventilator	Electric	-133	-0.07

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	**Program**	**PA**	**ISR**	**RR_E**	**RR_{SP}**	**RR_{WP}**	**CF_{SP}**	**CF_{WP}**
Heat Recovery Ventilator	Residential HEHE	All	1.00	1.00	1.00	1.00	0.00	1.00

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described the Cadmus Demand Impact Model .[199]

[197] Ibid
[198] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[199] Ibid.

HVAC – ECM Circulator Pump

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of high efficiency residential boiler circulator pumps, including electronically commutated variable speed air supply motors.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Retrofit
End Use: HVAC
Measure Type: Motors
Core Initiative: Electric - Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[200].

Savings for ECM Circulator Pump

Measure Name	ΔkWh	ΔkW[201]
Circulator Pump	142	0.08

Baseline Efficiency

The baseline efficiency case is the installation of a standard circulator pump.

High Efficiency

The high efficiency case is the installation of an ECM circulator pump.

Hours

Not applicable.

Measure Life

The measure life is 15 years. [202]

[200] The Cadmus Group (2012). *Impact Evaluation of the 2011-2012 ECM Circulator Pump Pilot Program.* Savings Values shown in MA PAs (2015). ECM Circulator Pump Savings Calculations Workbook.
[201] Ibid
[202] Assumed to be consistent with C&I Electric Motors & Drives – Energy & Resources Solutions (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities; Table 1-1.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Circulator Pump	RHVAC	All	1.00	1.00	1.00	1.00	0. 00	0.16

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based evaluation results[203].

[203] Ibid.

HVAC – Combo Condensing Boiler/Water Heater

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: This measure promotes the installation of a combined high-efficiency boiler and water heating unit. Combined boiler and water heating systems are more efficient than separate systems because they eliminate the standby heat losses of an additional tank.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Measure Type: Heating
Core Initiative: Gas - Residential Heating & Cooling Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results.[204]

Savings for Combination Water Heater/Boiler

Measure Name	ΔMMBtu/Unit
Combo Condensing Boiler/Water Heater 90%	10.3
Combo Condensing Boiler/Water Heater 95%	12.8

Baseline Efficiency

The baseline efficiency case is an 82% AFUE rated boiler (79.3% AFUE actual) with a 0.6 EF water heater. The ER baseline is an 80% AFUE rated boiler (77.4% AFUE actual) with either an indirect water heater or with a 0.55 EF water heater. 80% were indirect and 20% were storage water heaters.

High Efficiency

The high efficiency case is either an integrated water heater/boiler unit with a 90% AFUE condensing boiler (actual was 87.2% and a 0.9 EF water heater (actual was 87.2%) or a 95% AFUE condensing boiler (actual was 89.4%) and a 0.95 EF water heater(actual was 89.4% .

[204] The Cadmus Group (2015). *High Efficiency Heating Equipment Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts. Savings have been adjusted to reflect the mix of replace on failure and early replacement based on: The Cadmus Group (2013). *2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing*. Prepared for the Electric and Gas Program Administrators of Massachusetts. The calculation of the adjustment can be found in MA PAs (2015). 2016-2018 HEHE Savings Workbook.

Hours

Not applicable.

Measure Life

The measure life is 19 years.[205]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Combo Condensing Boiler/Water Heater 90%	RHVAC	All	1.00	1.00	n/a	n/a	n/a	n/a
Combo Condensing Boiler/Water Heater 95%	RHVAC	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

[205] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boiler*; measure life assumed to be the same as a boiler. Lifetime has been adjusted to reflect the mix of replace on failure and early replacement based on: The Cadmus Group (2013). *2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing*. Prepared for the Electric and Gas Program Administrators of Massachusetts. The calculation of the adjustment can be found in MA PAs (2015). 2016-2018 HEHE Savings Workbook.

HVAC – Boiler, Gas Forced Hot Water

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a new high efficiency gas-fired boiler for space heating.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Measure Type: Heating
Core Initiative: Gas - Residential Heating & Cooling Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are calculated based on deemed inputs and have been adjusted to reflect the mix of replace on failure and early replacement.[206]

Savings for Residential Boilers

Measure Name	Energy Type	ΔMMBtu
Boiler 90%	Gas	11.4
Boiler 95%	Gas	14.1

Baseline Efficiency

The baseline efficiency case is an 82% AFUE rated boiler (79.3% AFUE actual). The ER baseline is an 80% AFUE rated boiler (77.4% AFUE actual).

High Efficiency

The high efficiency case is a boiler with an AFUE rating of 90% or greater. Based on evaluation results the actual AFUE is 87.2% for a 90% AFUE rated boiler and 89.4% for a 95% AFUE rated boiler.

Hours

Not applicable.

[206] The Cadmus Group (2015). *High Efficiency Heating Equipment Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts Savings have been adjusted to reflect the mix of replace on failure and early replacement based on: The Cadmus Group (2013). *2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing*. Prepared for the Electric and Gas Program Administrators of Massachusetts. The calculation of the savings including this adjustment can be found in MA PAs (2015). 2016-2018 HEHE Savings Workbook.

Measure Life

The measure life is 20 years.[207]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	PA Type	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Boiler 90%	RHVAC	All	Gas	1.00	1.00	n/a	n/a	n/a	n/a
Boiler 95%	RHVAC	All	Gas	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

[207] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boiler*. Lifetime has been adjusted to reflect the mix of replace on failure and early replacement based on: The Cadmus Group (2013). *2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing*. Prepared for the Electric and Gas Program Administrators of Massachusetts. The calculation of the adjustment can be found in MA PAs (2015). 2016-2018 HEHE Savings Workbook.

HVAC – Boiler, Oil/Propane Forced Hot Water

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a new high efficiency boiler for space heating.
Primary Energy Impact: Oil, Propane
Secondary Energy Impact: Electric
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: HVAC
Measure Type: Heating
Core Initiative: Electric - Residential Home Energy Services

Algorithms for Calculating Primary Energy Impact

Unit savings are calculated based on deemed inputs.

ΔMMBtu = heating load MMBTUs * (1/AFUE base – 1/AFUEee)

Where:
Heating load = 96.51 MMBTUs[208]

Measure Name	Energy Type	ΔMMBtu/unit
Heating System Replacement (Boiler), Oil	Oil	2.7
Heating System Replacement (Boiler), Other	Propane	11.4

Baseline Efficiency

For oil the baseline efficiency case is a code compliant oil AFUE 84%[209] boiler. For propane the baseline is a code-compliant boiler (AFUE = 82%) adjusted by a degradation factor (0.967) to account for its metered efficiency (AFUE=79.3%).[210]

High Efficiency

For oil the high efficiency case is a new 86% AFUE oil boiler. For propane the high efficiency case AFUE 93% adjusted by a degradation factor (0.941) to account for its metered efficiency (AFUE=87.5%).[211]

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[208] The Cadmus Group, Inc. (2015). *High Efficiency Heating Equipment Impact Evaluation*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[209] http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/cacfurn_dfr.pdf
[210] The Cadmus Group, Inc. (2015). *High Efficiency Heating Equipment Impact Evaluation*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[211] Ibid.

Hours

Not applicable.

Measure Life

The measure life is 20 years.[212]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Heating System Replacement (Boiler), Oil	HES	All	1.00	1.00	n/a	n/a	n/a	n/a
Heating System Replacement (Boiler), Other	HES	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% since deemed savings are based on evaluation results.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

212 Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boiler*.

HVAC – Furnace, Gas

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a new high efficiency space heating furnace with an electronically commutated motor (ECM) for the fan.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: Electric
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Measure Type: Heating
Core Initiative: Gas - Residential Heating & Cooling Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are calculated based on deemed inputs and have been adjusted to reflect the mix of replace on failure and early replacement.[213]

Savings for Residential Furnaces

Measure Name	Energy Type	ΔMMBtu
Furnace w/ECM 95%	Gas	8.1
Furnace w/ECM 97%	Gas	9.2

Baseline Efficiency

For the replace on failure portion the baseline efficiency case is an 85% AFUE furnace.[214] For the early retirement portion the baseline efficiency is a 78% AFUE furnace (Actual 78.9% AFUE).

High Efficiency

The high efficiency case is either a new furnace with AFUE >= 95% (actual 95.4% AFUE) with an electronically commutated motor installed or AFUE >= 97% (Actual 97.2% AFUE) with an electronically commutated motor installed.

[213] The Cadmus Group (2015). *High Efficiency Heating Equipment Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts Savings have been adjusted to reflect the mix of replace on failure and early replacement based on: The Cadmus Group (2013). *2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing*. Prepared for the Electric and Gas Program Administrators of Massachusetts. The calculation of the savings including this adjustment can be found in MA PAs (2015). 2016-2018 HEHE Savings Workbook.

[214] Agreed upon value with EEAC consultants

Hours

Not applicable.

Measure Life

The measure life is 17 years.[215]

Secondary Energy Impacts

High efficiency furnaces equipped with ECM fan motors also save electricity from reduced fan energy requirements. See HVAC - Furnace Fan Motors (ECM).

ΔkWh = Average annual energy reduction per unit: 168 kWh
ΔkW = Average demand reduction per unit: 0.124 kW

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	PA Type	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Furnace w/ECM 95%	RHVAC	All	Gas	1.00	1.00	1.00	1.00	1.00	0.00	0.16
Furnace w/ECM 97%	RHVAC	All	Gas	1.00	1.00	1.00	1.00	1.00	0.00	0.16

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Coincident factors are based on evaluation results. See HVAC - Furnace Fan Motors (ECM).

[215] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Furnace*. Lifetime has been adjusted to reflect the mix of replace on failure and early replacement based on: The Cadmus Group (2013). *2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing*. Prepared for the Electric and Gas Program Administrators of Massachusetts. The calculation of the adjustment can be found in the 2016-2018 HEHE Savings Workbook.

HVAC – Furnace, Oil/Propane

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a new high efficiency space heating furnace. Electric savings can be attributed to reduced fan run time.
Primary Energy Impact: Oil, Propane
Secondary Energy Impact: Electric
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: HVAC
Measure Type: Heating
Core Initiative: Electric - Residential Home Energy Services

Algorithms for Calculating Primary Energy Impact

Unit savings are calculated based on deemed inputs.

ΔMMBtu = heating load MMBTUs * (1/AFUE base – 1/AFUEee)

Where:
Heating load = 58.35 MMBTUs[216]

Measure Name	Energy Type	ΔMMBtu/unit
Heating System Replacement (Furnace), Oil	Oil	2.5
Heating System Replacement (Furnace), Other	Propane	7.2

Baseline Efficiency

The baseline efficiency case is a code compliant oil furnace, AFUE 83%[217], or an 85% AFUE[218] propane furnace.

High Efficiency

The high efficiency case is a new 86% AFUE oil furnace or a 95% AFUE propane furnace.

Hours

Not applicable.

[216] The Cadmus Group, Inc. (2015). *High Efficiency Heating Equipment Impact Evaluation*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[217] http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/cacfurn_dfr.pdf
[218] Agreed upon value with EEAC consultants

Measure Life

The measure life is 18 years.[219]

Secondary Energy Impacts

For oil furnaces electric savings can be attributed to reduced fan run time. The unit savings are deemed based on study results. Propane high efficiency furnaces equipped with ECM fan motors also save electricity from reduced fan energy requirements. See HVAC - Furnace Fan Motors (ECM).

Measure Name	ΔkWh/unit	ΔkW/unit
Heating System Replacement (Furnace), Oil	98[220]	0.05[221]
Heating System Replacement (Furnace), Other	168	0.12

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Heating System Replacement (Furnace), Oil	HES	All	1.00	1.00	1.00	1.00	0.00	1.00
Heating System Replacement (Furnace), Other	HES	All	1.00	1.00	1.00	1.00	0.00	0.16

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% since deemed savings are based on evaluation results.

Coincidence Factors
- For Heating System Replacement (Furnace), Oil the summer and winter coincidence factors are estimated using demand allocation methodology described the Cadmus Demand Impact Model.[222]
- Heating System Replacement (Furnace), Other the coincident factors are based on evaluation results. See HVAC - Furnace Fan Motors (ECM).

[219] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Furnace*.
[220] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[221] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[222] Ibid.

HVAC – Early Retirement Boiler, Forced Hot Water

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Early retirement of inefficient forced hot water boiler and the installation of new high efficiency forced hot water boiler.
Primary Energy Impact: Natural Gas (Residential Heat), Oil, Propane
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: HVAC
Measure Type: Heating
Core Initiative: Gas - Residential Home Energy Services, Electric - Residential Home Energy Services

Algorithms for Calculating Primary Energy Impact

Unit savings for the early replacement of an existing boiler with a high efficiency boiler are counted in two parts: (1) early retirement savings for a code-compliant boiler compared to the existing boiler over the remaining lifetime of the existing boiler, and (2) efficiency savings for the high efficiency boiler compared to a code-compliant boiler for the full life of the new high efficiency boiler:

$$\Delta MMBtu = \Delta MMBtu_{RETIRE} + \Delta MMBtu_{EE}$$

$\Delta MMBtu_{RETIRE}$= *heating load MMBTUs * (1/AFUE base – 1/AFUEee)*
$\Delta MMBtu_{EE}$= *heating load MMBTUs * (1/AFUE base – 1/AFUEee)*

Where:

Unit	=	Removal of existing inefficient boiler and installation of new high efficiency boiler
$\Delta MMBtu_{RETIRE}$	=	Annual MMBtu savings of code-compliant boiler compared to existing boiler
$\Delta MMBtu_{EE}$	=	Annual MMBtu savings of high efficiency boiler compared to code-compliant boiler
Heating Load	=	96.51 MMBTUs for homes with boilers[223]

[223] The Cadmus Group (2015). *High Efficiency Heating Equipment Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.

Measure Name	Energy Type	MMBTU/unit[224]
Early Retirement Boiler, Forced Hot Water (EE)	Gas	11.4
Early Retirement Boiler, Forced Hot Water (Retire)	Gas	7.0
Early Retirement Boiler, Forced Hot Water (EE), Oil	Oil	2.7
Early Retirement Boiler, Forced Hot Water (Retire), Oil	Oil	13.8
Early Retirement Boiler, Forced Hot Water (EE), Other	Propane	11.4
Early Retirement Boiler, Forced Hot Water (Retire), Other	Propane	7.0

Baseline Efficiency

For the retirement savings over the remaining life of existing boiler, the baseline is the existing inefficient boiler estimated to be 75% AFUE for a forced hot water boiler. For the high efficiency unit savings over lifetime of the new boiler, the baseline for gas and propane boilers is a code-compliant boiler (AFUE = 82%) adjusted by a degradation factor (0.967) to account for its metered efficiency (AFUE=79.3%)[225]. For oil boilers the baseline is a code-compliant 84% AFUE boiler.

High Efficiency

For the retirement savings over the remaining life of existing boiler, the efficient case for gas and propane boilers is a code-compliant boiler (AFUE = 82%) adjusted by a degradation factor (0.967) to account for its metered efficiency (AFUE = 79.3%). For oil boilers the efficient case is a code-compliant 84% AFUE boiler. For the high efficiency savings over lifetime of the new boiler, the efficient case for gas and propane boilers is a new high efficiency boiler AFUE >= 93%) adjusted by a degradation factor (0.941) to account for its metered efficiency (AFUE >= 87.5%)[226]. For oil the efficient case is an 86% AFUE boiler.

Hours

Not applicable.

Measure Life

The remaining life for the existing unit is 10 years[227], and the measure life of new equipment is 20 years.[228]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[224] Calculated using information provided in The Cadmus Group (2015). *High Efficiency Heating Equipment Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[225] The Cadmus Group (2015). *High Efficiency Heating Equipment Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[226] Ibid.
[227] Agreed upon with EEAC consultants as a reasonable approximation for the number of years an existing boiler would continue to operate if it had not been replaced early due to the program.
[228] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boilers*.

One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	PA Type	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Early Retirement Boiler, Forced Hot Water (EE)	HES	All	Gas	1.00	1.00	n/a	n/a	n/a	n/a
Early Retirement Boiler, Forced Hot Water (Retire)	HES	All	Gas	1.00	1.00	n/a	n/a	n/a	n/a
Early Retirement Boiler, Forced Hot Water (EE), Oil	HES	All	Elec	1.00	1.00	n/a	n/a	n/a	n/a
Early Retirement Boiler, Forced Hot Water (Retire), Oil	HES	All	Elec	1.00	1.00	n/a	n/a	n/a	n/a
Early Retirement Boiler, Forced Hot Water (EE), Other	HES	All	Elec	1.00	1.00	n/a	n/a	n/a	n/a
Early Retirement Boiler, Forced Hot Water (Retire), Other	HES	All	Elec	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

HVAC – Early Retirement Boiler, Steam

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Early retirement of inefficient steam boiler and the installation of new high efficiency steam boiler.
Primary Energy Impact: Natural Gas (Residential Heat), Oil, Propane
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: HVAC
Measure Type: Heating
Core Initiative: Gas - Residential Home Energy Services, Electric - Residential Home Energy Services

Algorithms for Calculating Primary Energy Impact

Unit savings for the early replacement of an existing boiler with a high efficiency boiler are counted in two parts: (1) early retirement savings for a code-compliant boiler compared to the existing boiler over the remaining lifetime of the existing boiler, and (2) efficiency savings for the high efficiency boiler compared to a code-compliant boiler for the full life of the new high efficiency boiler:

$$\Delta MMBtu = \Delta MMBtu_{RETIRE} + \Delta MMBtu_{EE}$$

$\Delta MMBtu_{RETIRE}$= *heating load MMBTUs * (1/AFUE base – 1/AFUEee)*
$\Delta MMBtu_{EE}$= *heating load MMBTUs * (1/AFUE base – 1/AFUEee)*

Where:

Unit	=	Removal of existing inefficient boiler and installation of new high efficiency boiler
$\Delta MMBtu_{RETIRE}$	=	Annual MMBtu savings of code-compliant boiler compared to existing boiler
$\Delta MMBtu_{EE}$	=	Annual MMBtu savings of high efficiency boiler compared to code-compliant boiler
Heating Load	=	96.51 MMBTUs for homes with boilers[229]

[229] The Cadmus Group (2015). *High Efficiency Heating Equipment Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.

Measure Name	Energy Type	MMBTU/unit[230]
Early Retirement Boiler, Steam (EE)	Gas	2.9
Early Retirement Boiler, Steam (Retire)	Gas	8.0
Early Retirement Boiler, Steam (EE), Oil	Oil	2.8
Early Retirement Boiler, Steam (Retire), Oil	Oil	11.0
Early Retirement Boiler, Steam (EE), Other	Propane	2.9
Early Retirement Boiler, Steam (Retire), Other	Propane	8.0

Baseline Efficiency

For the retirement savings over the remaining life of existing boiler, the baseline is the existing inefficient boiler estimated to be 75% AFUE for a forced hot water boiler. For the high efficiency unit savings over lifetime of the new boiler, the baseline for gas and propane boilers is a code-compliant 80% AFUE boiler. For oil boilers the baseline is a code-compliant 82% AFUE boiler.

High Efficiency

For the retirement savings over the remaining life of existing boiler, the efficient case for gas and propane boilers is a code-compliant 80% AFUE boiler and for oil boilers it is a code-compliant 82% AFUE boiler. For the high efficiency savings over lifetime of the new boiler, the efficient case for gas and propane boilers is a new high efficiency 82% AFUE boiler and for oil it is an 84% AFUE boiler.

Hours

Not applicable.

Measure Life

The remaining life for the existing unit is 10 years[231], and the measure life of new equipment is 20 years.[232]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[230] Calculated using information provided in The Cadmus Group (2015). *High Efficiency Heating Equipment Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[231] Agreed upon with EEAC consultants as a reasonable approximation for the number of years an existing boiler would continue to operate if it had not been replaced early due to the program.
[232] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boilers*.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	PA Type	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Early Retirement Boiler, Steam (EE)	HES	All	Gas	1.00	1.00	n/a	n/a	n/a	n/a
Early Retirement Boiler, Steam (Retire)	HES	All	Gas	1.00	1.00	n/a	n/a	n/a	n/a
Early Retirement Boiler, Steam (EE), Oil	HES	All	Elec	1.00	1.00	n/a	n/a	n/a	n/a
Early Retirement Boiler, Steam (Retire), Oil	HES	All	Elec	1.00	1.00	n/a	n/a	n/a	n/a
Early Retirement Boiler, Steam (EE), Other	HES	All	Elec	1.00	1.00	n/a	n/a	n/a	n/a
Early Retirement Boiler, Steam (Retire), Other	HES	All	Elec	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

HVAC – Early Retirement Furnace

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Early retirement of inefficient furnace and installation of new high efficiency furnace
Primary Energy Impact: Oil, Propane, Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: HVAC
Measure Type: Heating
Core Initiative: Gas - Residential Home Energy Services, Electric - Residential Home Energy Services

Algorithms for Calculating Primary Energy Impact

Unit savings for the early replacement of an existing furnace with a high efficiency furnace are counted in two parts: (1) early retirement savings for a code-compliant furnace compared to the existing furnace over the remaining lifetime of the existing furnace, and (2) efficiency savings for the high efficiency furnace compared to a code-compliant furnace for the full life of the new high efficiency furnace:

$$\Delta MMBtu = \Delta MMBtu_{RETIRE} + \Delta MMBtu_{EE}$$

$\Delta MMBtu_{RETIRE}$= *heating load MMBTUs * (1/AFUE base – 1/AFUEee)*
$\Delta MMBtu_{EE}$= *heating load MMBTUs * (1/AFUE base – 1/AFUEee)*

Where:

Unit	=	Removal of existing inefficient furnace and installation of new high efficiency furnace
$\Delta MMBtu_{RETIRE}$	=	Annual MMBtu savings of code-compliant furnace compared to existing furnace
$\Delta MMBtu_{EE}$	=	Annual MMBtu savings of high efficiency furnace compared to code-compliant furnace
Heating Load	=	58.3 MMBTUs for homes with furnace [233]

[233] The Cadmus Group (2015). *High Efficiency Heating Equipment Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.

Savings for Early Retirement Furnaces

Measure Name	Energy Type	MMBTU/unit[234]
Early Retirement Furnace, (EE)	Gas	7.2
Early Retirement Furnace, (Retire)	Gas	6.2
Early Retirement Furnace (EE), Oil	Oil	2.5
Early Retirement Furnace (Retire), Oil	Oil	4.5
Early Retirement Furnace (EE), Other	Propane	7.2
Early Retirement Furnace (Retire), Other	Propane	6.2

Baseline Efficiency

For the retirement savings over the remaining life of existing furnace, the baseline is the existing inefficient furnace estimated to be 78% AFUE. For the high efficiency unit savings over lifetime of the new furnace, for gas and propane the baseline is an 85% AFUE furnace and for oil the baseline is an 83% AFUE furnace.

High Efficiency

For the retirement savings over the remaining life of existing furnace, the efficient case for gas and propane is an 85% AFUE furnace for oil it is an 83% AFUE furnace. For the high efficiency savings over the lifetime of the new furnace, the efficient case for gas and propane is a new high efficiency AFUE 95% furnace and for oil it is an 86% AFUE furnace.

Hours

Not applicable.

Measure Life

The remaining life for the existing unit is 6 years[235], and the measure life of new equipment is 18 years.[236]

Secondary Energy Impacts

High efficiency furnaces equipped with ECM fan motors also save electricity from reduced fan energy requirements. See HVAC - Furnace Fan Motors.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[234] Calculated using information provided in The Cadmus Group (2015). *High Efficiency Heating Equipment Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[235] Agreed upon with EEAC consultants as a reasonable approximation for the number of years an existing furnace would continue to operate if it had not been replaced early due to the program.
[236] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Furnace*.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	PA Type	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Early Retirement Furnace, (EE)	HES	All	Gas	1.00	1.00	1.00	1.00	0.00	0.16
Early Retirement Furnace, (Retire)	HES	All	Gas	1.00	1.00	1.00	1.00	0.00	0.16
Early Retirement Furnace (EE), Oil	HES	All	Elec	1.00	1.00	1.00	1.00	0.00	0.16
Early Retirement Furnace (Retire), Oil	HES	All	Elec	1.00	1.00	1.00	1.00	0.00	0.16
Early Retirement Furnace (EE), Other	HES	All	Elec	1.00	1.00	1.00	1.00	0.00	0.16
Early Retirement Furnace (Retire), Other	HES	All	Elec	1.00	1.00	1.00	1.00	0.00	0.16

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Coincident factors are based on evaluation results. See HVAC - Furnace Fan Motors

HVAC – Boiler Retrofit

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Replacement of an old inefficient space heating boiler with a new boiler.
Primary Energy Impact: Oil, Propane, Natural Gas (Residential Heat)
Secondary Energy Impact: Electric
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: HVAC
Measure Type: Heating
Core Initiative: Electric - Low-Income Single Family Retrofit, Gas - Low-Income Single Family Retrofit, Gas- Low-Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results.[237]

Measure Name	PA	PA Type	Energy Type	ΔMMBtu
Heating System Retrofit, Boiler, Oil	All	Elec	Oil	20.4
Heating System Retrofit, Boiler, Other	All	Elec	Propane	19.4
Heating System Retrofit, Boiler	All	Gas	Gas	19.4

Baseline Efficiency

The baseline efficiency case is the existing inefficient furnace

High Efficiency

The high efficiency case is the new efficient furnace.

Hours

Not applicable.

Measure Life

The measure life is 20 years.[238]

[237] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[238] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Boiler.*

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Heating System Retrofit, Boiler, Oil	LI 1-4 Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Heating System Retrofit, Boiler, Other	LI 1-4 Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Heating System Retrofit, Boiler	LI 1-4 Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Heating System Retrofit, Boiler	LI MF Retrofit	Liberty	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% since deemed savings are based on evaluation results.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

HVAC – Furnace Retrofit

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Replacement of an old inefficient space heating furnace with a new furnace.
Primary Energy Impact: Oil, Propane, Natural Gas (Residential Heat)
Secondary Energy Impact: Electric
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: HVAC
Measure Type: Heating
Core Initiative: Electric - Low-Income Single Family Retrofit, Gas - Low-Income Single Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results.[239]

Measure Name	PA	PA Type	Energy Type	ΔMMBtu/unit
Heating System Retrofit, Furnace, Oil	All	Elec	Oil	14.3
Heating System Retrofit, Furnace, Other	All	Elec	Propane	20.7
Heating System Retrofit, Furnace	All	Gas	Gas	20.7

Baseline Efficiency

The baseline efficiency case is the existing inefficient furnace

High Efficiency

The high efficiency case is the new efficient furnace.

Hours

Not applicable.

Measure Life

The measure life is 18 years.[240]

[239] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[240] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Furnace.*

Secondary Energy Impacts

Electric savings can be attributed to reduced fan run time. The unit savings are deemed based on study results[241]

Measure	PA Type	ΔkWh/unit	ΔkW/Unit[242]
Heating System Retrofit, Furnace, Oil	Elec	132	0.07
Heating System Retrofit, Furnace, Other	Elec	172	0.09
Heating System Retrofit, Furnace	Gas	172	0.09

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Heating System Retrofit, Furnace, Oil	LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	0.00	1.00
Heating System Retrofit, Furnace, Other	LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	0.00	1.00
Heating System Retrofit, Furnace	LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	0.00	1.00

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% since deemed savings are based on evaluation results.

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[243]

[241] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[242] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[243] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

HVAC – Heating System

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of high efficiency heating equipment to replace the existing inefficient furnace, hydronic boiler or steam boiler.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: HVAC
Measure Type: Heating
Core Initiative: Gas- Low-Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta MMBtu = \frac{Btu}{hr} \times \left(\frac{1}{AFUE_{BASE}} - \frac{1}{AFUE_{EE}} \right) \times EFLH_{Heat} \times \frac{1}{1{,}000{,}000}$$

Where:

Btu/hr	=	Nominal heating capacity of the installed equipment (Btu/hr)
$AFUE_{BASE}$	=	Average fuel utilization efficiency of the existing equipment (%)
$AFUE_{EE}$	=	Average fuel utilization efficiency of the efficient equipment (%)
$EFLH_{Heat}$	=	Equivalent full load heating hours for the facility (Hr)
1/1,000,000	=	Conversion from Btu to MMBtu

Baseline Efficiency

The baseline efficiency is determined based on the type of heating equipment installed. For boilers it is 75% AFUE and for furnaces it is 78% AFUE..

High Efficiency

The high efficiency case is characterized by the rated efficiency ($AFUE_{EE}$) of the new high efficiency furnace or boiler.

Hours

The equivalent full load hours are assumed to be 1,418 for all multi-family residential facilities in Massachusetts.

Measure Life

Measure Name	Lifetime (years)
Heating System Retrofit, Boiler	20 [244]
Heating System Retrofit, Furnace	18 [245]
Heating System Retrofit, Commercial Boiler	25

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Heating System Retrofit, Boiler	LI MF Retrofit	National Grid	1.00	0.75	n/a	n/a	n/a	n/a
Heating System Retrofit, Furnace	LI MF Retrofit	National Grid	1.00	0.75	n/a	n/a	n/a	n/a
Heating System Retrofit, Boiler	LI MF Retrofit	Berkshire	1.00	0.80	n/a	n/a	n/a	n/a
Heating System Retrofit, Furnace	LI MF Retrofit	Berkshire	1.00	0.80	n/a	n/a	n/a	n/a
Heating System Retrofit, Boiler	LI MF Retrofit	Columbia, Unitil	1.00	0.96	n/a	n/a	n/a	n/a
Heating System Retrofit, Furnace	LI MF Retrofit	Columbia, Unitil	1.00	0.96	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since all PA programs include verification of equipment installations.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
The realization rate is based on evaluation results[246].

Coincidence Factors
There are no electric savings for this measure.

[244] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boilers*.
[245] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Furnace*.
[246] The Cadmus Group, Inc. (2015). *Massachusetts Low-Income Multifamily Initiative Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.

Lighting – CFL Bulbs

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Compact fluorescent lamps offer comparable luminosity to incandescent and halogen lamps at significantly less wattage and significantly longer lamp lifetimes.
Primary Energy Impact: Electric
Secondary Energy Impact: Natural Gas (Residential Heat)
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Lost Opportunity, Retrofit
End Use: Lighting
Measure Type: Interior
Core Initiative: Residential Lighting, Residential New Construction, Residential Home Energy Services, Electric - Low-Income Single Family Retrofit, Electric - Multi-Family Retrofit, Electric - Low-Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are calculated using deemed inputs based on study results:

$$\Delta kW = \Delta watts \; / 1000$$
$$\Delta kWh = \Delta kW * hours$$

Where:
ΔkW = Average kW reduction[247,248]
hours = Hours of use[249]

Factors for Calculating Savings for Residential CFL Bulbs

Measure Name	Core Initiative	PA	2016 Δwatts	2017 Δwatts	2018 Δwatts	Hours
CFL Bulb	Res Lighting	All	44.1	42.0	38.3	1,200
CFL Bulb (EISA Exempt)	Res Lighting	All	43.6	43.6	43.6	1,200
CFL Bulb (Hard to Reach)	Res Lighting	All	44.1	42.0	38.3	1,200
CFL Bulb (School Fundraiser)	Res Lighting	All	44.1	42.0	38.3	1,058
CFL Bulb	HES, RNC	All	44.1	42.0	38.3	986
CFL Bulb	LI Retrofit 1-4	All	44.1	42.0	38.3	986
CFL Bulb	MF Retrofit	Eversource	44.1	41.9	38.8	986
CFL Bulb	LI MF Retrofit	Eversource, CLC	44.1	38.9	35.9	986

[247] NMR Group (2015). *Baseline Sensitivity Analysis Spreadsheet, 2016-2018 Plan Version.* Prepared for the Massachusetts PAs.
[248] The Cadmus Group, Inc. (2015). *Massachusetts Low-Income Multifamily Initiative Impact Evaluation*. Prepared for the Electric and Gas Program Administrators of MA.
[249] NMR Group Inc. (2014). *Northeast Residential Lighting Hours of Use Study.*

Savings for Residential CFLs

Measure Name	Core Initiative	PA	2016 ΔkW	2017 ΔkW	2018 ΔkW	2016 ΔkWh	2017 ΔkWh	2018 ΔkWh
CFL Bulb	Res Lighting	All	0.04	0.04	0.04	53.0	50.4	46.0
CFL Bulb (EISA Exempt)	Res Lighting	All	0.04	0.04	0.04	52.4	52.4	52.4
CFL Bulb (Hard to Reach)	Res Lighting	All	0.04	0.04	0.04	53.0	50.4	46.0
CFL Bulb (School Fundraiser)	Res Lighting	All	0.04	0.04	0.04	53.0	50.4	46.0
CFL Bulb	HES, RNC, LI Retrofit 1-4	All	0.04	0.04	0.04	43.4	41.3	37.8
CFL Bulb	MF Retrofit	Eversource	0.04	0.04	0.04	43.4	41.3	37.8
CFL Bulb	LI MF Retrofit	Eversource, CLC	0.04	0.04	0.04	40.8	38.3	35.3

Baseline Efficiency

The baseline efficiency case is a combination of an incandescent bulb and halogen bulb.

High Efficiency

The high efficiency case is an ENERGY STAR® rated CFL bulb.

Hours

Average annual operating hours for efficient bulbs in the Res Lighting program are 1,200 hours/year ((93%*2.9 hours/day + 7% *8.46 hours/day)* 365 days/year). [250, 251,252] Average annual operating hours for all bulbs in the HES, RNC, LI Retrofit 1-4, MF Retrofit and LI MF Retrofit programs are 985.5 hours/year (2.7 hours/day * 365 days/year). [253,]

Measure Life

The measure life for bulbs with an EISA exempt baseline is 7 years.[254] For Residential Lighting the adjusted measure life is 4 years for screw-in bulbs in 2016 – 2018 and for all other initiatives the adjusted measure life is 5 years in 2016 and 4 years in 2017-2018.[255]

Secondary Energy Impacts

There is a heat loss of 2,237 Btu/kWh counted for bulbs sold upstream.[256]

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[250] NMR Group Inc. (2014). *Northeast Residential Lighting Hours of Use Study.* The study recommended the use of the regional lighting hours of use numbers for both the efficient and all bulb lighting values.
[251] The Cadmus Group, Inc. (2015). *Massachusetts Residential Lighting Cross-Sector Sales Research.*
[252] DNV-GL (2015). Massachusetts Commercial and Industrial Upstream Lighting Program: "In Storage" Lamps Follow-Up Study
[253] NMR Group Inc. (2014). *Northeast Residential Lighting Hours of Use Study.* The study recommended the use of the regional lighting hours of use numbers for both the efficient and all bulb lighting values.
[254] The calculated measure life for screw-in bulbs is 8, based on a component life of 8,000 and hours of use of 1,200.
[255] MA PAs (2015). 2016-2018 MA Lighting Worksheet
[256] The Cadmus Group, Inc. (2015). *Lighting Interactive Effects Study Preliminary Results*. For the upstream program only.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
CFL Bulb	Res Lighting	All	0.95	1.00	1.00	1.00	0.14	0.18
CFL Bulb (EISA Exempt)	Res Lighting	All	0.95	1.00	1.00	1.00	0.14	0.18
CFL Bulb (Hard to Reach)	Res Lighting	All	1.00	1.00	1.00	1.00	0.14	0.18
CFL Bulb (School Fundraiser)	Res Lighting	All	0.50	1.00	1.00	1.00	0.14	0.18
CFL Bulb	RNC	All	0.99	1.00	1.00	1.00	0.13	0.16
CFL Bulb	HES	All	1.00	1.00	1.00	1.00	0.13	0.16
CFL Bulb	LI Retrofit 1-4	All	1.00	1.00	1.00	1.00	0.13	0.16
CFL Bulb	MF Retrofit	Eversource	0.97	0.60	0.60	0.60	0.13	0.16
CFL Bulb	LI MF Retrofit	Eversource, CLC	1.00	1.00	1.00	1.00	0.17	1.00

In-Service Rate

- Res Lighting: Baseline Sensitivity Analysis Spreadsheet, 2016-2018 Plan Version.[257]
- HTR, LI Retrofit 1-4, LI MF Retrofit: PAs assume a 100% installation rate.
- MF Retrofit: 2012 MF Impact Analysis.[258]
- RNC: 2006 ENERGY STAR® Homes New Homebuyer Survey Report[259]
- HES: Impact evaluation of the HES program[260]

Realization Rates

Realization rates are 100% since savings estimates are based on evaluation results except for MF Retrofit which is based on MA Common Assumptions.

Coincidence Factors

Coincidence factors are based on the 2014 Lighting Hours of Use Study for all initiatives except for LI MF Retrofit which is estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012).[261,262]

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[257] MA PAs (2015). 2016-2018 MA Lighting Worksheet
[258] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.
[259] Nexus Market Research & Dorothy Conant (2006). *Massachusetts ENERGY STAR® Homes: 2005 Baseline Study: Part II: Homeowner Survey Analysis Incorporating Inspection Data Final Report.* Prepared for the Massachusetts Joint Management Committee.
[260] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[261] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.
[262] NMR Group Inc. (2014). *Northeast Residential Lighting Hours of Use Study.*

Lighting – CFL Fixtures

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The installation of ENERGY STAR® compact fluorescent (CFL) indoor or outdoor fixtures. Compact fluorescent fixtures offer comparable luminosity to incandescent or halogen fixtures at significantly less wattage and significantly longer lifetimes.
Primary Energy Impact: Electric
Secondary Energy Impact: Natural Gas (Residential Heat)
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Lost Opportunity, Retrofit
End Use: Lighting
Measure Type: Interior
Core Initiative: Electric – Residential Lighting

Algorithms for Calculating Primary Energy Impact

For Residential Lighting unit savings are deemed based on the following algorithms, which use averaged inputs.

$$\Delta kW = Bulbs \times Save_{kW}$$
$$\Delta kWh = \Delta kW \times hours$$

Where:

Bulbs = Average # of bulbs per indoor unit:1.49[263]
$Save_{kw}$ = Average kW savings per bulb : See Lighting – CFL Bulbs
Hours = Annual hours of use : 1,200 for Res Lighting and 985.5 for RNC, LI RNC

Savings for CFL Fixtures

Measure Name	Core Initiative	PA	2016 ΔkW	2017 ΔkW	2018 ΔkW	2016 ΔkWh	2017 ΔkWh	2018 ΔkWh
Fixture	Res Lighting	All	0.07	0.06	0.06	78.9	75.1	68.6

Baseline Efficiency

The baseline efficiency case is an incandescent or halogen, screw-based fixture with an incandescent or halogen lamp.

[263] NMR Group, Inc. (2013). *Results of the Massachusetts Onsite Lighting Inventory.* Prepared for the Massachusetts PAs.

High Efficiency

The high efficiency case is an ENERGY STAR® qualified compact fluorescent light fixture wired for exclusive use with pin-based CFLs.

Hours

Average annual operating hours for efficient fixtures in the Residential Lighting program are 1,200 hours/year ((93%*2.9 hours/day + 7% *8.46 hours/day)* 365 days/year). [264, 265,266]

Measure Life

The adjusted measure life is 4 years for Residential Lighting for 2016 – 2018.[267]

Secondary Energy Impact

There is a heat loss of 2,237 Btu/kWh counted for fixtures sold upstream. [268].

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Fixture	Res Lighting	All	0.95	1.00	1.00	1.00	0.14	0.18

In-Service Rates
2004 Impact Evaluation of MA, RI, VT Residential Lighting Program[269]

Realization Rates
Realization rates are set to 100% since deemed savings are based on evaluation results.

Coincidence Factors
Coincidence factors are based on the 2014 Lighting Hours of Use Study[270].

264 NMR Group Inc. (2014). *Northeast Residential Lighting Hours of Use Study.* The study recommended the use of the regional lighting hours of use numbers for both the efficient and all bulb lighting values.
265 The Cadmus Group, Inc. (2015). *Massachusetts Residential Lighting Cross-Sector Sales Research.*
266 DNV-GL (2015). Massachusetts Commercial and Industrial Upstream Lighting Program: "In Storage" Lamps Follow-Up Study
267 MA PAs (2015). 2016-2018 MA Lighting Worksheet
268 Cadmus (2015) Lighting Interactive Effects Study Preliminary Results; For the upstream program only.
269 Nexus Market Research and RLW Analytics (2004). *Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs*. Submitted to The Cape Light Compact, State of Vermont Public Service Department for Efficiency Vermont, National Grid, Northeast Utilities, Eversource (NSTAR) and Unitil Energy Systems, Inc.; Page 11.
270 NMR Group Inc. (2014). *Northeast Residential Lighting Hours of Use Study.*

Lighting – LED Bulbs

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The installation of Light-Emitting Diode (LED) screw-in bulbs. LEDs offer comparable luminosity to incandescent and halogen bulbs at significantly less wattage and significantly longer lamp lifetimes.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Lost Opportunity
End Use: Lighting
Measure Type: Interior
Core Initiative: Residential Lighting, Electric - Residential Home Energy Services, Electric - Low-Income Single Family Retrofit, Electric - Low-Income Multi-Family Retrofit, Electric – Residential New Construction

Algorithms for Calculating Primary Energy Impact

Unit savings are based on the following algorithms which use averaged inputs:

$$\Delta kW = \Delta watts \ / 1000$$
$$\Delta kWh = \Delta kW * hours$$

Where:
ΔkW = Average kW reduction[271,272]
hours = Hours of use

[271] NMR Group (2015). *Baseline Sensitivity Analysis Spreadsheet, 2016-2018 Plan Version.* Prepared for the Massachusetts PAs.
[272] The Cadmus Group, Inc. (2015). *Massachusetts Low-Income Multifamily Initiative Impact Evaluation*. Prepared for the Electric and Gas Program Administrators of MA.

Factors for Calculating Savings for Residential LED Bulbs

Measure Name	Core Initiative	PA	2016 Δwatts	2017 Δwatts	2018 Δwatts	Hours
LED Bulb	Res Lighting	All	33.5	31.0	28.4	1200
LED (EISA Exempt)	Res Lighting	All	43.6	43.6	43.6	1200
LED Bulb (Hard to Reach)	Res Lighting	All	33.4	31.0	28.4	1200
LED Bulb (School Fundraiser)	Res Lighting	All	33.5	31.0	28.4	1,058
LED Bulb (Reflectors)	Res Lighting	All	47.6	47.6	47.6	1200
LED Bulb	HES	All	48.3	46.3	43.6	986
LED Bulb	LI Retrofit 1-4	All	48.3	46.3	43.6	986
LED Bulb	MF Retrofit	Eversource	48.3	46.3	43.6	986
LED Bulb	LI MF Retrofit	Eversource, CLC	55.9	53.1	50.0	986
LED Bulb	RNC	All	33.5	31.0	28.4	986

Savings for Residential LEDs

Measure Name	Core Initiative	PA	2016 ΔkW	2017 ΔkW	2018 ΔkW	2016 ΔkWh	2017 ΔkWh	2018 ΔkWh
LED Bulb	Res Lighting	All	0.03	0.03	0.03	40.2	37.3	34.1
LED (EISA Exempt)	Res Lighting	All	0.04	0.04	0.04	52.4	52.4	52.4
LED Bulb (Hard to Reach)	Res Lighting	All	0.03	0.03	0.03	40.2	37.3	34.1
LED Bulb (School Fundraiser)	Res Lighting	All	0.03	0.03	0.03	35.4	32.9	40.0
LED Bulb (Reflectors)	Res Lighting	All	0.05	0.05	0.05	57.2	57.2	57.2
LED Bulb	HES	All	0.05	0.05	0.04	47.6	45.6	43.0
LED Bulb	MF Retrofit	Eversource	0.05	0.05	0.04	47.6	45.6	43.0
LED Bulb	LI Retrofit 1-4	All	0.05	0.05	0.04	47.6	45.6	43.0
LED Bulb	LI MF Retrofit	Eversource, CLC	0.06	0.05	0.05	55.1	52.4	49.2
LED Bulb	RNC	All	0.03	0.03	0.03	33.0	30.6	28.0

Baseline Efficiency

The baseline efficiency case for the Res Lighting and RNC initiatives is a combination of an incandescent bulb, halogen bulb, and a compact fluorescent bulb. The baseline efficiency case for direct install retrofit initiatives is a combination of an incandescent bulb and halogen bulb.

High Efficiency

The high efficiency case is an ENERGY STAR® rated LED bulb.

Hours

Average annual operating hours for efficient bulbs in the Res Lighting program are 1,200 hours/year ((93%*2.9 hours/day + 7% *8.46 hours/day)* 365 days/year).[273, 274,275] Average annual operating hours for all bulbs in the HES, RNC, LI RNC, LI Retrofit 1-4, MF Retrofit and LI MF Retrofit programs are 985.5 hours/year (2.7 hours/day * 365 days/year).[276]

Measure Life

The measure life for LED EISA Exempt Baseline and Reflectors is 17 years.[277] In the Res Lighting program the adjusted measure life for LED bulbs is 8 years. In the HES, RNC, LI RNC, LI Retrofit 1-4, MF Retrofit and LI MF Retrofit programs the adjusted measure life is 9 years.[278]

Secondary Energy Impacts

There is a heat loss of 2,237 Btu/kWh counted for bulbs sold upstream.[279]

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
LED Bulb	Res Lighting	All	0.98	1.00	1.00	1.00	0.14	0.18
LED (EISA Exempt)	Res Lighting	All	0.98	1.00	1.00	1.00	0.14	0.18
LED Bulb (Hard to Reach)	Res Lighting	All	1.00	1.00	1.00	1.00	0.14	0.18
LED Bulb (School Fundraiser)	Res Lighting	All	0.50	1.00	1.00	1.00	0.14	0.18
LED Bulb (Reflectors)	Res Lighting	All	0.98	1.00	1.00	1.00	0.14	0.18
LED Bulb	HES, LI Retrofit 1-4, RNC	All	1.00	1.00	1.00	1.00	0.13	0.16
LED Bulb	MF Retrofit	Eversource	0.97	0.60	0.60	0.60	0.13	0.16
LED Bulb	LI MF Retrofit	Eversource, CLC	1.00	1.00	1.00	1.00	0.17	1.00
LED Bulb	RNC	All	1.00	1.00	1.00	1.00	0.13	0.16

[273] NMR Group Inc. (2014). *Northeast Residential Lighting Hours of Use Study.* The study recommended the use of the regional lighting hours of use numbers for both the efficient and all bulb lighting values.
[274] The Cadmus Group (2015). *Massachusetts Residential Lighting Cross-Sector Sales Research.*
[275] DNV-GL (2015). Massachusetts Commercial and Industrial Upstream Lighting Program: "In Storage" Lamps Follow-Up Study
[276] NMR Group Inc. (2014). *Northeast Residential Lighting Hours of Use Study.* The study recommended the use of the regional lighting hours of use numbers for both the efficient and all bulb lighting values.
[277] MA PAs (2015). 2016-2018 MA Lighting Worksheet
[278] Ibid.
[279] The Cadmus Group (2015) Lighting Interactive Effects Study Preliminary Results; for the upstream program only.

In-Service Rates

- Res Lighting: Baseline Sensitivity Analysis Spreadsheet, 2016-2018 Plan Version.[280]
- HTR, LI Retrofit 1-4 and LI MF Retrofit: PAs assume a 100% installation rate.
- RNC: 2006 ENERGY STAR® Homes New Homebuyer Survey Report[281]
- MF Retrofit: MF Retrofit: 2012 MF Impact Analysis.[282]
- HES: Impact evaluation of the HES program[283]

Realization Rates

Realization rates are based on Massachusetts Common Assumptions except for MF Retrofit which is based on MA Common Assumptions.

Coincidence Factors

Coincidence factors are based on the 2014 Lighting Hours of Use Study for all initiatives except for LI MF Retrofit which is estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012).[284,285]

[280] MA PAs (2015). 2016-2018 MA Lighting Worksheet

[281] Nexus Market Research & Dorothy Conant (2006). *Massachusetts ENERGY STAR® Homes: 2005 Baseline Study: Part II: Homeowner Survey Analysis Incorporating Inspection Data Final Report.* Prepared for the Massachusetts Joint Management Committee.

[282] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.

[283] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation*. Prepared for the Electric and Gas Program Administrators of Massachusetts.

[284] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

[285] NMR Group Inc. (2014). *Northeast Residential Lighting Hours of Use Study.*

Lighting – LED Fixtures

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The installation of Light-Emitting Diode (LED) fixtures. LEDs offer comparable luminosity to incandescent or halogen bulbs at significantly less wattage and significantly longer lamp lifetimes.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Lost Opportunity
End Use: Lighting
Measure Type: Interior
Core Initiative: Residential Lighting, Electric – Low-Income Single Family Retrofit, Electric - Low-Income Multi-Family Retrofit, Electric - Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

For LI Retrofit 1-4 unit savings are deemed based on study results[286].

Savings for Single Family Low-Income Fixtures

Measure Name	Core Initiative	ΔkWh	ΔkW[287]
Indoor Fixture	LI Retrofit 1-4	140	0.14

For Residential Lighting MF Retrofit and LI MF Retrofit unit savings are based on the following algorithms which use averaged inputs.

$$\Delta kW = Bulbs \times Save_{kW}$$
$$\Delta kWh = \Delta kW \times hours$$

Where:

Bulbs	=	Average # of bulbs per unit for indoor is 1.49 and for outdoor it is 2.0[288]
$Save_{kw}$	=	Average kW savings per bulb : See Lighting – LED Bulbs[289]
Hours	=	Annual hours of use : 1,200 for Res Lighting and 985.5 for MF Retrofit and LI MF Retrofit

Savings for Residential LED Fixtures

[286] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[287] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[288] NMR Group, Inc. (2013). *Results of the Massachusetts Onsite Lighting Inventory.* Prepared for the Massachusetts PAs.
[289] NMR Group (2015). *Baseline Sensitivity Analysis Spreadsheet, 2016-2018 Plan Version.* Prepared for the Massachusetts PAs.

Measure Name	Core Initiative	2016 ΔkW	2017 ΔkW	2018 ΔkW	2016 ΔkWh	2017 ΔkWh	2018 ΔkWh
LED Fixture	Res Lighting	0.05	0.05	0.04	59.9	55.5	50.8
In Unit Indoor LED Fixture	MF Retrofit	0.07	0.08	0.06	70.9	68.0	64.0
In Unit Outdoor LED Fixture	MF Retrofit	0.10	0.09	0.09	95.0	91.3	86.5
In Unit Indoor LED Fixture	LI MF Retrofit	0.07	0.07	0.06	70.9	68.0	64.0
In Unit Outdoor LED Fixture	LI MF Retrofit	0.10	0.09	0.09	95.0	91.3	86.5

Baseline Efficiency

The baseline efficiency case is a combination of an incandescent bulb, halogen bulb, and compact florescent bulb for Residential Lighting. The baseline efficiency case for LI MF Retrofit is an incandescent bulb, or a halogen bulb.

High Efficiency

The high efficiency case is an LED fixture.

Hours

Average annual operating hours for efficient bulbs in the Res Lighting program are 1,200 hours/year ((93%*2.9 hours/day + 7% *8.46 hours/day)* 365 days/year).[290, 291,292] The average annual operating hours for efficient bulbs in MF Retrofit and LI MF Retrofit is 985.5 (2.7 hours/day *365 days/year).[293]

Measure Life

The adjusted measure lives for LED Fixtures are[294]:

Measure Name	Core Initiative	2016	2017	2018
LED Fixture	Res Lighting	8	8	8
Indoor Fixture	LI Retrofit 1-4	9	9	9
In Unit Indoor LED Fixture	MF Retrofit	9	9	9
In Unit Outdoor LED Fixture	MF Retrofit	9	9	9
In Unit Indoor LED Fixture	LI MF Retrofit	9	9	9
In Unit Outdoor LED Fixture	LI MF Retrofit	9	9	9

Secondary-Energy Impacts

There is a heat loss of 2,237 Btu/kWh counted for bulbs and fixtures sold upstream.[295]

[290] NMR Group Inc. (2014). *Northeast Residential Lighting Hours of Use Study.* The study recommended the use of the regional lighting hours of use numbers for both the efficient and all bulb lighting values.
[291] The Cadmus Group (2015). *Massachusetts Residential Lighting Cross-Sector Sales Research.*
[292] DNV-GL (2015). Massachusetts Commercial and Industrial Upstream Lighting Program: “In Storage” Lamps Follow-Up Study
[293] NMR Group Inc. (2014). *Northeast Residential Lighting Hours of Use Study.* The study recommended the use of the regional lighting hours of use numbers for both the efficient and all bulb lighting values.
[294] MA PAs (2015). 2012-2018 MA Lighting Worksheet.
[295] Cadmus (2015) Lighting Interactive Effects Study Preliminary Results; For the upstream program only.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
LED Fixture	Res Lighting	All	1.00	1.00	1.00	1.00	0.14	0.18
Indoor Fixture	LI Retrofit 1-4	All	1.00	1.00	1.00	1.00	0.17	1.00
In Unit Indoor LED Fixture	MF Retrofit	Eversource	0.97	0.60	0.60	0.60	0.13	0.16
In Unit Outdoor LED Fixture	MF Retrofit	Eversource	0.97	0.60	0.60	0.60	0.13	0.16
In Unit Indoor LED Fixture	LI MF Retrofit	Eversource, CLC	1.00	1.00	1.00	1.00	0.13	0.16
In Unit Outdoor LED Fixture	LI MF Retrofit	Eversource, CLC	1.00	1.00	1.00	1.00	0.13	0.16

In-Service Rates

- Res Lighting: Baseline Sensitivity Analysis Spreadsheet, 2016-2018 Plan Version.[296]
- LI MF Retrofit: PAs assume a 100% installation rate.
- MF Retrofit: MF Retrofit: 2012 MF Impact Analysis.[297]

Realization Rates

Realization rates are based on Massachusetts Common Assumptions except for MF Retrofit which is based on MA Common Assumptions.

Coincidence Factors

Coincidence factors are based on the 2014 Lighting Hours of Use Study[298]

[296] MA PAs (2015). 2016-2018 MA Lighting Worksheet

[297] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.

[298] NMR Group Inc. (2014). *Northeast Residential Lighting Hours of Use Study.*

Lighting – Bulbs

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Removal of existing inefficient bulbs with the installation of new efficient bulbs
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Retrofit
End Use: Lighting
Measure Type: Interior, Exterior
Core Initiative: Electric - Multi-Family Retrofit, Electric - Low-Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are calculated using the following algorithms and assumptions:

$$\Delta kWh = [(QTY_{PRE} \times Watts_{PRE} \times Hours_{PRE}) - (QTY_{EE} \times Watts_{EE} \times Hours_{EE})] / 1000 \times 52$$
$$\Delta kW = \Delta kWh \times kW / kWh$$

Where:
QTY_{PRE} = Quantity of pre-retrofit fixtures/bulbs
QTY_{EE} = Quantity of efficient fixtures/bulbs installed
$Watts_{PRE}$ = Rated watts of pre-retrofit fixtures/bulbs
$Watts_{EE}$ = Rated watts of efficient fixtures/bulbs installed
$Hours_{PRE}$ = Weekly hours of operation for pre-retrofit case lighting fixtures/bulbs
$Hours_{EE}$ = Weekly hours of operation for efficient lighting fixtures/bulbs
52 = Weeks per year
kW/kWh = Average kW reduction per kWh reduction: 0.00030 kW/kWh[299]

Baseline Efficiency

The baseline efficiency case is the existing bulbs.

High Efficiency

The high efficiency case is the new bulbs.

Measure Life

The estimated expected useful lives are as shown below[300].

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[299] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators. Loadshape: Res Multi Family Electric Lighting - Indoor (LIGHTING) Normal

Measure Name	2016 EUL	2017 EUL	2018 EUL
CFL Bulb	5	4	4
LED Bulb	9	9	9

Hours

Operating hours are estimated by the vendor for each facility. Typical assumptions are 24 hours/day for common area lighting, 12 hours/day for exterior lighting, and 2.7 hours/day for in-unit lighting, but may be adjusted based on type of housing. Study-determined hours of use by room type may also be applied.[301] Estimates are verified with facility maintenance staff when possible.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
CFL Bulb	MF Retrofit	National Grid, CLC, Unitil	0.97	0.60	0.60	0.60	0.17	1.00
LED Bulb	MF Retrofit	National Grid, CLC, Unitil	0.97	0.60	0.60	0.60	0.17	1.00
CFL Bulb	LI MF Retrofit	National Grid, Unitil	1.00	1.00	1.00	1.00	0.17	1.00
LED Bulb	LI MF Retrofit	National Grid, Unitil	1.00	1.00	1.00	1.00	0.17	1.00

In-Service Rates
In service rate for MF Retrofit is from an evaluation study.[302]

Realization Rates
MF Retrofit is set to 60% based on draft evaluation results.[303]

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[304]

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[300] MA PAs (2015). 2012-2018 MA Lighting Worksheet. The adjusted measure life accounts for changes in the baseline due to EISA standards.
[301] NMR Group, Inc. (2014) *Northeast Residential Lighting Hours-of-Use Study*. Table 3-1
[302] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.
[303] Massachusetts Common Assumptions (2015).
[304] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Lighting - Fixtures

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Removal of existing inefficient fixtures with the installation of new efficient fixtures
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Retrofit
End Use: Lighting
Measure Type: Interior, Exterior
Core Initiative: Electric - Multi-Family Retrofit, Electric - Low-Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are calculated using the following algorithms and assumptions:

$$\Delta kWh = [(QTY_{PRE} \times Watts_{PRE} \times Hours_{PRE}) - (QTY_{EE} \times Watts_{EE} \times Hours_{EE})]/1000 \times 52$$
$$\Delta kW = \Delta kWh \times kW / kWh$$

Where:

QTY_{PRE}	=	Quantity of pre-retrofit fixtures/bulbs
QTY_{EE}	=	Quantity of efficient fixtures/bulbs installed
$Watts_{PRE}$	=	Rated watts of pre-retrofit fixtures/bulbs
$Watts_{EE}$	=	Rated watts of efficient fixtures/bulbs installed
$Hours_{PRE}$	=	Weekly hours of operation for pre-retrofit case lighting fixtures/bulbs
$Hours_{EE}$	=	Weekly hours of operation for efficient lighting fixtures/bulbs
52	=	Weeks per year
kW/kWh	=	Average kW reduction per kWh reduction: 0.00030 kW/kWh[305]

Baseline Efficiency

The baseline efficiency case is the existing fixture.

High Efficiency

The high efficiency case is the new fixtures.

[305] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators. Loadshape: Res Multi Family Electric Lighting - Indoor (LIGHTING) Normal

Measure Life

The estimated expected useful lives are as shown below[306].

Measure Name	2016 EUL	2017 EUL	2018 EUL
In Unit Indoor LED Fixture	9	9	9
In Unit Outdoor LED Fixture	9	9	9
Common Area Int LED Fixture	4	4	4
Common Area Int Linear LED Fixture	9	9	9
Common Area Ext LED Fixture	11	11	11

Hours

Operating hours are estimated by the vendor for each facility. Typical assumptions are 24 hours/day for common area lighting, 12 hours/day for exterior lighting, and 2.7 hours/day for in-unit lighting, but may be adjusted based on type of housing. Study-determined hours of use by room type may also be applied.[307] Estimates are verified with facility maintenance staff when possible.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
In Unit Indoor LED Fixture	MF Retrofit	National Grid, CLC, Unitil	0.97	0.60	0.60	0.60	0.17	1.00
In Unit Outdoor LED Fixture	MF Retrofit	National Grid, CLC, Unitil	0.97	0.60	0.60	0.60	0.00	1.00
Common Area Int LED Fixture	MF Retrofit	All	0.97	0.60	0.60	0.60	0.17	1.00
Common Area Int Linear LED Fixture	MF Retrofit	All	0.97	0.60	0.60	0.60	0.17	1.00
Common Area Ext LED Fixture	MF Retrofit	All	0.97	0.60	0.60	0.60	0.00	1.00
In Unit Indoor Fixture	LI MF Retrofit	National Grid, Unitil	1.00	1.00	1.00	1.00	0.17	1.00
In Unit Outdoor Fixture	LI MF Retrofit	National Grid, Unitil	1.00	1.00	1.00	1.00	0.00	1.00
In Unit Indoor LED Fixture	LI MF Retrofit	National Grid, Unitil	1.00	1.00	1.00	1.00	0.17	1.00

[306] Measure Lives are based on ENERGY STAR and manufacturing rated measure lives, adjusted for changes in the baseline due to EISA standards. See 2016-2018 MA Lighting Worksheet
[307] NMR Group, Inc. (2014) *Northeast Residential Lighting Hours-of-Use Study*. Table 3-1

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
In Unit Outdoor LED Fixture	LI MF Retrofit	National Grid, Unitil	1.00	1.00	1.00	1.00	0.00	1.00
Common Area Int Fixture	LI MF Retrofit	National Grid	1.00	1.01	1.01	1.01	0.17	1.00
Common Area Int Fixture	LI MF Retrofit	Unitil	1.00	0.97	0.97	0.97	0.17	1.00
Common Area Int Fixture	LI MF Retrofit	Eversource	1.00	0.96	0.96	0.96	0.17	1.00
Common Area Int Fixture	LI MF Retrofit	CLC	1.00	0.97	0.97	0.97	0.17	1.00
Common Area Int LED Fixture	LI MF Retrofit	National Grid	1.00	1.01	1.01	1.01	0.17	1.00
Common Area Int LED Fixture	LI MF Retrofit	Unitil	1.00	0.97	0.97	0.97	0.17	1.00
Common Area Int LED Fixture	LI MF Retrofit	Eversource	1.00	0.96	0.96	0.96	0.17	1.00
Common Area Int LED Fixture	LI MF Retrofit	CLC	1.00	0.97	0.97	0.97	0.17	1.00
Common Area Ext LED Fixture	LI MF Retrofit	National Grid	1.00	1.01	1.01	1.01	0.00	1.00
Common Area Ext LED Fixture	LI MF Retrofit	Unitil	1.00	0.97	0.97	0.97	0.00	1.00
Common Area Ext LED Fixture	LI MF Retrofit	Eversource	1.00	0.96	0.96	0.96	0.00	1.00
Common Area Ext LED Fixture	LI MF Retrofit	CLC	1.00	0.97	0.97	0.97	0.17	1.00
Common Area Ext Fixture	LI MF Retrofit	National Grid	1.00	1.01	1.01	1.01	0.00	1.00
Common Area Ext Fixture	LI MF Retrofit	Unitil	1.00	0.97	0.97	0.97	0.00	1.00
Common Area Ext Fixture	LI MF Retrofit	Eversource	1.00	0.96	0.96	0.96	0.00	1.00
Common Area Ext Fixture	LI MF Retrofit	CLC	1.00	0.97	0.97	0.97	0.17	1.00

In-Service Rates
In service rate for MF Retrofit is from an evaluation study.[308]

Realization Rates
- MF Retrofit is set to 60% based on draft evaluation results.[309]
- LI MF Retrofit realization rates are based on evaluation results.[310]

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[311]

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[308] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.
[309] Massachusetts Common Assumptions (2015).
[310] The Cadmus Group (2015). *Massachusetts Low-Income Multifamily Initiative Impact Analysis.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[311] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Lighting - Occupancy Sensors

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The installation of occupancy sensors for lighting fixtures. This measure involves installing an occupancy sensor that controls lighting fixtures and limits their use when the space is unoccupied
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: Lighting
Measure Type: Controls
Program: Electric - Multi-Family Retrofit, Electric - Low Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are based on the following algorithms which use averaged inputs[312]:

$$\Delta kWh = \frac{(Watts_{controlled}) \times Hrs \ \times svg}{1{,}000}$$

Where:

Watts controlled	=	Connected load wattage controlled by Occupancy Sensor
Hours	=	Assumed run time of fixture (before the installation of occupancy sensors (Auditor Input)
svg	=	Percentage of annual lighting energy saved by occupancy sensor is 30% [313]

Baseline Efficiency

The baseline condition for this measure is a lighting fixture that is not controlled by an occupancy sensor.

High Efficiency

The high efficiency case is a lighting fixture that operates with connected occupancy sensors.

Hours

Deemed values for hours may be used if auditor does not collect information.

[312] The Cadmus Group, Inc. (2012). *Massachusetts Multifamily Program Impact Analysis*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[313] Ibid.

Zone	Usage Category	Hours/Day (Calc.)[314]
Common Area (Exterior)	Exterior	10.3
Common Area (Interior)	Extended Hours & 24/7	24.0
Common Area (Interior)	Low Usage	3.4
Common Area (Interior)	Medium Usage	12.5
Common Area (Interior)	Non-Area Specific	16.2
Dwelling Unit	Unit	2.7

Measure Life

The measure life is 10 years.[315]

Secondary-Energy Impacts

There are no secondary energy impacts counted for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Common Area Occupancy Sensors	MF Retrofit	All	1.00	0.60	0.60	0.60	0.00	0.00
Common Area Occupancy Sensors	LI MF Retrofit	All	1.00	1.00	1.00	1.00	0.00	0.00

In-Service Rates
In-service rates are set to 100% based on the assumption that all purchased units are installed.

Realization Rates
Realization rates are set to 100% since this program has not been evaluated.

Coincidence Factors
Coincidence factors are set to zero since demand savings typically occur during off- peak periods.

314 Ibid.
315 GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.

Motors/Drives – Pool Pump

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The installation of a 2-speed or variable speed drive pool pump. Operating a pool pump for a longer period of time at a lower wattage can move the same amount of water using significantly less energy.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: Process
Measure Type: Variable Speed Drive
Core Initiative: Electric - Residential Consumer Products

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on averaged results from the ENERGY STAR pool pump calculator.[316] The calculator was run for 6 scenarios; a two-speed replacement pump and a variable speed replacement pump, for 3 baseline sizes ranging from 1HP to 2HP.

Demand savings are deemed based on the following algorithms, which use averaged inputs aligning with the scenarios run for the calculator.

$$MD = \frac{FR*60}{EF} \times \frac{RT}{24} \times \frac{1}{1000}$$

$MD_{Efficient} = MD_{High\ Flow} + MD_{Low\ Flow}$
Demand Savings = $MD_{Efficient} - MD_{Baseline}$

Where:

MD	=	Maximum Demand of Pump under given operating conditions
FR	=	Maximum Flow Rate of Pump (gallons/minute); From EnergyStar calculator
60	=	Minutes per hour
RT	=	Pump run time (hours/day)
24	=	Hours per day
EF	=	Energy Factor (gallons/Watt-hour); From EnergyStar calculator

For each pump, the run time was set to achieve 1.5 turnovers per day, with 2 hours at high speed for cleaning.
For 1horsepower pumps, pool size was assumed to be 20,000 gallons

[316] http://www.energystar.gov/sites/default/files/asset/document/Pool%20Pump%20Calculator.xlsx

For 1.5 horsepower pumps, pool size was assumed to be 22,500 gallons
For 2 horsepower pumps, pool size was assumed to be 23,000 gallons

Savings for Pool Pumps

Measure Name	Core Initiative	PA Type	ΔkWh	ΔkW
Pool Pump (Two Speed)	Res Products	Elec	842	0.38
Pool Pump (Variable Speed)	Res Products	Elec	1,062	0.50

Baseline Efficiency

The baseline efficiency case is a single speed 1.5 horsepower pump that pumps 64 gallons per minute and runs 8.5 hours per day for 91 days a year. It has an EF = 2.1 and cycles 32,640 gallons per day.

High Efficiency

The high efficiency case is a 2-speed or variable speed pump.

For the two-speed pump the high efficiency case is a 2.0 HP pump rated at 66 gpm high speed (oversized motor compared to the base case). It has a 2.0 EF at high speed, a 5.2 EF at low speed (50% flow) and runs 2 hr/day at high speed for filter & cleaning and 12.5 hr/day for filtering alone to deliver the equivalent total gallons of cycling per day.

For the variable speed pump the high efficiency case is a variable speed pump rated at 50 gpm high speed. It has a 4.0 EF at high speed, a 8.8EF at low speed and runs 2 hr/day at high speed for filter & cleaning and 18 hr/day for filtering alone

Hours

Hours of use are dependent on the efficiency of the pump and the size of the pool, as described above. Pumps are assumed to be in use for 91 days per year.

Measure Life

The measure life is 10 years.[317]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

[317] Davis Energy Group (2008). *Proposal Information Template for Residential Pool Pump Measure Revisions*. Prepared for Pacific Gas and Electric Company.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Pool Pump (Two Speed)	Res Products	All	1.00	1.00	1.00	1.00	1.00	0.00
Pool Pump (Variable Speed)	Res Products	All	1.00	1.00	1.00	1.00	1.00	0.00

In-Service Rates
In-service rates are set to 100% based on the assumption that all purchased units are installed.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factor
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[318]

[318] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

Plug Load – Room Air Cleaner

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Rebates provided for the purchase of an ENERGY STAR® qualified room air cleaner. ENERGY STAR® air cleaners are 40% more energy-efficient than standard models.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: Process
Measure Type: Room Air Cleaners
Core Initiative: Electric - Residential Consumer Products

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on averaged inputs.[319]

Measure Name	Core Initiative	ΔkWh	ΔkW[320]
Room Air Cleaner	Res Products	391	0.08

Baseline Efficiency

The baseline efficiency case is a conventional unit with clean air delivery rate (CADR) of 51-100.

High Efficiency

The high efficiency case is an ENERGY STAR® qualified air cleaner with a CADR of 51-100.

Hours

The savings are based on 16 operating hours per day, 365 days per year.[321]

Measure Life

The measure life is 9 years.[322]

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[319] Environmental Protection Agency (2014). *Savings Calculator for Energy Star Qualified Appliances.*
[320] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[321] Environmental Protection Agency (2014). *Savings Calculator for Energy Star Qualified Appliances.* http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
[322] Ibid.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Room Air Cleaner	Res Products	All	1.00	1.00	1.00	1.00	0.73	1.00

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[323]

[323] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

Plug Load – Smart Strips

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Switches off plug load using current sensors and switching devices which turn off plug load when electrical current drops below threshold low levels. Smart Strips can be used on electrical home appliances or in the workplace.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential, Low-Income
Market: Lost Opportunity, Retrofit
End Use: Process
Measure Type: Smart Strips
Core Initiative: Electric - Residential Consumer Products, Electric - Residential Home Energy Services, Electric - Low-Income Single Family Retrofit, Electric - Multi-Family Retrofit, Electric - Low-Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[324]

Savings for Smart Strips

Measure Name	Core Initiative	ΔkWh	ΔkW[325]
Smart Strip	Res Products, HES, LI Retrofit 1-4	75.1	0.02
Smart Strip	MF Retrofit, LI MF Retrofit	75.1	0.01

Baseline Efficiency

The baseline efficiency case is no power strip and leaving peripherals on or using a power surge protector.

High Efficiency

The high efficiency case is a Smart Strip Energy Efficient Power Bar

Hours

Since the power strip is assumed to be plugged in all year, the savings are based on 8,760 operational hours per year.

[324] NEEP (2012). *Advanced Power Strips Deemed Savings Methodology.*
[325] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Measure Life

The measure life is 5 years[326]

Secondary-Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Smart Strip	Res Products	All	1.00	1.00	1.00	1.00	0.73	1. 00
Smart Strip	HES	All	1.00	1.00	1.00	1.00	0.73	1.00
Smart Strip	MF Retrofit	All	1.00	1.00	1.00	1.00	0.77	1.00
Smart Strip	LI Retrofit 1-4	All	1.00	1.00	1.00	1.00	0.73	1.00
Smart Strip	LI MF Retrofit	All	1.00	1.00	1.00	1.00	0.77	1.00

In-Service Rates
In-service rates are set to 100% based on the assumption that all purchased units are installed.

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[327]

[326] Massachusetts Common Assumption.
[327] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

Plug Load – Advanced Smart Strips

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Advanced power strips can automatically eliminate standby power loads of electronic peripheral devices that are not needed (DVD player, computer printer, scanner, etc.) either automatically or when an electronic control device (typically a television or personal computer) is in standby or off mode.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential, Low-Income
Market: Lost Opportunity, Retrofit
End Use: Process
Measure Type: Smart Strips
Core Initiative: Electric - Residential Consumer Products

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[328]

Savings for Smart Strips

Measure Name	Core Initiative	ΔkWh	ΔkW[329]
Power Strip (Tier 2)	Res Products	346	0.07

Baseline Efficiency

The baseline efficiency case is no power strip and leaving peripherals.

High Efficiency

The high efficiency case is an Advanced Smart Strip Energy Efficient Power Bar

Hours

Since the power strip is assumed to be plugged in all year, the savings are based on 8,760 operational hours per year.

Measure Life

The measure life is 5 years[330]

328 California Plug Load Research Center (2014). *Tier 2 Advanced PowerStrip Evaluation for Energy Savings Incentive.*
329 Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Secondary-Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Power Strip (Tier 2)	Res Products	All	1.00	1.00	1.00	1.00	0.73	1. 00

In-Service Rates
In-service rates are set to 100% based on the assumption that all purchased units are installed.

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[331]

[330] Massachusetts Common Assumption.
[331] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

Plug Load – Dehumidifier

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of an Energy Star dehumidifier.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: Process
Measure Type: Dehumidifiers
Core Initiative: Electric - Residential Consumer Products

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms and assumptions:

$$\Delta kWh = Capacity \times \frac{0.473}{24} \times \left(\frac{1}{Eff_{BASE}} - \frac{1}{Eff_{EE}} \right) \times Hours$$

$$\Delta kW = \Delta kWh_{EE} / Hours$$

Where:

Capacity = Average capacity of dehumidifier in Pints/24 Hours: 35 Pints/Day[332]
Eff_{BASE} = Average efficiency of conventional model in Liters/kWh
Eff_{EE} = Average efficiency of ENERGY STAR® model in Liters/kWh
Hours = Dehumidifier annual operating hours
0.473 = Conversion factor: 0.473 Liters/Pint
24 = Conversion factor: 24 Hours/Day
CF = Summer Peak Coincidence Factor; 0.37[333]

Savings for Dehumidifiers

Measure Name	Core Initiative	ΔkWh	ΔkW
Dehumidifier	Res Products	239	0.04

Baseline Efficiency

The baseline efficiency is a unit meeting the current federal standard:[334]

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332 35 pints per day was the average capacity for units turned in at the Cape Light Compact's May 2010 event.
333 Assumes usage is evenly distributed day vs. night, weekend vs. weekday and is used for 8 months per year (5760 possible hours). Coincidence during summer peak is therefore 2160/5760 = 37.5%
334 http://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf

Unit Size	EF
30 Pint/Day	1.35
50 Pint/Day	1.60
70 Pint/Day	1.70

High Efficiency

The high efficiency case is an ENERGY STAR® unit with an efficiency of 1.85 L/kWh[335].

Hours

Average annual operating hours are 2,160 hours.[336]

Measure Life

The measure life is 12 years.[337]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Dehumidifier	Res Products	All	1.00	1.00	1.00	1.00	0.85	1.00

In-Service Rates
In-service rates are set to 100% based on the assumption that all purchased units are installed.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on Massachusetts Common Assumptions.

[335] Energy Star Dehumidifiers Product List, posted to the Energy Star website on August 2, 2012.
[336] The Cadmus Group, Inc. http://aceee.org/files/proceedings/2012/data/papers/0193-000291.pdf
[337] Environmental Protection Agency (2014). *Savings Calculator for Energy Star Qualified Appliances.* http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx

Plug Load – Dehumidifier Recycling

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Early retirement of existing dehumidifiers
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Retrofit
End Use: Process
Measure Type: Dehumidifiers
Core Initiative: Electric - Residential Consumer Products, Electric - Low-Income Single Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms and assumptions:

$$\Delta kWh_{RETIRE} = Capacity \times \frac{0.473}{24} \times \left(\frac{1}{Eff_{RETIRE}} - \frac{1}{Eff_{BASE}} \right) \times Hours$$

$$\Delta kW_{RETIRE} = \Delta kWh_{RETIRE} / Hours$$

Where:

Unit	=	Replacement of existing dehumidifier with new ENERGY STAR® dehumidifier
Capacity	=	Average capacity of dehumidifier in Pints/24 Hours: 35 Pints/Day[338]
Eff_{BASE}	=	Average efficiency of new conventional model in Liters/kWh
Eff_{RETIRE}	=	Average efficiency of existing model in Liters/kWh
Hours	=	Dehumidifier annual operating hours
0.473	=	Conversion factor: 0.473 Liters/Pint
24	=	Conversion factor: 24 Hours/Day

Savings for Dehumidifiers
The total savings are the result of a weighted average for the algorithm above for three sizes, 30 pint, 50 pint, and 70 pint.

Measure Name	ΔkWh	ΔkW
Dehumidifier Recycling (EE)	239	0.04
Dehumidifier Recycling (Retire)	152	0.03

The baseline efficiency case for a retired dehumidifier ($Eff_{RETIRED}$) is the pre-2012 federal standards:[339]

Unit Size	Pre-2012 EF

[338] 35 pints per day was the average turn in at the Cape Light Compact's May 2010 event. This event retired 125 units.
[339] United States Congress. http://energy.gov/sites/prod/files/2013/10/f3/epact_2005.pdf

30 Pint/Day	1.20
50 Pint/Day	1.30
70 Pint/Day	1.50

High Efficiency

The high efficiency case assumes replacement with a unit meeting the current minimum federal standard[340].

Unit Size	EF
30 Pint/Day	1.35
50 Pint/Day	1.60
70 Pint/Day	1.70

Hours

Average annual operating hours are 2,106 hours.[341]

Measure Life

The measure life is 5 years.[342]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Dehumidifier Recycling	LI Retrofit 1-4	All	1.00	1.00	1.00	1.00	0.85	0. 00

In-Service Rates
In-service rates are set to 100% based on the assumption that all purchased units are installed.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on Massachusetts Common Assumptions.

[340] Department of Energy. https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/55#standards
[341] The Cadmus Group, Inc. http://aceee.org/files/proceedings/2012/data/papers/0193-000291.pdf
[342] On average, turn-in units at the Cape Light Compact's May 2010 event were 7 years old. The full measure life of 12 years minus the average age of the retired equipment of 7 years equals a remaining life of 5 years.

Water Heating – Pipe Wrap

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of DHW pipe wraps
Energy Impact: Electric, Oil, Propane, Gas
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Retrofit
End Use: Hot Water
Measure Type: Insulation
Core Initiative: Electric - Residential Home Energy Services, Gas - Residential Home Energy Services, Electric - Low-Income Single Family Retrofit, Gas - Low-Income Single Family Retrofit, Electric – Multi-Family Retrofit, Gas – Multi-Family Retrofit, Electric – Low Income Multi-Family Retrofit, Gas – Low Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[343,344,345] where unit is a household with pipe wrap installed on hot water pipes.

Savings for Pipe Wrap (Water Heating)

Measure Name	Core Initiative	Energy Type	ΔkWh	ΔkW[346]	ΔMMBtu
Pipe Wrap (Water Heating), Electric	HES	Electric	64	0.01	
Pipe Wrap (Water Heating), Oil	HES	Oil			0.4
Pipe Wrap (Water Heating), Other	HES	Propane			0.3
Pipe Wrap (Water Heating), Gas; Pipe Wrap (Water Heating)	HES	Gas			0.3
Pipe Wrap (Water Heating), Electric	LI Retrofit 1-4	Electric	41	0.01	
Pipe Wrap (Water Heating), Oil	LI Retrofit 1-4	Oil			0.4
Pipe Wrap (Water Heating), Other	LI Retrofit 1-4	Propane			0.4
Pipe Wrap (Water Heating)	LI Retrofit 1-4	Gas			0.4
Pipe Wrap (Water Heating), Electric	MF Retrofit	Electric	129	0.02	
Pipe Wrap (Water Heating), Oil	MF Retrofit	Oil			1.14
Pipe Wrap (Water Heating), Other	MF Retrofit	Propane			1.14

343 The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
344 The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
345 The Cadmus Group (2012). *Massachusetts Multifamily Program Impact Analysis July 2012 – Revised May 2013.* Prepared for Massachusetts Program Administrators.
346 Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Measure Name	Core Initiative	Energy Type	ΔkWh	ΔkW[346]	ΔMMBtu
Pipe Wrap (Water Heating)	MF Retrofit	Gas			1.14
Pipe Wrap (Water Heating), Electric	LI MF Retrofit	Electric	129	0.02	
Pipe Wrap (Water Heating), Oil	LI MF Retrofit	Oil			1.14
Pipe Wrap (Water Heating), Other	LI MF Retrofit	Propane			1.14
Pipe Wrap (Water Heating)	LI MF Retrofit	Gas			1.14

Baseline Efficiency

The baseline efficiency case is the existing hot water equipment.

High Efficiency

The high efficiency case includes pipe wrap.

Hours

Not applicable.

Measure Life

The measure life is 15 years.[347]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[347] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA Type	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Pipe Wrap (Water Heating)	HES	Electric	All	1.00	1.00	1.00	1.00	1.00	0.94
Pipe Wrap (Water Heating)	LI Retrofit 1-4	Electric	All	1.00	1.00	1.00	1.00	1.00	0.94
Pipe Wrap (Water Heating)	MF Retrofit	Electric	All	1.00	0.60	0.60	0.60	0.58	1.00
Pipe Wrap (Water Heating)	LI MF Retrofit	Electric	All	1.00	1.00	1.00	1.00	0.58	1.00
Pipe Wrap (Water Heating)	HES	Gas	All	1.00	1.00	n/a	n/a	n/a	n/a
Pipe Wrap (Water Heating)	LI Retrofit 1-4	Gas	All	1.00	1.00	n/a	n/a	n/a	n/a
Pipe Wrap (Water Heating)	MF Retrofit	Gas	All	1.00	0.60	n/a	n/a	n/a	n/a
Pipe Wrap (Water Heating)	LI MF Retrofit	Gas	Eversource	1.00	1.05	n/a	n/a	n/a	n/a
Pipe Wrap (Water Heating)	LI MF Retrofit	Gas	National Grid	1.00	0.75	n/a	n/a	n/a	n/a
Pipe Wrap (Water Heating)	LI MF Retrofit	Gas	Columbia	1.00	0.96	n/a	n/a	n/a	n/a
Pipe Wrap (Water Heating)	LI MF Retrofit	Gas	Unitil	1.00	0.96	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
- For HES, LI Retrofit 1-4 the realization rates are set to 100% since deemed savings are based on evaluation results.
- For LI MF Retrofit the realization rates are based on evaluation results. [348]
- For MF Retrofit the realization rate is based on draft evaluation results.[349]

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[350]

[348] The Cadmus Group (2015). *Massachusetts Low-Income Multifamily Initiative Impact Analysis.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[349] MA Common Assumptions (2015).
[350] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

Water Heating – Showerheads

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: An existing showerhead with a high flow rate is replaced with a new low flow showerhead.
Primary Energy Impact: Electric, Oil, Propane, Gas
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts, Residential Water
Sector: Residential, Low Income
Market: Retrofit
End Use: Hot Water
Measure Type: Flow Control
Core Initiative: Electric - Residential Home Energy Services, Gas - Residential Home Energy Services, Electric - Low-Income Single Family Retrofit, Gas - Low-Income Single Family Retrofit, Electric – Multi-Family Retrofit, Gas – Multi-Family Retrofit, Electric – Low Income Multi-Family Retrofit, Gas – Low Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results. [351,352,353,354]

Measure Name	Core Initiative	Energy Type	ΔkWh	ΔkW[355]	ΔMMBtu
Low-Flow Showerhead, Electric	HES	Electric	237	0.03	
Low-Flow Showerhead, Oil	HES	Oil			1.3
Low-Flow Showerhead, Other	HES	Propane			1.2
Low-Flow Showerhead, Gas; Low-Flow Showerhead	HES	Gas			1.2
Low-Flow Showerhead	LI Retrofit 1-4	Electric	188	0.03	
Low-Flow Showerhead, Oil	LI Retrofit 1-4	Oil			1.1
Low-Flow Showerhead, Other	LI Retrofit 1-4	Propane			0.9
Low-Flow Showerhead, Gas	LI Retrofit 1-4	Gas			0.9
Low-Flow Showerhead, Electric	MF Retrofit	Electric	129	0.02	
Low-Flow Showerhead, Other	MF Retrofit	Oil			1.14

351 The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
352 The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
353 The Cadmus Group (2012). *Massachusetts Multifamily Program Impact Analysis July 2012 – Revised May 2013.* Prepared for Massachusetts Program Administrators.
354 The Cadmus Group, Inc. (2015). *Massachusetts Low-Income Multifamily Initiative Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
355 Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Measure Name	Core Initiative	Energy Type	ΔkWh	ΔkW[355]	ΔMMBtu
Low-Flow Showerhead, Other	MF Retrofit	Propane			1.14
Low-Flow Showerhead, Gas	MF Retrofit	Gas			1.14
Low-Flow Showerhead, Electric	LI MF Retrofit	Electric	217	0.04	
Low-Flow Showerhead, Oil	LI MF Retrofit	Oil			1.07
Low-Flow Showerhead, Gas	LI MF Retrofit	Gas			1.07

Baseline Efficiency

The baseline efficiency case is the existing showerhead with a baseline flow rate of 2.5 GPM.

High Efficiency

The high efficiency case is a low flow showerhead having a maximum flow rate between 1.5 and 1.7 GPM.

Hours

Not applicable.

Measure Life

The measure life is 7 years[356]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Residential Water	Residential water savings for low-flow showerheads [357]	2,401 Gallons/Unit
Residential Water	Multifamily water savings for low-flow showerheads [358]	2,165 Gallons/Unit
Residential Water	Low-Income Multifamily water savings for low-flow showerheads [359]	1,759 Gallons/Unit
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[356] Massachusetts common assumption
[357] Staff calculation based on methodology from The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[358] Staff calculation based on methodology from The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts
[359] The Cadmus Group (2015). *Massachusetts Low-Income Multifamily Initiative Impact Evaluation.* The Electric and Gas Program Administrators of Massachusetts.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA Type	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Low-Flow Showerhead	HES	Electric	All	1.00	1.00	1.00	1.00	1.00	0.94
Low-Flow Showerhead	LI Retrofit 1-4	Electric	All	1.00	1.00	1.00	1.00	1.00	0.94
Low-Flow Showerhead	MF Retrofit	Electric	All	1.00	0.60	0.60	0.60	0.58	1.00
Low-Flow Showerhead	LI MF Retrofit	Electric	All	1.00	1.00	1.00	1.00	0.58	1.00
Low-Flow Showerhead	HES	Gas	All	1.00	1.00	n/a	n/a	n/a	n/a
Low-Flow Showerhead	LI Retrofit 1-4	Gas	All	1.00	1.00	n/a	n/a	n/a	n/a
Low-Flow Showerhead	MF Retrofit	Gas	All	1.00	0.60	n/a	n/a	n/a	n/a
Low-Flow Showerhead	LI MF Retrofit	Gas	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. For MF Retrofit, realization rate is based upon draft evaluation results.

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[360]

[360] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

Water Heating – Faucet Aerator

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: An existing faucet aerator with a high flow rate is replaced with a new low flow aerator.
Primary Energy Impact: Electric, Oil, Propane, Gas
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts, Residential Water
Sector: Residential, Low Income
Market: Retrofit
End Use: Hot Water
Measure Type: Flow Control
Core Initiative: Electric - Residential Home Energy Services, Gas - Residential Home Energy Services, Electric - Low-Income Single Family Retrofit, Gas - Low-Income Single Family Retrofit, Electric – Multi-Family Retrofit, Gas – Multi-Family Retrofit, Electric – Low Income Multi-Family Retrofit, Gas – Low Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results. [361,362,363,364]

Measure Name	Core Initiative	Energy Type	ΔkWh	ΔkW[365]	ΔMMBtu
Faucet Aerator, Electric	HES	Electric	49	0.01	
Faucet Aerator, Oil	HES	Oil			0.3
Faucet Aerator, Other	HES	Propane			0.2
Faucet Aerator, Gas; Faucet Aerator	HES	Gas			0.2
Faucet Aerator, Electric	LI Retrofit 1-4	Electric	40	0.01	
Faucet Aerator, Oil	LI Retrofit 1-4	Oil			0.2
Faucet Aerator, Other	LI Retrofit 1-4	Propane			0.2
Faucet Aerator, Gas	LI Retrofit 1-4	Gas			0.2
Faucet Aerator, Electric	MF Retrofit	Electric	97	0.02	
Faucet Aerator, Oil	MF Retrofit	Oil			0.86
Faucet Aerator, Other	MF Retrofit	Propane			0.86

361 The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
362 The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
363 The Cadmus Group (2012). *Massachusetts Multifamily Program Impact Analysis July 2012 – Revised May 2013.* Prepared for Massachusetts Program Administrators.
364 The Cadmus Group (2015). *Massachusetts Low-Income Multifamily Initiative Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
365 Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

Measure Name	Core Initiative	Energy Type	ΔkWh	ΔkW[365]	ΔMMBtu
Faucet Aerator, Gas	MF Retrofit	Gas			0.86
Faucet Aerator, Electric	LI MF Retrofit	Electric	62	0.01	
Faucet Aerator, Oil	LI MF Retrofit	Oil			0.3
Faucet Aerator, Gas	LI MF Retrofit	Gas			0.3

Baseline Efficiency

The baseline efficiency case is the existing faucet aerator with a high flow.

High Efficiency

The high efficiency case is a low flow faucet aerator.

Hours

Not applicable.

Measure Life

The measure life is 7 years[366]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Residential Water	Residential water savings for faucet aerators [367]	332 Gallons/Unit
Residential Water	LI Multifamily water savings for faucet aerators [368]	708 Gallons/Unit
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[366] Massachusetts common assumption
[367] NMR Group, Inc., Tetra Tech (2011). *Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation,* Prepared for Massachusetts Program Administrators
[368] The Cadmus Group (2015). *Massachusetts Low-Income Multifamily Initiative Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA Type	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Faucet Aerator	HES	Electric	All	1.00	1.00	1.00	1.00	1.00	0.94
Faucet Aerator	LI Retrofit 1-4	Electric	All	1.00	1.00	1.00	1.00	1.00	0.94
Faucet Aerator	MF Retrofit	Electric	All	1.00	0.60	0.60	0.60	0.58	1.00
Faucet Aerator	LI MF Retrofit	Electric	All	1.00	1.00	1.00	1.00	0.58	1.00
Faucet Aerator	HES	Gas	All	1.00	1.00	n/a	n/a	n/a	n/a
Faucet Aerator	LI Retrofit 1-4	Gas	All	1.00	1.00	n/a	n/a	n/a	n/a
Faucet Aerator	MF Retrofit	Gas	All	1.00	0.60	n/a	n/a	n/a	n/a
Faucet Aerator	LI MF Retrofit	Gas	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. For MF Retrofit, realization rate is based upon draft evaluation results.

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[369]

[369] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

Water Heating - Showerhead with Thermostatic Valve

Version Date and Revision History

Effective date: 1/1/2016
End date: TBD

Measure Overview

Description: An existing showerhead is replaced with a low-flow showerhead with an integrated thermostatic shut-off valve (TSV).
Primary Energy Impact: Electric, Oil, Propane, Gas
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts, Residential Water
Sector: Residential
Market: Retrofit
End Use: Hot Water
Measure Type: Flow Control
Core Initiative: Electric - Residential Consumer Products, Electric - Multi-Family Retrofit, Gas - Multi-Family Retrofit

Notes

Thermostatic shut-off valve technology is known by the trademarked name ShowerStart™.

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on engineering analysis.[370]

Measure Name	Core Initiative	Energy Type	ΔkW[371]	ΔkWh	ΔMMBtu
Low-Flow Showerhead with TSV, Electric	Res Products	Electric	0.06	372	
Low-Flow Showerhead with TSV, Oil	Res Products	Oil			2.09
Low-Flow Showerhead with TSV, Other	Res Products	Propane			1.84
Low-Flow Showerhead with TSV, Gas	Res Products	Gas			1.84
Low-Flow Showerhead with TSV, Electric	MF Retrofit	Electric	0.06	335	
Low-Flow Showerhead with TSV, Oil	MF Retrofit	Oil			1.88
Low-Flow Showerhead with TSV, Other	MF Retrofit	Propane			1.66
Low-Flow Showerhead with TSV	MF Retrofit	Gas			1.66

Baseline Efficiency

The Baseline Efficiency case is an existing standard-flow showerhead (2.5 GPM) with no thermostatic shut-off valve.

370 National Grid (2014). *Review of ShowerStart evolve.*
371 Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

High Efficiency

The high efficiency case is a low-flow showerhead (1.5 GPM) with integrated thermostatically actuated valve.

Hours

Not applicable.

Measure Life

The measure life is 7 years.[372]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Residential Water	Residential water savings for showerhead with integrated TSV	3,022 Gallons/Unit-year[373]
Residential Water	Multifamily water savings for showerhead with integrated TSV	2,723 Gallons/Unit-year[374]
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Low-Flow Showerhead with TSV	Res Products	All	1.00	1.00	1.00	1.00	1.00	0.94
Low-Flow Showerhead with TSV	MF Retrofit	All	1.00	0.60	1.60	1.60	0.58	1.00

In-Service Rates
All installations have 100% in service rate.

Realization Rates
All PAs use 100% energy realization rate except for MF Retrofit where the realization rate is based on draft evaluation results.

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[375]

372 Massachusetts common assumption
373 National Grid (2014). *Review of ShowerStart evolve.*
374 National Grid (2014). *Review of ShowerStart evolve.*

375 The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

Water Heating - Thermostatic Valve

Version Date and Revision History

Effective date: 1/1/2016
End date: TBD

Measure Overview

Description: A stand-alone valve that may be used with existing showerhead.
Primary Energy Impact: Electric, Oil, Propane, Gas
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts, Residential Water
Sector: Residential
Market: Retrofit
End Use: Hot Water
Measure Type: Flow Control
Core Initiative: Electric - Residential Consumer Products, Electric - Multi-Family Retrofit, Gas - Multi-Family Retrofit

Notes

Thermostatic shut-off valve technology is known by the trademarked name ShowerStart™.

Algorithms for Calculating Primary Energy Impacts

The unit savings are deemed based on engineering analysis. [376]

Measure Name	Core Initiative	Energy Type	ΔkWh	ΔkW[377]	ΔMMBtu
Thermostatic Shut-off Valve, Electric	Res Products	Electric	76	0.01	
Thermostatic Shut-off Valve, Oil	Res Products	Oil			0.43
Thermostatic Shut-off Valve, Other	Res Products	Propane			0.38
Thermostatic Shut-off Valve, Gas	Res Products	Gas			0.38
Thermostatic Shut-off Valve, Electric	MF Retrofit	Electric	69	0.01	
Thermostatic Shut-off Valve, Oil	MF Retrofit	Oil			0.39
Thermostatic Shut-off Valve, Other	MF Retrofit	Propane			0.34
Thermostatic Shut-off Valve	MF Retrofit	Gas			0.34

Baseline Efficiency

The Baseline Efficiency case is an existing standard-flow showerhead (2.5 GPM) with no thermostatic shut-off valve.

[376] National Grid (2014). *Review of ShowerStart evolve.*
[377] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

High Efficiency

The high efficiency case is a standard-flow showerhead (2.5 GPM) with the addition of the stand-alone thermostatic shut-off valve (the "Ladybug").

Hours

Not applicable.

Measure Life

The measure life is 7 years.[378]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Residential Water	Residential water savings for TSV	621 Gallons/Unit-year[379]
Residential Water	Residential water savings for TSV	558 Gallons/Unit-year[380]
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Thermostatic Shut-off Valve	Res Products	All	1.00	1.00	1.00	1.00	1.00	0.94
Thermostatic Shut-off Valve	MF Retrofit	All	1.00	0.60	0.60	0.60	0.58	1.00

In-Service Rates
All installations have 100% in service rate.

Realization Rates
All PAs use 100% energy realization rate.

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2013). Prepared for Massachusetts Program Administrators.[381]

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[378] Massachusetts common assumption
[379] National Grid (2014). *Review of ShowerStart evolve.*
[380] National Grid (2014). *Review of ShowerStart evolve.*
[381] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

Water Heating – Waterbed Mattress Replacement

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Replacement of waterbed mattress with a standard mattress.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: Hot Water
Measure Type: Flow Control
Core Initiative: Electric - Low-Income Single Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[382]:

Measure Name	Core Initiative	ΔkWh	ΔkW[383]
Waterbed	LI Retrofit 1-4	872	0.19

Baseline Efficiency

The baseline efficiency case is an existing waterbed mattress.

High Efficiency

The high efficiency case is a new standard mattress.

Hours

Not applicable.

Measure Life

The measure life is 10 years.[384]

[382] The Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid.
[383] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[384] See the response to the question “How do I know when I need to buy a new mattress?” at the following link for more details: http://www.serta.com/#/best-mattress-FAQs-mattresses-Serta-Number-1-Best-Selling-Mattress.html (8/19/2010).

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Waterbed	LI Retrofit 1-4	All	1.00	1.00	1.00	1.00	0.73	1.00
Waterbed	LI MF Retrofit	All	1.00	1.00	1.00	1.00	0.67	1.00

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% since deemed savings are based on evaluation results.

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[385]

[385] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

Water Heating – Indirect Water Heater

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Indirect water heaters use a storage tank that is heated by the main boiler. The energy stored by the water tank allows the boiler to turn off and on less often, saving considerable energy.
Primary Energy Impact: Oil, Propane, Gas
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: Hot Water
Measure Type: Water Heater
Core Initiative: Electric - Residential Home Energy Services, Gas - Residential Heating & Cooling Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results.

Measure Name	Core Initiative	Energy Type	ΔMMBtu/Unit
Indirect Water Heater, Oil	HES	Oil	6.4[386]
Indirect Water Heater	RHVAC	Gas	8.0[387]
Indirect Water Heater, Other	HES	Propane	8.0[388]

Baseline Efficiency

The baseline efficiency case is the existing water heater.

High Efficiency

The high efficiency case is an indirect water heater attached to an ENERGY STAR® rated forced hot water boiler.

Hours

Not applicable.

[386] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[387] The Cadmus Group, Inc. (2012) *Memo to HEHE Program Administrators Re: Impacts of Upcoming Federal Standards on HEHE Gas Space and Water Heating Measures*; June 8, 2012.
[388] Ibid.

Measure Life

The measure life is 20 years.[389]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Indirect Water Heater	HES	All	1.00	1.00	n/a	n/a	n/a	n/a
Indirect Water Heater	RHVAC	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. Summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

[389] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks.

Water Heating – On Demand/Tankless Water Heater

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Tankless water heaters circulate water through a heat exchanger to be heated for immediate use, eliminating the standby heat loss associated with a storage tank
Primary Energy Impact: None
Secondary Energy Impact: Propane, Gas
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: Hot Water
Measure Type: Water Heater
Core Initiative: Electric - Residential Home Energy Services, Gas - Residential Heating & Cooling Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[390].

Measure Name	Core Initiative	Energy Type	ΔMMBtu/Unit
On-Demand Water Heater, Other	HES	Propane	8.3
Tankless Water Heater 0.82	RHVAC	Gas	9.4
Tankless Water Heater 0.94	RHVAC	Gas	9.9

Baseline Efficiency

The baseline efficiency case is a standalone tank water heater with a 0.6 EF. For the early retirement portion, the baseline efficiency is an existing 0.55 EF standalone water heater.

High Efficiency

The high efficiency case is either an On Demand tankless water heater with an energy factor >= 0.82 or an On Demand tankless water heater with an energy factor >= 0.94.

Hours

Not applicable.

Measure Life

The measure life is 19 years for gas equipment[391] and 20 years for propane equipment[392].

[390] The calculation of the adjustment can be found in the 2016-2018 HEHE Savings Workbook.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
On Demand Water Heater, Other	HES	All	1.00	1.00	n/a	n/a	n/a	n/a
Tankless Water Heater 0.82	RHVAC	All	1.00	1.00	n/a	n/a	n/a	n/a
Tankless Water Heater 0.94	RHVAC	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
100% energy realization rate. Summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

[391] DOE (2008). *ENERGY STAR® Residential Water Heaters: Final Criteria Analysis*. Prepared for the DOE; Page 10. Lifetime has been adjusted to reflect the mix of replace on failure and early replacement based on: The Cadmus Group (2013). *2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing*. Prepared for the Electric and Gas Program Administrators of Massachusetts. The calculation of the adjustment can be found in the 2014 HEHE Application of Results Excel Workbook.
[392] DOE (2008). *ENERGY STAR® Residential Water Heaters: Final Criteria Analysis*. Prepared for the DOE; Page 10.

Water Heating – Stand Alone Storage Water Heater

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Stand-alone storage water heaters are high efficiency water heaters that are not combined with space heating devices.
Primary Energy Impact: Gas
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: Hot Water
Measure Type: Water Heater
Core Initiative: Gas - Residential Heating & Cooling Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[393].

Measure Name	Core Initiative	Energy Type	ΔMMBtu/Unit
Stand Alone Water Heater 0.67	RHVAC	Gas	3.6

Baseline Efficiency

The baseline efficiency case is a standalone tank water heater with an energy factor of 0.60. For the early retirement portion. the baseline efficiency is an existing 0.55 EF standalone water heater.

High Efficiency

The high efficiency case is a stand-alone storage water heater with an energy factor >= 0.67.

Hours

Not applicable.

Measure Life

The measure life is 11 years. [394]

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[393] The calculation of the adjustment can be found in the 2016-2018 HEHE Savings Workbook.
[394] DOE (2008). *ENERGY STAR® Residential Water Heaters: Final Criteria Analysis*. Prepared for the DOE; Page 10. Lifetime has been adjusted to reflect the mix of replace on failure and early replacement based on: The Cadmus Group (2013). *2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing*. Prepared for the Electric and Gas Program Administrators of Massachusetts. The calculation of the adjustment can be found in the 2014 HEHE Application of Results Excel Workbook.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Stand Alone Water Heater 0.67	RHVAC	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
100% energy realization rate. Summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

Water Heating – Condensing Water Heater

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Condensing water heaters recover energy by using either a larger heat exchanger or a second heat exchanger to reduce the flue-gas temperature to the point that water vapor condenses, thus releasing even more energy.
Primary Energy Impact: None
Secondary Energy Impact: Gas
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: Hot Water
Measure Type: Water Heater
Core Initiative: Gas - Residential Heating & Cooling Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results.

Measure Name	Core Initiative	Energy Type	ΔMMBtu/Unit
Condensing Water Heater 0.95	RHVAC	Gas	8.5[395]

Baseline Efficiency

The baseline efficiency case is a standalone tank water heater with an energy factor of 0.60.

High Efficiency

The high efficiency case is a condensing water heater with a TE>= 0.95.

Hours

Not applicable.

Measure Life

The measure life is 15 years. [396]

[395] The Cadmus Group, Inc. (2012) *Memo to HEHE Program Administrators Re: Impacts of Upcoming Federal Standards on HEHE Gas Space and Water Heating Measures*; June 8, 2012.
[396] DOE (2008). *ENERGY STAR® Residential Water Heaters: Final Criteria Analysis*. Prepared for the DOE; Page 10.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Condensing Water Heater 0.95	RHVAC	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
100% energy realization rate. Summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

Water Heating – Heat Pump Water Heater (Electric)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a heat pump water heater (HPWH) instead of an electric resistance water heater.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity, Low-Income
End Use: Hot Water
Measure Type: Water Heater
Core Initiative: Electric - Residential Cooling & Heating Equipment, Electric - Low-Income Single Family Retrofit, Electric - Low Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[397]:

Measure Name	ΔkWh	ΔkW[398]
Heat Pump Water Heater <55 gallon, Electric	1,654	0.34

Baseline Efficiency

The baseline efficiency case is a new, standard efficiency electric resistance hot water heater.

High Efficiency

The high efficiency case is a high efficiency heat pump water heater.

Hours

Not applicable.

Measure Life

The measure life is 10 years.[399]

[397] Ibid.
[398] Ibid.
[399] Based on warranty of equipment.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Heat Pump Water Heater <55 gallon, Electric	RHVAC	All	1.00	1.00	1.00	1.00	0.47	1.00
Heat Pump Water Heater <55 gallon, Electric	LI Retrofit 1-4	All	1.00	1.00	1.00	1.00	0.47	1.00
Heat Pump Water Heater <55 gallon	LI MF Retrofit	All	1.00	1.00	1.00	1.00	0.47	1.00

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% since deemed savings are based on evaluation results.

Coincidence Factors
Coincidence factors are based on evaluation results.[400] Winter coincidence equal to 1 since gross kW savings are equal to winter peak demand savings.

[400] Steven Winter Associates, Inc (2012). *Heat Pump Water Heaters Evaluation of Field Installed Performance*. Sponsored by National Grid and Eversource (NSTAR).

Water Heating – Water Heating Systems

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of high efficiency water heating equipment to replace the existing inefficient water heater.
Primary Energy Impact: Natural Gas (Residential DHW)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: Hot Water
Measure Type: Water Heater
Core Initiative: Gas - Low-Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta MMBtu = Units \times \frac{18\ MMBtu}{Unit} \times \left(\frac{1}{EF_{BASE}} - \frac{1}{EF_{EE}} \right)$$

Where:

Unit	=	Total number of dwelling units utilizing the water heater
18 MMBtu/Unit	=	Average annual water heating energy demand per dwelling unit[401]
EF_{BASE}	=	Energy Factor for the baseline water heater
EF_{EE}	=	Energy Factor for the new efficient water heater

Baseline Efficiency

The baseline efficiency case is a stand-alone tank water heater with an energy factor of 0.575.

High Efficiency

The high efficiency case includes the new efficient water heater with an Energy Factor > 0.60.

Hours

Not applicable.

[401] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks.

Measure Life

Measure Name	Measure Life (years)
Indirect Water Heater	20 [402]
Stand Alone Water Heater	13 [403]
Tankless Water Heater	20 [404]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Indirect Water Heater	LI MF Retrofit	National Grid	1.00	0.75	n/a	n/a	n/a	n/a
Indirect Water Heater	LI MF Retrofit	Unitil	1.00	0.96	n/a	n/a	n/a	n/a
Stand Alone Water Heater	LI MF Retrofit	National Grid	1.00	0.75	n/a	n/a	n/a	n/a
Stand Alone Water Heater	LI MF Retrofit	Unitil	1.00	0.96	n/a	n/a	n/a	n/a
Tankless Water Heater	LI MF Retrofit	National Grid	1.00	0.75	n/a	n/a	n/a	n/a
Tankless Water Heater	LI MF Retrofit	Unitil	1.00	0.96	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since all PA programs include verification of equipment installations.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
Realization rates are based on evaluation results[405].

Coincidence Factors
There are no electric savings for this measure.

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[402] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks.
[403] DOE (2008). *ENERGY STAR® Residential Water Heaters: Final Criteria Analysis*. Prepared for the DOE; Page 10.
[404] Ibid.
[405] The Cadmus Group (2015). *Massachusetts Low-Income Multifamily Initiative Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts

Whole Home – Heating, Cooling, and DHW Measures

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: To capture lost opportunities, encourage the construction of energy-efficient homes, and drive the market to one in which new homes are moving towards net-zero energy.
Primary Energy Impact: Electric, Natural Gas, Oil, Propane
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Lost Opportunity
End Use: Energy Star Homes, Hot Water
Measure Type: Custom
Core Initiative: Electric - Residential New Construction, Gas - Residential New Construction

Algorithms for Calculating Primary Energy Impact

Savings are derived from three components within this initiative: Low-Rise Performance Path, Low-Rise Prescriptive Path, and Multi-Family High-Rise Path.

The Program Administrators currently use vendor calculated energy savings for Low-Rise Performance Path projects. These savings are calculated using a RESNET accredited Rating Software Tool (REM/Rate) where a user inputs a detailed set of technical data about a project, comparing as-built projected energy consumption to that of a Baseline Home. This process is used to calculate electric and fossil fuel energy savings due to heating, cooling, and water heating for all homes, both single family and multifamily buildings (three stories and below).[406]

For homes participating in the program via the Low-Rise Prescriptive Path, deemed savings are applied to each unit completing the requirements of the Program. The deemed savings were derived by ICF International using energy simulation tools to create a sample set of 168 homes that represented every type of home that would typically participate in the initiative, including various building types, sizes, fuel types, HVAC system types and climate locations.[407]

For homes participating in the Multi-Family High-Rise Path, ICF International created 98 customized engineering formulas for energy conservation measures spanning the following: Domestic Hot Water, Envelope, HVAC, Lighting, Refrigeration/Appliances and Motors & Drives.[408]

406 ICF International (2008). *Energy/Demand Savings Calculation and Reporting Methodology for the Massachusetts ENERGY STAR ® Homes Program*. Prepared for Joint Management Committee.
407 ICF International (2012). 2013 Prescriptive Modeling Summary Final
408 ICF International (2012). Multi-Family Savings Methodology

Baseline Efficiency

The User Defined Reference Home was revised for 2012 as a result of the baseline study completed in 2012.[409] [410]

High Efficiency

The high efficiency case is represented by the specific energy characteristics of each "as-built" home completed through the program.

Hours

Not applicable.

Measure Life

Measure Name	Measure Life (years)[411]
Cooling	25
Heating	25
Water Heating	15
Heating (High Rise)	25
Cooling (High Rise)	25
Water Heating (High Rise)	15
Lighting (High Rise)	4

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[409] NMR Group, Inc., KEMA, Inc., The Cadmus Group, Inc., Dorothy Conant (2012). *Massachusetts 2011 Baseline Study of Single-family Residential New Construction, Final Report*.
[410] NMR Group, Inc., KEMA, Inc., The Cadmus Group, Inc., Dorothy Conant (2012). *Final UDRH Inputs: Addendum to Massachusetts 2011 Baseline Study of Single-family Residential New Construction, Final Report*.
[411] Massachusetts Common Assumption.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Cooling	RNC	All	1.00	1.00	1.00	1.00	1.00	0.00
Heating	RNC	All	1.00	1.00	1.00	1.00	0.00	1.00
Water Heating	RNC	All	1.00	1.00	1.00	1.00	1.00	0.94
Heating (High Rise)	RNC	All	1.00	1.00	1.00	1.00	0.01	1.00
Cooling (High Rise)	RNC	All	1.00	1.00	1.00	1.00	1.00	0.00
Water Heating (High Rise)	RNC	All	1.00	1.00	1.00	1.00	0.58	1.00
Lighting (High Rise)	RNC	All	1.00	1.00	1.00	1.00	0.17	1.00

In-Service Rates
All installations have 100% in service rate since all PA programs include verification of equipment installations.

Realization Rates
Realization rates are 100% because energy and demand savings are custom calculated based on project specific detail.

Coincidence Factors
Coincidence factors are custom calculated based on project-specific detail.

Whole Home – Weatherization and Heating and Water Heating Systems

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Weatherization measures installed through the Low Income Multifamily program including insulation, air sealing, heating and water heating systems.
Primary Energy Impact: Electric, Gas
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: Envelope
Measure Type: Custom
Core Initiative: Low-Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

The program delivery agency uses vendor calculated energy savings for all allowed measures. These savings values are calculated using vendor proprietary software where the user inputs a set of technical data about the house and the software calculates building heating and cooling loads and other key parameters. The proprietary building model is based on thermal transfer, building gains, and a variable-based heating/cooling degree day/hour climate model. This provides an initial estimate of energy use that may be compared with actual billing data to adjust as needed for existing conditions. Then, specific recommendations for improvements are added and savings are calculated using measure-specific heat transfer algorithms.

Rather than using a fixed degree day approach, the building model estimates both heating degree days and cooling degree hours based on the actual characteristics and location of the house to determine the heating and cooling balance point temperatures. Savings from shell measures use standard U-value, area, and degree day algorithms, (see attached for details). Infiltration savings use site-specific seasonal factors to convert measured leakage to seasonal energy impacts. HVAC savings are estimated based on changes in system and/or distribution efficiency improvements, using ASHRAE 152 and BPI recommendations as their basis. Interactivity between architectural and mechanical measures is always included, to avoid overestimating savings due to incorrectly "adding" individual measure results.

Baseline Efficiency

The baseline efficiency case is the existing conditions of the participating household.

High Efficiency

The high efficiency case includes installed energy efficiency measures that reduce heating energy use.

Hours

Not applicable.

Measure Life

Measure Name	Measure Life (years)
Insulation	25[412]
Air Sealing	15[413]
Boiler	20 [414]
Furnace	18 [415]
Indirect Water Heater	20 [416]
Stand Alone Water Heater	13 [417]
Tankless Water Heater	20 [418]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[412] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.
[413] Ibid.
[414] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boilers*.
[415] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Furnace*.
[416] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks.
[417] DOE (2008). *ENERGY STAR® Residential Water Heaters: Final Criteria Analysis*. Prepared for the DOE; Page 10.
[418] Ibid.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Insulation	LI MF Retrofit	Eversource (NSTAR)	1.00	1.05	n/a	n/a	n/a	n/a
Air Sealing	LI MF Retrofit	Eversource (NSTAR)	1.00	1.05	n/a	n/a	n/a	n/a
Boiler	LI MF Retrofit	Eversource (NSTAR)	1.00	1.05	n/a	n/a	n/a	n/a
Furnace	LI MF Retrofit	Eversource (NSTAR)	1.00	1.05	n/a	n/a	n/a	n/a
Indirect Water Heater	LI MF Retrofit	Eversource (NSTAR)	1.00	1.05	n/a	n/a	n/a	n/a
Stand Alone Water Heater	LI MF Retrofit	Eversource (NSTAR)	1.00	1.05	n/a	n/a	n/a	n/a
Tankless Water Heater	LI MF Retrofit	Eversource (NSTAR)	1.00	1.05	n/a	n/a	n/a	n/a
Insulation	LI MF Retrofit	Columbia	1.00	0.96	n/a	n/a	n/a	n/a
Air Sealing	LI MF Retrofit	Columbia	1.00	0.96	n/a	n/a	n/a	n/a
Boiler	LI MF Retrofit	Columbia	1.00	0.96	n/a	n/a	n/a	n/a
Furnace	LI MF Retrofit	Columbia	1.00	0.96	n/a	n/a	n/a	n/a
Indirect Water Heater	LI MF Retrofit	Columbia	1.00	0.96	n/a	n/a	n/a	n/a
Stand Alone Water Heater	LI MF Retrofit	Columbia	1.00	0.96	n/a	n/a	n/a	n/a
Tankless Water Heater	LI MF Retrofit	Columbia	1.00	0.96	n/a	n/a	n/a	n/a

<u>In-Service Rates</u>
All installations have 100% in service rate since all PA programs include verification of equipment installations.

<u>Realization Rates</u>
Realization rates are based on evaluation results[419].

<u>Coincidence Factors</u>
There are no electric savings for these measures.

[419] The Cadmus Group (2015). *Massachusetts Low-Income Multifamily Initiative Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts

Whole Home – Basic Educational Measures

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of basic educational measures during an audit to help customers become more aware of energy efficiency.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: Behavior
Measure Type: Audit
Core Initiative: Electric - Low-Income Single Family Retrofit; Electric - Low-Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[420].

Measure Name	Core Initiative	PA	ΔkWh	ΔkW[421]
Participants/TLC Kit	LI Retrofit 1-4	National Grid, Eversource, Unitil	69	0.01
Participants/TLC Kit	LI Retrofit 1-4	CLC	126	0.03
Participants/TLC Kit	LI MF Retrofit	Eversource	69	0.01
Participant	LI MF Retrofit	CLC	126	0.03

Baseline Efficiency

The baseline efficiency case assumes no measures installed.

High Efficiency

The high efficiency case includes basic educational measures such as LED nightlights, refrigerator thermostats, hot water thermostats, refrigerator coil brush, wall plate stoppers (and low flow showerheads and aerators for CLC).

Hours

Not applicable.

[420] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[421] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

Measure Life

The measure life is 5 years.[422]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Participants/TLC Kit	LI Retrofit 1-4	All	1.00	1.00	1.00	1.00	0.73	1.00
Participant	LI MF Retrofit	All	1.00	1.00	1.00	1.00	0.77	1.00

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Realization rates are set to 100% since deemed savings are based on evaluation results.

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[423]

[422] Massachusetts Common Assumption.
[423] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

Whole Home – Education Kits

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Through Cape Light Compacts Energy Education Outreach Program, we are reaching out to each town through existing school partnerships and will now include Energy Education kits for students to bring home. Each kit will includes 3 LED light bulbs, and a 2 faucet aerators for students to install as well as other non-savings measures such as hot water temperature and refrigerator/freezer thermometer cards to assist students in learning more about energy efficiency.
Primary Energy Impact: Electric, Gas, Oil, Propane
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Lost Opportunity
End Use: Lighting, Hot Water
Measure Type: Education
Core Initiative: Electric – Residential Behavior/Feedback

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed.

Measure Name	PA	ΔkWh 2016	ΔkWh 2017	ΔkWh 2018	ΔkW 2016	ΔkW 2017	ΔkW 2018	ΔMMBtu
Energy Education kit, Electric Hot Water	CLC	242.9	236.9	228.8	0.05	0.05	0.05	
Energy Education kit, Gas Hot Water	CLC	144.9	138.9	130.8	0.03	0.03	0.03	0.3
Energy Education kit, Oil Hot Water	CLC	144.9	138.9	130.8	0.03	0.03	0.03	0.2
Energy Education kit, Propane Hot Water	CLC	144.9	138.9	130.8	0.03	0.03	0.03	0.2

Baseline Efficiency

The baseline efficiency case assumes no measures installed.

High Efficiency

The high efficiency case includes the savings measures in the Educational Kit: 3 LED Bulbs and 2 low flow faucet aerators. See: Lighting – LED Bulbs, Water Heating – Faucet Aerator.

Hours

Not applicable.

Measure Life

The measure life is 10 years[424].

Secondary Energy Impacts

There are no secondary impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Residential Water	Residential water savings from kit	664 gallons/kit
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Energy Education, Electric	Behavior/ Feedback	CLC	0.50	1.00	1.00	1.00	0.73	1.00
Energy Education, Gas	Behavior/ Feedback	CLC	0.50	1.00	1.00	1.00	0.73	1.00
Energy Education, Oil	Behavior/ Feedback	CLC	0.50	1.00	1.00	1.00	0.73	1.00
Energy Education, Other	Behavior/ Feedback	CLC	0.50	1.00	1.00	1.00	0.73	1.00

In-Service Rates
All installations have 50% in service rates based on Massachusetts Common Assumptions.

Realization Rates
Realization rates are set to 100% based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[425]

[424] Massachusetts Common Assumptions
[425] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

Whole Home – Home Energy Reports

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The Behavior/Feedback programs send energy use reports to participating electric and natural gas customers in order to change customers' energy-use behavior.
Primary Energy Impact: Electric, Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Products and Services
End Use: Behavior
Measure Type: Behavior
Core Initiative: Electric - Residential Behavior/Feedback, Gas - Residential Behavior/Feedback

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed and based on calculations from vendor prepared forecasts. [426]

$$\Delta kWh = (kWh_{BASE})(\%SAVE)$$

$$\Delta MMBtu = (MMBtu_{BASE})(\%SAVE)$$

Where:

Unit = One participant household.
$kWh/MMBTU_{BASE}$ = Baseline energy consumption kWh/MMBTu.
%SAVE = Energy savings percent per program participant.

Savings Factors for Home Energy Reports 2016

Measure Name	PA	PA Type	kWh/ MMBTu BASE	% Save	ΔkWh	ΔkW[427]	ΔMMBTu
Home Energy Reports	National Grid	Elec	8,305	1.494%	124.1	0.03	
Home Energy Reports	Eversource (NSTAR)	Elec	8,221	1.35%	111.0	0.02	
Home Energy Reports	Eversource (WMECO)	Elec	7,750	1.31%	101.3	0.02	
Home Energy Reports	CLC	Elec					
Home Energy Reports	National Grid	Gas	104.89	1.16%			1.213
Home Energy Reports	Eversource (NSTAR)	Gas	93.1	1.28%			1.19
Home Energy Reports	Berkshire	Gas					0.79

Savings Factors for Home Energy Reports 2017

[426] Navigant Consulting and Illume Advising (2015). *Massachusetts Cross-Cutting Behavioral Program Evaluation Opower Results*. Prepared for the Massachusetts Program Administrators
[427] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

Measure Name	PA	PA Type	kWh/ MMBTu BASE	% Save	ΔkWh	ΔkW[428]	ΔMMBTu
Home Energy Reports	National Grid	Elec	8,278	1.494%	123.7	0.03	
Home Energy Reports	Eversource (NSTAR)	Elec	8,216	1.34%	110.0	0.02	
Home Energy Reports	Eversource (WMECO)	Elec	7,751	1.25%	96.9	0.02	
Home Energy Reports	CLC	Elec					
Home Energy Reports	National Grid	Gas	105.01	1.16%			1.212
Home Energy Reports	Eversource (NSTAR)	Gas	92.0	1.20%			1.10
Home Energy Reports	Berkshire	Gas					0.79

Savings Factors for Home Energy Reports 2018

Measure Name	PA	PA Type	kWh/ MMBTu BASE	% Save	ΔkWh	ΔkW[429]	ΔMMBTu
Home Energy Reports	National Grid	Elec	8,256	1.502%	124.1	0.03	
Home Energy Reports	Eversource (NSTAR)	Elec	8,158	1.37%	111.7	0.02	
Home Energy Reports	Eversource (WMECO)	Elec	7,751	1.24%	96.1	0.02	
Home Energy Reports	CLC	Elec					
Home Energy Reports	National Grid	Gas	105.07	1.15%			1.211
Home Energy Reports	Eversource (NSTAR)	Gas	90.7	1.09%			0.99
Home Energy Reports	Berkshire	Gas					0.79

Baseline Efficiency

The baseline efficiency case is a customer who does not receive a Home Energy Report.

High Efficiency

The high efficiency case is a customer who receives a Home Energy Report.

Hours

Not applicable.

Measure Life

The measure life is 1 year.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

[428] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.
[429] Ibid

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	PA Type	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Home Energy Reports	Behavior/Feedback	Eversource (NSTAR)	Elec	1.00	1.04	1.04	1.04	0.73	1.00
Home Energy Reports	Behavior/Feedback	National Grid	Elec	1.00	0.95	0.95	0.95	0.73	1.00
Home Energy Reports	Behavior/Feedback	Eversource (WMECO)	Elec	1.00	1.04	1.04	1.04	0.73	1.00
Home Energy Reports	Behavior/Feedback	CLC	Elec	1.00	1.04	1.00	1.00	0.73	1.00
Home Energy Reports	Behavior/Feedback	National Grid	Gas	1.00	0.98	n/a	n/a	n/a	n/a
Home Energy Reports	Behavior/Feedback	Eversource (NSTAR)	Gas	1.00	0.98	n/a	n/a	n/a	n/a
Home Energy Reports	Behavior/Feedback	Berkshire	Gas	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
In-services rates are 100% since the program tracks all participating customers.

Realization Rates
Realization rates are based on evaluation results.[430]

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[431]

[430] The savings factors listed are net numbers derived directly from Navigant Consulting and Illume Advising (2015). *Massachusetts Cross-Cutting Behavioral Program Evaluation Opower Results* and already include the impact of the realization rates. The realization rates listed in the Impact Factors table were derived from the report cited above and will be applied to gross vendor estimates going forward.
[431] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

Whole Home - Code Compliance Support Initiative (CCSI)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The MassSave Code Compliance Support Initiative (CCSI) is focused on improving the energy code compliance rates of residential and commercial buildings in the state. The initiative includes trainings, technical support, and the development of compliance documentation tools. This effort will support code officials, as well as design and construction professionals.
Primary Energy Impact: Electric, Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: Energy Star Homes
Measure Type: Codes & Standards
Core Initiative: Residential New Construction

Algorithms for Calculating Primary Energy Impact

Energy Savings = Gross Technical Potential * (((1 - Non-Compliance) – Baseline Compliance)/(1 – Baseline Compliance)) * Attribution Factor * Annual Ramp Factor.

Where:

Gross Technical Potential (GTP) - This represents the residential energy savings (kWh and Therms) through building simulations described below under Baseline Efficiency. The Gross technical potential for residential is the difference between homes modelled with the the same UDRH that was used for program activity in 2014 and homes modelled as 100% compliant with 2012 IECC multiplied by the total number of single family and multifamily new construction permits in MA.

Non-Compliance – represents the percentage of potential energy savings not realized at the end of an energy code cycle due to buildings on average not fully meeting code requirements, i.e. the difference between 100% compliance and actual compliance at the end of the energy code cycle[432].

Baseline Compliance – represents the percentage of energy savings realized at the beginning of a new code cycle[433].

Attribution Factor – The percentage of potential energy savings above the normal compliance level, on average, at the end of a typical energy code cycle attributable to PA CCSI efforts[434].

[432] This value is estimated at 17%.
[433] A value of 63% is used based on the following study, NMR Group, Inc. (2014). *Massachusetts Electric and Gas Program Administrators Code Compliance Results for Single-Family Non-Program Homes in Massachusetts*.
[434] A deemed rate of 35% is used.

Annual Ramp Factor – Factor used to simulate how quickly the CCSI reaches the target compliance goal across years. That is, since it takes time for the education efforts of the CCSI to take hold only a portion of the attributable savings are claimed each year during the initiative and ramped up to 100% over the entire three year term[435].

Baseline Efficiency

The baseline efficiency case assumes energy consumption using a measured compliance level[436]. Inputs from the 2014 Massachusetts User Defined Reference Home (UDRH) were used to develop a building energy model, and simulations were run to compare energy consumption with that of the same building prototype built to 2012 IECC prescriptive code specifications. The energy impact was separated into estimates of kWh and Therms for HVAC, DHW, and Lighting (kWh), and then multiplied by the number of single family and low-rise multifamily residential new construction units for Massachusetts as estimated by the 2014 U.S. Census results.

High Efficiency

The high efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code.

Hours

Not Applicable.

Measure Life

20 years.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA Type	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Codes and Standards	RNC	Elec	All	1.00	1.00	1.00	1.00	n/a	n/a
Codes and Standards	RNC	Gas	All	1.00	1.00	n/a	n/a	n/a	n/a

[435] The 2016 – 2018 term includes savings from 2015 – 2018 where the Annual Ramp Factor is 20% for 2015, 30% for 2016, 50% for 2017, and 100% for 2018.
[436] NMR Group, Inc. (2014). *Massachusetts Electric and Gas Program Administrators Code Compliance Results for Single-Family Non-Program Homes in Massachusetts*.

In-Service Rates
All PAs use 100% in service rate.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
All PAs use 100% realization rates as all adjustments are made via the factors listed in the algorithm above.

Coincidence Factors
Not applicable as no demand savings are counted.

Commercial and Industrial Electric Efficiency Measures

Lighting – Advanced Lighting Design (Performance Lighting)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Advanced lighting design refers to the implementation of various lighting design principles aimed at creating a quality and appropriate lighting experience while reducing unnecessary light usage. This is often done by a professional in a new construction situation. Advanced lighting design uses techniques like maximizing task lighting and efficient fixtures to create a system of optimal energy efficiency and functionality.
Primary Energy Impact: Electric
Secondary Energy Impact: Gas, Oil
Non-Energy Impact: O&M
Sector: Commercial and Industrial
Market: Lost Opportunity
End Use: Lighting
Measure Type: Interior
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = \sum_{i=1}^{n}\left(\frac{LPD_{BASE,i} \times Area_i \times Hours_i}{1000}\right) - \sum_{j=1}^{m}\left(\frac{Count_{EE,j} \times Watts_{EE,j} \times Hours_j}{1000}\right)$$

$$\Delta kW = \sum_{i=1}^{n}\left(\frac{LPD_{BASE,i} \times Area_i}{1000}\right) - \sum_{j=1}^{m}\left(\frac{Count_{EE,j} \times Watts_{EE,j}}{1000}\right)$$

Where:

n	=	Total number of spaces in Space-by-Space Method or 1 for Building Area Method
m		Total number of efficient fixture types installed
$LPD_{BASE,i}$	=	Baseline lighting power density for building or space type i (Watts/ft^2)
$Area_i$	=	Area of building or space *i* (ft^2)
$Hours_i$	=	Annual hours of operation of the lighting equipment for building or space type *i*
$Count_{EE,j}$	=	Quantity of efficient fixture type j
$Watts_{EE,j}$	=	Wattage of fixture type j (Watts)
1000	=	Conversion factor: 1000 watts per 1 kW

Note on HVAC system interaction: Additional Electric savings from cooling system interaction are included in the calculation of adjusted gross savings for Lighting Systems projects. The HVAC interaction adjustment factor is determined from lighting project evaluations and is included in the energy realization rates and demand coincidence factors and realization rates.

Baseline Efficiency

The Baseline Efficiency assumes compliance with lighting power density requirements as mandated by Massachusetts State Building Code, which currently reflects IECC 2012. IECC 2012 offers two compliance paths, the Building Area Method and Space-by-Space Method. For completeness, the lighting power density requirements for both the Building Area Method and the Space-by-Space Method are presented in Appendix A: Common Lookup Tables, Table 1 and Table 2.

High Efficiency

The high efficiency scenario assumes lighting systems that achieve lighting power densities below those required by Massachusetts State Building Code. Actual site lighting power densities should be determined on a case-by-case basis. Please refer to the current year application form for minimum percentage better than code efficiency requirements.

Hours

The annual hours of operation for lighting systems are site-specific and should be determined on a case-by-case basis. If site-specific hours are unavailable, refer to the default hours in Table 5 in Appendix A: Common Lookup Tables.

Measure Life

The measure life for all new construction lighting installations is 15 years.[437]

Secondary Energy Impacts

Heating energy will be increased due to reduced lighting waste heat. This impact is estimated as an average impact in heating fossil fuel consumption per unit of energy saved.

Measure	Energy Type	Impact (MMBtu/ΔkWh)[438]
Interior Lighting	C&I Gas Heat	-0.000175

Non-Energy Impacts

Annual non-energy benefits are claimed due to the reduced operation and maintenance costs associated with the longer measure lived of lamps and ballasts as compared to the base or pre-retrofit case. See Appendix C: Non-Resource Impacts.

[437] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[438] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations*. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
All	NB and EUL	National Grid	1.00	0.98	1.16	0.85	custom	custom	n/a	n/a
All	NB and EUL	All PAs except National Grid	1.00	1.25	1.01	1.01	0.52	0.44	0.48	.044

Note: Realization Rates and Coincidence Factors have the HVAC Interactive Effect incorporated, see note in Algorithm section.

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
- National Grid: energy and demand RRs derived from impact evaluation of the PAs 2010 Custom Lighting programs. [439]
- All Other PAs: Energy and demand RRs from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs[440]. Demand RR is the connected demand RR; energy RR includes connected kWh RR, hours of use RR and HVAC Interactive adjustment

Coincidence Factors
- National Grid, CFs are custom calculated based on site-specific information.
- All Other PAs: All CFs from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting program.[441]

[439] KEMA, Inc. (2012). *Impact Evaluation of 2010 Custom Lighting Installations*. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council
[440] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installation.*
[441] Ibid

Lighting – Lighting Systems

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: This measure promotes the installation of efficient lighting including, but not limited to, efficient fluorescent lamps, ballasts, and fixtures, and solid state lighting.
Primary Energy Impact: Electric
Secondary Energy Impact: Gas, Oil
Non-Energy Impact: O&M
Sector: Commercial & Industrial
Market: Lost Opportunity, Retrofit
End Use: Lighting
Measure Type: Interior, Exterior
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life, C&I Existing Building Retrofit, C&I Small Business, C&I Upstream Lighting

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = \left[\sum_{i=1}^{n} \left(\frac{Count_i * Watts_i}{1000} \right)_{BASE} - \sum_{j=1}^{m} \left(\frac{Count_j * Watts_j}{1000} \right)_{EE} \right] (Hours)$$

$$\Delta kW = \sum_{i=1}^{n} \left(\frac{Count_i * Watts_i}{1000} \right)_{BASE} - \sum_{j=1}^{m} \left(\frac{Count_j * Watts_j}{1000} \right)_{EE}$$

Where:

n	=	Total number of fixture types in baseline or pre-retrofit case
m	=	Total number of installed fixture types
$Count_i$	=	Quantity of existing fixtures of type i (for lost-opportunity, $Count_i = Count_j$).
$Watts_i$	=	Existing fixture or baseline wattage for fixture type i
$Count_j$	=	Quantity of efficient fixtures of type j.
$Watts_j$	=	Efficient fixture wattage for fixture type j.
1000	=	Conversion factor: 1000 watts per kW.
Hours	=	Lighting annual hours of operation.

Note on HVAC system interaction: Additional Electric savings from cooling system interaction are included in the calculation of adjusted gross savings for Lighting Systems projects. The HVAC interaction adjustment factor is determined from lighting project evaluations and is included in the energy realization rates and demand coincidence factors and realization rates (See Impact Factors section).

Baseline Efficiency

For retrofit installations, the baseline efficiency case is project-specific and is determined using actual fixture counts from the existing space. For lost opportunity installations, the baseline efficiency case is determined using assumed baseline wattages for each of the installed fixtures.[442]

High Efficiency

For both new construction and retrofit installations, the high efficiency case is project-specific and is determined using actual fixture counts for the project and the MassSave Wattage Tables in Appendix A: Common Lookup Tables (Table 3 and Table 4).

Hours

The annual hours of operation for lighting systems are site-specific and should be determined on a case-by-case basis with the exception of measures offered via the Upstream Lighting initiative. Upstream Lighting measures use a deemed operating hours value based on the Upstream Lighting Impact evaluation[443] with the exception of Stairwell fixtures which use a deemed operating hours of 8,760. If site-specific hours of operation are unavailable, refer to the default hours presented in Table 5 in Appendix A: Common Lookup Tables.

Measure Life

Lighting system measure lives vary by market sector and equipment type.

Measure Lives for Downstream C&I Lighting Systems[444]

Equipment Type	Measure Life (years)	
	Retrofit	Lost Opportunity
Bulb – CFL screw base	5	N/A
Fluorescent Fixture[445]	13	15
Hardwired CFL	13	15
LED Exit Signs	13	15
LED Lighting Fixtures	13	15
LED Integral Replacement Lamps	13	15
LED Low Bay – Garage & Canopy Fixtures	13	15

[442] Massachusetts Common Assumption: Baseline wattage per fixture type based on comparable code-compliant installations and standard practice.
[443] DNV-GL (2015). *Massachusetts Commercial and Industrial Upstream Lighting Program: "In Storage" Lamps Follow-Up Study, Final Report.*
[444] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1 AND GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measure*s. Prepared for The New England State Program Working Group; Table 2
[445] To account for the effects of EISA (Energy Independence and Security Act of 2007), the lifetime of measures replacing T12s has been reduced for 2016 to 4.30. Beginning in 2007 and into the future T12s will no longer be used as a baseline measure.

Measure Lives for Upstream C&I Lighting Systems[446]

Equipment Type	Measure Life (years)		
	2016	2017	2018
PAR20	8.56	8.12	7.67
PAR30	8.36	7.88	7.40
PAR38	8.50	8.04	7.59
MR16	8.42	7.95	7.48
LED, A-Line	3.66	3.20	2.83
LED, Decoratives	3.93	3.64	3.37
LED Retrofit Kits	5.50	4.98	4.65
LED Stairwell with Occupancy Sensors	7	7	7
G24 LED lamps	13	13	13
TLEDs	12	12	12
T8/T5	10	10	10
T8-28, 25 U-Bend	7	7	7

Secondary Energy Impacts

Heating energy will be increased due to reduced lighting waste heat. This impact is estimated as an average impact in heating fossil fuel consumption per unit of energy saved.

Core Initiative	Measure	Energy Type	Impact (MMBtu/ΔkWh)[447]
NB, EUL, Large Retrofit	Interior Lighting	C&I Gas Heat	-0.00023
NB, EUL, Large Retrofit	Interior Lighting	Oil	-0.00046
Upstream LEDs	Interior Lighting	C&I Gas Heat	-0.00038
Upstream LEDs	Interior Lighting	Oil	-0.00073
Upstream T8/T5	Interior Lighting	C&I Gas Heat	-0.00030
Upstream T8/T5	Interior Lighting	Oil	-0.00059
Small Retrofit	Interior Lighting	Gas Heat	-0.001075
Small Retrofit	Interior Lighting	Oil Heat	-0.000120

Non-Energy Impacts

Annual non-energy benefits are claimed due to the reduced operation and maintenance costs associated with the longer measure lives of lamps and ballasts as compared to the base or pre-retrofit case. See Appendix C: Non-Resource Impacts.

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[446] For all Upstream measures estimate based on average life of eligible products and average annual operating hours derived from the 2014 Upstream Lighting Impact evaluation. The following measures in this table have been adjusted for the years 2016-2018 to account for the effects of EISA (Energy Independence and Security Act of 2007); PAR lamps, MR16s, LED A-Lines, LED Decoratives, and LED Retrofit Kits.

[447] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations;* DNV-GL (2015). *Massachusetts Commercial and Industrial Upstream Lighting Program: "In Storage" Lamps Follow-Up Study, Final Report, (Percent split between gas and oil based on spreadsheet associated with Optimal 2008 MEMO: Non Electric Benefits Analysis Update)*; **AND** for Small Retrofit; The Cadmus Group (2012). *Non-Controls Lighting Evaluation for the Massachusetts Small Business Direct Install Program: Multi-Season*.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
All	NB, EUL, Large Retrofit	All	1.00	1.12	1.00	1.00	0.83	0.66	0.84	0.67
Upstream LED	Upstream	All	1.00	1.19	1.13	1.13	0.72	0.53	0.67	0.49
Upstream T8/T5	Upstream	All	1.00	0.92	0.85	0.85	0.76	0.51	0.68	0.45
Upstream LED Stairwell with Occ Sensor	Upstream	All	1.00	1.00	1.00	1.00	0.78	0.86	0.78	0.86
All	Small Retrofit	All except Eversource (WMECO)	1.00	1.02	0.99	0.99	0.73	0.44	n/a	n/a
All	Small Retrofit	Eversource (WMECO)	1.00	1.02	0.99	0.99	0.73	0.44	0.67	0.42

Note: Realization Rates and Coincidence Factors have the HVAC Interactive Effect incorporated, see note in Algorithm section.

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates

- C&I New Construction: For all measures except Upstream Lighting, all PAs Energy and Demand RRs from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs. [448]. Demand RR is the Connected Demand RR; Energy RR includes connected kWh RR, Hours of Use RR and HVAC Interactive adjustment. For Upstream measures (except LED Stairwell fixtures) all PAs Energy and Demand RRs are from the 2015 Upstream Lighting "In Storage" Follow-up Impact evaluation[449]. Demand RR is the Connected Demand RR; Energy RR includes connected kWh RR and HVAC Interactive adjustment. Upstream LED Stairwell fixture RRs are estimates as these fixtures have not been evaluated yet.
- C&I Existing Building Retrofit: All PAs energy and demand RRs from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs.[450]. Demand RR is the connected demand RR; energy RR includes connected kWh RR, hours of use RR and HVAC Interactive adjustment
- C&I Small Business: Energy and demand RRs are the statewide results from the 2011 Small C&I Non-Controlled Lighting impact evaluation[451]

Coincidence Factors

- C&I New Construction: For all measures except Upstream Lighting, all CFs are from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs.[452] For Upstream measures (except LED Stairwell fixtures) all PAs CFs are from the 2014 Upstream Lighting Impact evaluation.[453] Upstream LED Stairwell fixture CFs are estimates as these fixtures have not been evaluated yet.
- C&I Existing Building Retrofit: All CFs are from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs.[454]
- C&I Small Business: All PAs use CF values from the 2012 the Cadmus Non-Controls Multi-Season Lighting Evaluation.[455]

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[448] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations*
[449] DNV-GL (2015). *Massachusetts Commercial and Industrial Upstream Lighting Program: "In Storage" Lamps Follow-Up Study, Final Report* (All PAs use the results from this study, but they may be applied in slightly different manners due to differences in individual tracking systems).
[450] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations*.
[451] The Cadmus Group. (2012). *Non-Controls Lighting Evaluation for the Massachusetts Small Business Direct Install Program: Multi-Season Study*. Prepared for Massachusetts Joint Utilities.
[452] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations*.
[453] KEMA, Inc. (2014). *Impact Evaluation of the Massachusetts Upstream Lighting Program, Final Report.*
[454] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations*.

Lighting – Lighting Controls

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: This measure promotes the installation of lighting controls in both lost-opportunity and retrofit applications. Promoted technologies include occupancy sensors and daylight dimming controls.
Primary Energy Impact: Electric
Secondary Energy Impact: Heating energy (non-electric)
Non-Energy Impacts: O&M
Sector: Commercial & Industrial
Market: Lost Opportunity, Retrofit
End Use: Lighting
Measure Type: Controls
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life, C&I Existing Building Retrofit, C&I Small Business

Algorithms for Calculating Primary Energy Impact[456]

C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life, C&I Existing Building Retrofit:

$$\Delta kWh = Controlled\ kW * Hours_{Base} * \%Sav$$

$$\Delta kW = (Controlled\ kW)$$

C&I Small Business:

$$\Delta kWh = (Controlled\ kW)(Hours_{BASE} - Hours_{EE})$$

$$\Delta kW = (Controlled\ kW)$$

Where:

Controlled kW	=	Controlled fixture wattage
%Sav	=	Percentage of kWh that is saved by utilizing the control measure.[457]
$Hours_{BASE}$	=	Total annual hours that the connected Watts operated in the pre-retrofit case (retrofit installations) or would have operated with code-compliance controls (new construction installations).
$Hours_{EE}$	=	Annual hours that the connect Watts operate with controls implemented.

[455] The Cadmus Group. (2012). *Non-Controls Lighting Evaluation for the Massachusetts Small Business Direct Install Program: Multi-Season Study*. Prepared for Massachusetts Joint Utilities.
[456] Note of HVAC system interaction: Additional Electric savings from cooling system interaction are included in the calculation of adjusted gross savings for Lighting Systems projects. The HVAC interaction adjustment factor is determined from lighting project evaluations and is included in the energy realization rates and demand coincidence factors and realization rates (See Impact Factors section).
[457] A percent savings value of 24% is used for Occupancy Sensors and a value of 28% for Daylight Dimming based on the following report: DNV KEMA (2014) *Retrofit Lighting Controls Measures Summary of Findings FINAL REPORT*

Baseline Efficiency

The baseline efficiency case assumes no controls (retrofit) or code-compliant controls (new construction).

High Efficiency

The high efficiency case involves lighting fixtures connected to controls that reduce the pre-retrofit or baseline hours of operation.

Hours

The annual hours of reduction for lighting controls are site-specific and should be determined on a case-by-case basis.

Measure Life

Measure Lives for C&I Lighting Controls[458]

Measure	Retrofit	Lost Opportunity
Occupancy Sensors	9	10
Daylight Dimming	9	10

Secondary Energy Impacts

Heating energy will be increased due to reduced lighting waste heat. This impact is estimated as an average impact in heating fossil fuel consumption per unit of energy saved.

Core Initiative	Measure	Energy Type	Impact (MMBtu/ΔkWh)[459]
NB, EUL, Large Retrofit	Interior Lighting	C&I Gas Heat	-0.00092 MMBtu/kWh
NB, EUL, Large Retrofit	Interior Lighting	Oil	-0.00180 MMBtu/kWh
Small Retrofit	Interior Lighting	Gas Heat	-0.000743 MMBtu/kWh
Small Retrofit	Interior Lighting	Oil	-0.000132 MMBtu/kWh

Non-Energy Impacts

Annual non-energy benefits are claimed due to the reduced operation and maintenance costs associated with the longer measure lives of lamps and ballasts as compared to the base or pre-retrofit case. See Appendix C: Non-Resource Impacts.

[458] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[459] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations (Percent split between gas and oil based on spreadsheet associated with Optimal 2008 MEMO: Non Electric Benefits Analysis Update)* AND The Cadmus Group, Inc. (2012), *Final Report, Small Business Direct Install Program: Pre/Post Occupancy Sensor Study*.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
All	NB, EUL, Large Retrofit	All	1.00	0.72	0.94	0.94	0.15	0.13	0.14	0.14
Occupancy Sensors	Small Business	National Grid	1.00	0.42	0.92	0.92	0.18	0.12	n/a	n/a
All	Small Business	Eversource (NSTAR), CLC	1.00	0.42	0.92	0.92	0.18	0.12	n/a	n/a
All	Small Business	Unitil	1.00	0.42	0.92	0.92	0.18	0.12	n/a	n/a
All	Small Business	Eversource (WMECO)	1.00	0.42	0.92	0.92	0.18	0.12	custom	custom

Note: Realization Rates and Coincidence Factors have the HVAC Interactive Effect incorporated, see note in Algorithm section.

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
- Large C&I: energy and demand RRs from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs.[460]. Demand RR is the connected demand RR; energy RR includes connected kWh RR, hours of use RR and HVAC Interactive adjustment.
- Small C&I Existing Building Retrofit: RRs from statewide Pre/Post Occupancy Sensor study.[461]

Coincidence Factors
- Large C&I: CFs are from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs.[462]
- C&I Small Business: CFs from statewide Pre/Post Occupancy Sensor study.[463]

[460] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations*.
[461] The Cadmus Group, Inc. (2012). *Final Report, Small Business Direct Install Program: Pre/Post Occupancy Sensor Study.*
[462] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations*.
[463] The Cadmus Group, Inc. (2012). *Final Report, Small Business Direct Install Program: Pre/Post Occupancy Sensor Study.*

Lighting – Freezer/Cooler LEDs

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of LED lighting in freezer and/or cooler cases. The LED lighting consumes less energy, and results in less waste heat which reduces the cooling/freezing load.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Lighting
Measure Type: Interior
Core Initiative: C&I Existing Building Retrofit, C&I Small Business

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = \Delta kWh_{LED} + \Delta kWh_{Heat}$$

$$\Delta kWh_{LED} = \sum_{i=1}^{n}\left(Count_i * kW_i * Hours_i\right)_{BASE} - \sum_{i=1}^{m}\left(Count_j * kW_j * Hours_j\right)_{LED}$$

$$\Delta kWh_{Heat} = \Delta kWh_{LED} * 0.28 * Eff_{RS}$$

$$\Delta kW = \Delta kWh / Hours_j$$

Where:

ΔkWh_{LED}	=	Reduction in lighting energy
ΔkWh_{Heat}	=	Reduction in refrigeration energy due to reduced heat loss from the lighting fixtures
N	=	Total number of lighting fixture types in the pre-retrofit case
M	=	Total number of lighting fixture types in the post-retrofit case
$Count_i$	=	Quantity of type i fixtures in the pre-retrofit case
kW_i	=	Power demand of pre-retrofit lighting fixture type i (kW/fixture)
$Hours_i$	=	Pre-retrofit annual operating hours of fixture type i
$Count_j$	=	Quantity of type j fixtures in the pre-retrofit case
kW_j	=	Power demand of lighting fixture type j (kW/fixture)
$Hours_j$	=	Post-retrofit annual operating hours of fixture type j
0.28	=	Unit conversion between kW and tons calculated as 3,413 Btuh/kW divided by 12,000 Btuh/ton
Eff_{RS}	=	Efficiency of typical refrigeration system: 1.6 kW/ton[464] for C&I Small Business; 1.9 kW/ton for Large C&I[465]

[464] Select Energy (2004). *Cooler Control Measure Impact Spreadsheet Users' Manual*. Prepared for Eversource (NSTAR).
[465] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations*

Baseline Efficiency

The baseline efficiency case is the existing lighting fixtures in the cooler or freezer cases.

High Efficiency

The high efficiency case is the installation of LED lighting fixtures on the cooler or freezer cases, replacing the existing lighting fixtures.

Hours

Annual hours of operation are determined on a case-by-case basis and are typically 8760 hours/year. Post-retrofit operating hours are assumed to be the same as pre-retrofit hours unless lighting occupancy sensors were also implemented.

Measure Life

The measure life is 13 years.[466]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Freezer/Cooler LEDs	Large Retrofit	All	1.00	0.94	1.01	1.01	0.99	1.00	1.00	1.00
Freezer/Cooler LEDs	Small Retrofit	National Grid	1.00	0.94	1.01	1.01	0.99	1.00	n/a	n/a
Freezer/Cooler LEDs	Small Retrofit	Eversource (NSTAR)	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Freezer/Cooler LEDs	Small Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Freezer/Cooler LEDs	Small Retrofit	CLC	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Freezer/Cooler LEDs	Small Retrofit	Eversource (WMECO)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

In-Service Rates
All installations have 100% in service rate since PA programs include verification of equipment installations.

[466] Energy & Resource Solutions (2005*). Measure Life Study*. Prepared for The Massachusetts Joint Utilities.

Realization Rates

- All PAs Large C&I energy and demand RRs from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs.[467]
- National Grid: RRs for C&I Small Business installations based on 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs[468];
- Eversource (NSTAR), Eversource (WMECO), CLC, Unitil: energy and demand RRs are 100% based on no evaluations

Coincidence Factors

- All PAs Large C&I CFs from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs[469].
- National Grid C&I Small Business based on 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs[470].
- Unitil, Eversource (NSTAR), Eversource (WMECO): C&I Small Business CFs set to 100% because pre-retrofit unit operate 8760 hours/year.

[467] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations*.
[468] Ibid.
[469] Ibid.
[470] Ibid.

HVAC – Unitary Air Conditioners

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: This measure promotes the installation of high efficiency unitary air conditioning equipment in lost opportunity applications. Air conditioning (AC) systems are a major consumer of electricity and systems that exceed baseline efficiencies can save considerable amounts of energy. This measure applies to air, water, and evaporatively-cooled unitary AC systems, both single-package and split systems.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC
Measure Type: Cooling
Core Initiative: C&I New Buildings & Major Renovations and C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

For units with cooling capacities less than 65 kBtu/h:

$$\Delta kWh = (kBtu/h)\left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}\right)(EFLH_{Cool})$$

$$\Delta kW = (kBtu/h)\left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)$$

For units with cooling capacities equal to or greater than 65 kBtu/h and EER available:

$$\Delta kWh = (kBtu/h)\left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)(EFLH_{Cool})$$

$$\Delta kW = (kBtu/h)\left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)$$

For units with cooling capacities equal to or greater than 65 kBtu/h and IEER available:

$$\Delta kWh = (kBtu/h)\left(\frac{1}{IEER_{BASE}} - \frac{1}{IEER_{EE}}\right)(Hours_{Cool})(Cap_{adj})$$

$$\Delta kW = (kBtu/h)\left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)$$

Where:

ΔkWh	=	Gross annual kWh savings from the measure.
ΔkW	=	Gross connected kW savings from the measure.
kBtu/h	=	Capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h)
$SEER_{BASE}$	=	Seasonal Energy Efficiency Ratio of the baseline equipment.
$SEER_{EE}$	=	Seasonal Energy Efficiency Ratio of the energy efficient equipment.
$EFLH_{Cool}$	=	Cooling equivalent full load hours.
EER_{BASE}	=	Energy Efficiency Ratio of the baseline equipment.
EER_{EE}	=	Energy Efficiency Ratio of the energy efficient equipment.
$IEER_{BASE}$	=	Integrated Energy Efficiency Ratio of the baseline equipment.
$IEER_{EE}$	=	Integrated Energy Efficiency Ratio of the energy efficient equipment.
$Hours_{Cool}$	=	Annual Cooling Hours
Cap_{adj}		Capacity Adjustment Factor: [471] See table below for values.

PA specific Capacity Adjustment Factors for IEER[472]

PA	Capacity Adjustment Factor
National Grid	1.009
Eversource (NSTAR), CLC	0.927
WMECO, Unitil	1.104

Baseline Efficiency

The baseline efficiency case for new installations assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. For 2016, baseline efficiency requirements will follow IECC 2012 with Massachusetts specific amendments. [473] Baseline requirements for 2017 and on have not been finalized.

[471] The capacity adjustment factor is used only when IEER is used to determine energy savings. Since IEER takes into account performance at different loading points, the capacity adjustment factor helps to account for the fact that more load occurs at lower temperatures and capacities. The adjustment factor is greater than 1 for climate zones with lower full load hours and runtime, and the factor is less than 1 for zones with more full load hours and runtime.
[472] DNV GL (2014). *Memo – Develop Modified Runtime from NEEP HVAC Loadshape Study*. Prepared for National Grid and Northeast Utilities. August 20, 2014. Capacity Factors are weighted using information about PA specific load zones.
[473] International Code Council (2012). *2012 International Energy Conservation Code*; Page C-38, Table C403.2.3(1).

Unitary Air Conditioners Baseline Efficiency Levels[474]

Equipment Type	Size Category	Subcategory or Rating Condition	2016 Baseline Efficiency
Air conditioners, air cooled	<65,000 Btu/h[b]	Split system	13.0 SEER
		Single package	13.0 SEER
	≥65,000 Btu/h and <135,000 Btu/h	Split system and single package	11.2 EER[a] 11.4 IEER[a]
	≥135,000 Btu/h and <240,000 Btu/h	Split system and single package	11.0 EER[a] 11.2 IEER[a]
	≥240,000 Btu/h and <760,000 Btu/h	Split system and single package	10.0 EER[a] 10.1 IEER[a]
	≥760,000 Btu/h	Split system and single package	9.7 EER[a] 9.8 IEER[a]
Air conditioners, Water cooled	<65,000 Btu/h	Split system and single package	12.1 EER 12.3 IEER
	≥65,000 Btu/h and <135,000 Btu/h	Split system and single package	12.1 EER[a] 12.3 IEER[a]
	≥135,000 Btu/h and <240,000 Btu/h	Split system and single package	12.5 EER[a] 12.7 IEER[a]
	≥240,000 Btu/h	Split system and single package	12.4 EER[a] 12.6 IEER[a]
Air conditioners, evaporatively cooled	<65,000 Btu/h	Split system and single package	12.1 EER 12.3 IEER
	≥65,000 Btu/h and <135,000 Btu/h	Split system and single package	12.1 EER[a] 12.3 IEER[a]
	≥135,000 Btu/h and <240,000 Btu/h	Split system and single package	12.0 EER[a] 12.2 IEER[a]
	≥240,000 Btu/h	Split system and single package	11.9 EER[a] 12.1 IEER[a]

a. Deduct 0.2 from the required EERs for units with a heating section other than electric heat.[475]
b. Single-phase air-cooled air conditioners <65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA); SEER values are those set by NAECA.

High Efficiency

The high efficiency case assumes the HVAC equipment meets or exceeds the Consortium for Energy Efficiency's (CEE) specification. This specification results in cost-effective energy savings by specifying higher efficiency HVAC equipment while ensuring that several manufacturers produce compliant equipment. The CEE specification is reviewed and updated annually to reflect changes to the ASHRAE and IECC energy code baseline as well as improvements in the HVAC equipment technology. Equipment efficiency is the rated efficiency of the installed equipment for each project.

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474 For air-cooled air conditioners < 65 kBtu/h, if the actual EER_{EE} is unknown, assume the following conversion from SEER to EER: EER≈SEER/1.1.
475 The PAs do not differentiate between units by heating section types. To be conservative, the highest Baseline Efficiency is assumed for all heating section types in each equipment category.

Hours

Whenever EER or SEER is used to determine energy savings, Equivalent Full Load Hours should be used. Whenever IEER is used to determine energy savings, Annual Cooling Hours should be used. Annual cooling hours or equivalent full load hours for unitary AC equipment may be site specific or default PA specific values made be used, see Table 6 in Appendix A: Common Lookup Tables.

Measure Life

The measure life is 15 years.[476]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Unitary AC	NB, EUL	CLC	1.00	1.00	0.74	0.00	0.45	0.00	n/a	n/a
Unitary AC	NB, EUL	National Grid	1.00	1.00	1.00	1.00	0.40	0.00	n/a	n/a
Unitary AC	NB, EUL	Eversource (NSTAR)	1.00	1.00	0.74	0.00	0.45	0.00	n/a	n/a
Unitary AC	NB, EUL	Unitil	1.00	1.00	1.00	1.00	0.33	0.00	n/a	n/a
Unitary AC	NB, EUL	Eversource (WMECO)	1.00	0.91	0.74	0.00	0.45	0.00	0.42	0.00

In-Service Rates
All installations have 100% in service rate since all programs include verification of equipment installations.

Realization Rates
- CLC, National Grid, Eversource (NSTAR), Unitil: Energy RRs set to 1.00 based 2011 NEEP C&I Unitary HVAC Loadshape Project.[477]
- Eversource (WMECO): Energy RRs are from 2007/2008 Large C&I Programs impact evaluation[478]

Coincidence Factors
CFs based 2011 NEEP C&I Unitary HVAC Loadshape Project.[479]

[476] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[477] KEMA (2011). C&I Unitary HVAC LoadShape Project – Final Report. Prepared for the Regional Evaluation, Measurement & Verification Forum.
[478] KEMA, Inc. (2010). *2007/2008 Large C&I Programs, Phase 1 Report Memo for Lighting and Process Measures*. Prepared for Western Massachusetts Electric Company.
[479] KEMA (2011). C&I Unitary HVAC LoadShape Project – Final Report. Prepared for the Regional Evaluation, Measurement & Verification Forum.

HVAC – Heat Pump Systems

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: This measure applies to the installation of high-efficiency air cooled, water source, ground water source, and ground source heat pump systems.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC
Measure Type: Heat Pumps
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

For air cooled units with cooling capacities less than 65 kBtu/h:

$$\Delta kWh = \Delta kWh_{Cool} + \Delta kWh_{Heat}$$

$$\Delta kWh_{Cool} = (kBtu/h)\left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}\right)(EFLH_{COOL})$$

$$\Delta kWh_{Heat} = (kBtu/h)\left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}}\right)(EFLH_{HEAT})$$

$$\Delta kW_{Cool} = (kBtu/h)_{Cool}\left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)$$

For all water source, groundwater source, and ground source units. Also for air cooled units with cooling capacities equal to or greater than 65 kBtu/h and EER available:

$$\Delta kWh = \Delta kWh_{Cool} + \Delta kWh_{Heat}$$

$$\Delta kWh_{Cool} = (kBtu/h_{COOL})\left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)(EFLH_{COOL})$$

$$\Delta kWh_{Heat} = \frac{(kBtu/h_{HEAT})}{3.412}\left(\frac{1}{COP_{BASE}} - \frac{1}{COP_{EE}}\right)(EFLH_{HEAT})$$

$$\Delta kW_{Cool} = (kBtu/h)_{Cool}\left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)$$

For air cooled units with cooling capacities equal to or greater than 65 kBtu/h with available IEER:

$$\Delta kWh = \Delta kWh_{Cool} + \Delta kWh_{Heat}$$

$$\Delta kWh_{Cool} = (kBtu/h_{COOL})\left(\frac{1}{IEER_{BASE}} - \frac{1}{IEER_{EE}}\right)(Hours_{COOL})(Cap_{adj})$$

$$\Delta kWh_{Heat} = \frac{(kBtu/h_{HEAT})}{3.412}\left(\frac{1}{COP_{BASE}} - \frac{1}{COP_{EE}}\right)(EFLH_{HEAT})$$

$$\Delta kW_{Cool} = (kBtu/h)_{Cool}\left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)$$

Where:

ΔkWh_{COOL}	=	Gross annual cooling mode kWh savings from the measure.
ΔkWh_{HEAT}	=	Gross annual heating mode kWh savings from the measure.
ΔkW_{COOL}	=	Gross annual kW savings from the measure. Heating kW savings are negligible.
kBtu/h[480]	=	Capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h).
$SEER_{BASE}$	=	Seasonal Energy Efficiency Ratio of the baseline equipment.
$SEER_{EE}$	=	Seasonal Energy Efficiency Ratio of the energy efficient equipment.
$EFLH_{COOL}$	=	Cooling mode equivalent full load hours.
$HSPF_{BASE}$	=	Heating Seasonal Performance Factor of the baseline equipment.
$HSPF_{EE}$	=	Heating Seasonal Performance Factor of the energy efficient equipment.
$EFLH_{HEAT}$	=	Heating mode equivalent full load hours.
$kBtu/h_{COOL}$	=	Capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h).
EER_{BASE}	=	Energy Efficiency Ratio of the baseline equipment.
EER_{EE}	=	Energy Efficiency Ratio of the energy efficient equipment.
$kBtu/h_{HEAT}$	=	Capacity of the heating equipment in kBtu per hour. If the heating capacity is unknown, it can be calculated from the cooling capacity[481]
3.412	=	Conversion factor: 3.412 Btu per Wh.
COP_{BASE}	=	Coefficient of performance of the baseline equipment. See table below for values.
COP_{EE}	=	Coefficient of performance of the energy efficient equipment.
$IEER_{BASE}$	=	Integrated Energy Efficiency Ratio of the baseline equipment. See table below for values.
$IEER_{EE}$	=	Integrated Energy Efficiency Ratio of the energy efficient equipment.
$Hours_{Cool}$	=	Annual Cooling Hours
Cap_{adj}		Capacity Adjustment Factor: [482] See table below for values.

[480] For equipment with cooling capacities less than 65 kBtu/h, it is assumed that the heating capacity and cooling capacity are equal.
[481] For Air Source HPs: Heating Capacity = Cooling Capacity * 13,900/12,000 (ratio of heat produced in heating mode to cooling produced in cooling mode). For Water/Ground Source HPs: Heating Capacity = Cooling Capacity * COP/EER (converts the rated cooling output to the rated heating output.
[482] The capacity adjustment factor is used only when IEER is used to determine energy savings. Since IEER takes into account performance at different loading points, the capacity adjustment factor helps to account for the fact that more load occurs at lower temperatures and capacities. The adjustment factor is greater than 1 for climate zones with lower full load hours and runtime, and the factor is less than 1 for zones with more full load hours and runtime.

PA Specific Capacity Adjustment Factors for IEER[483]

PA	Capacity Adjustment Factor
National Grid	1.009
Eversource (NSTAR), CLC	0.927
WMECO, Unitil	1.104

Baseline Efficiency

The baseline efficiency case for new installations assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. For 2016, baseline efficiency requirements will follow IECC 2012 with Massachusetts specific amendments. [484] Baseline requirements for 2017 and on have not been finalized. The table below details the specific efficiency requirements by equipment type and capacity.

Unitary and Applied Heat Pumps Baseline Efficiency Levels[485]

Equipment Type	Size Category (Cooling Capacity)	Subcategory or Rating Condition	2016 Baseline Efficiency	
			Cooling Mode	Heating Mode
Air cooled	<65,000 Btu/h[b]	Split system	13.0 SEER	7.7 HSPF
		Single package	13.0 SEER	7.7 HSPF
	≥65,000 Btu/h and <135,000 Btu/h	Split system and single package / 47°F db/43°F wb outdoor air	11.0 EER[a] 11.2 IEER[a]	3.3 COP
	≥135,000 Btu/h and <240,000 Btu/h	Split system and single package / 47°F db/43°F wb outdoor air	10.6 EER[a] 10.7 IEER[a]	3.2 COP
	≥240,000 Btu/h	Split system and single package / 47°F db/43°F wb outdoor air	9.5 EER[a] 9.6 IEER[a]	3.2 COP
Water source	<17,000 Btu/h	86°F entering water (Cooling Mode) / 68°F entering water (Heating Mode)	11.2 EER	4.2 COP
	≥17,000 Btu/h and <135,000 Btu/h	86°F entering water / 68°F entering water (Heating Mode)	12.0 EER	4.2 COP
Groundwater source	<135,000 Btu/h	59°F entering water (Cooling Mode) / 50°F entering water (Heating Mode)	16.2 EER	3.6 COP
Ground source	<135,000 Btu/h	77°F entering water / 32°F entering water (Heating Mode)	13.4 EER	3.1 COP

db = dry-bulb temperature, °F; wb = wet-bulb temperature, °F.
a. Deduct 0.2 from the required EERs for units with a heating section other than electric heat.[486]
b. Single-phase air-cooled air conditioners <65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA); SEER values are those set by NAECA.

[483] DNV GL (2014). *Memo – Develop Modified Runtime from NEEP HVAC Loadshape Study*. Prepared for National Grid and Northeast Utilities. August 20, 2014. Capacity Factors are weighted using information about PA specific load zones.
[484] International Code Council (2012). *2012 International Energy Conservation Code*; Page C-40, Table C403.2.3(2).
[485] Since IECC 2012 does not provide EER requirements for air-cooled heat pumps < 65 kBtu/h, assume the following conversion from SEER to EER: EER≈SEER/1.1.
[486] The PAs do not differentiate between units by heating section types. To be conservative, the highest baseline efficiency is assumed for all heating section types in each equipment category.

High Efficiency

The high efficiency case assumes the HVAC equipment meets or exceeds the Consortium for Energy Efficiency's (CEE) specification. This specification results in cost-effective energy savings by specifying higher efficiency HVAC equipment while ensuring that several manufacturers produce compliant equipment. The CEE specification is reviewed and updated annually to reflect changes to the ASHRAE and IECC energy code baseline as well as improvements in the HVAC equipment technology. Equipment efficiency is the rated efficiency of the installed equipment for each project.

Hours

Whenever EER or SEER is used to determine energy savings, Equivalent Full Load Hours should be used. Whenever IEER is used to determine energy savings, Annual Operating Hours should be used. Annual cooling hours or equivalent full load hours for heat pump equipment may be site specific or default PA specific hours may be used, see Table 6 in Appendix A: Common Lookup Tables.

Measure Life

The measure life is 15 years.[487]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Heat Pumps	NB, EUL	National Grid	1.00	1.05	1.00	1.00	0.40	0.00	n/a	n/a
Heat Pumps	NB, EUL	Eversource (NSTAR)	1.00	1.01	1.09	1.57	0.45	0.00	n/a	n/a
Heat Pumps	NB, EUL	CLC	1.00	1.01	1.09	1.57	0.45	0.00	n/a	n/a
Heat Pumps	NB, EUL	Unitil	1.00	1.00	1.00	1.00	0.33	0.00	n/a	n/a
Heat Pumps	NB, EUL	Eversource (WMECO)	1.00	0.91	1.09	1.57	0.45	0.00	0.42	0.00

In-Service Rates
All installations have 100% in service rate since PA programs include verification of equipment installations.

Realization Rates
- National Grid and energy and demand RRs based on a 1994 study of HVAC and process cooling equipment.[488]
- Eversource (NSTAR) energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations[489]
- CLC energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations.
- Unitil realization rates same as Unitary AC.

[487] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[488] The Fleming Group (1994). *Persistence of Commercial/Industrial Non-Lighting Measures, Volume 2, Energy Efficient HVAC and Process Cooling Equipment*. Prepared for New England Power Service Company.
[489] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.

- Eversource (WMECO): Energy RRs are from 2007/2008 Large C&I Programs impact evaluation[490], demand realization rates from impact evaluation of NSTAR 2006 HVAC installations referenced above.

Coincidence Factors

CFs based 2011 NEEP C&I Unitary HVAC Loadshape Project.[491]

[490] KEMA, Inc. (2011). *2007/2008 Large C&I Programs,*
[491] KEMA (2011). C&I Unitary HVAC LoadShape Project – Final Report. Prepared for the Regional Evaluation, Measurement & Verification Forum.

HVAC – Demand Control Ventilation (DCV)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The measure controls the quantity of outside air to an air handling system based on detected space CO_2 levels. The installed systems monitor the CO_2 in the spaces or return air and reduce the outside air use when possible to save energy while meeting indoor air quality standards.
Primary Energy Impact: Electric
Secondary Energy Impact: Gas, Oil
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC
Measure Type: Ventilation
Core Initiative: C&I Existing Building Retrofit

Algorithms for Calculating Primary Energy Impacts

Gross energy and demand savings for implementation of demand control ventilation are custom **c**alculated using the PA's DCV savings calculation tools. These tools are used to calculate energy and demand savings based on site-specific project details including hours of operation, HVAC system efficiency and total air flow, and enthalpy and temperature set points.[492] Alternatively, the energy and demand savings may be calculated using the following algorithms and inputs:

$$\Delta kWh = (kBtu/h)\left(\frac{1\,Ton}{12\ kBtu/h}\right)(SAVE_{kWh})$$

$$\Delta kW = (kBtu/h)\left(\frac{1\,Ton}{12\ kBtu/h}\right)(SAVE_{kW})$$

Where:

kBtu/h	=	Capacity of the cooling equipment in kBtu per hour
$SAVE_{kWh}$	=	Average annual kWh reduction per ton of cooling capacity: 170 kWh/ton[493]
$SAVE_{kW}$	=	Average kW reduction per ton of cooling capacity: 0.15 kW/ton[494]

Baseline Efficiency

The baseline efficiency case assumes the relevant HVAC equipment has no ventilation control.

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[492] Detailed descriptions of the DCV Savings Calculation Tools are included in the TRM Library under the "C&I Spreadsheet Tools" folder.
[493] Keena, Kevin (2008). *Analysis of CO2 Control Energy Savings on Unitary HVAC Units.* Prepared for National Grid.
[494] Ibid.

High Efficiency

The high efficiency case is the installation of an outside air intake control based on CO_2 sensors.

Hours

The operating hours are site-specific for custom savings calculations.

Measure Life

The measure life is 10 years.[495]

Secondary Energy Impacts

Custom or default gas and oil heat impacts are counted for DCV measures for reduction in space heating.

Measure	Energy Type	Savings[496]
DCV	C&I Gas Heat	0.001277 MMBtu/kWh
DCV	Oil	0.002496 MMBtu/kWh

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
DCV	NB, EUL	CLC	1.00	1.01	1.09	1.57	0.82	0.05	n/a	n/a
DCV	NB, EUL	Eversource (NSTAR)	1.00	1.01	1.09	1.57	0.82	0.05	n/a	n/a
DCV	NB, EUL	Eversource (WMECO)	1.00	0.91	1.09	1.57	0.82	0.05	n/a	n/a

In-Service Rates
All installations have 100% in service rate.

Realization Rates
For Eversource (NSTAR) and CLC, RRs are from an impact evaluation 2006 HVAC installations.[497] For Eversource (WMECO) the energy RR is from and impact evaluation of 2007/2008 installations.[498]

Coincidence Factors
CFs based on standard assumptions.

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[495] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1. Measure life is assumed to be the same as Enthalpy Economizer.
[496] Optimal Energy, Inc. (2008). *Non-Electric Benefits Analysis Update*. Memo Prepared for National Grid.
[497] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification 2006 Final Report*. Prepared for NSTAR; Table 17.
[498] KEMA (2011). 2007/2008 Large C&I Programs Final Report. Prepared for Western Massachusetts Electric Company.

HVAC – Dual Enthalpy Economizer Controls (DEEC)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The measure is to upgrade the outside-air dry-bulb economizer to a dual enthalpy economizer. The system will continuously monitor the enthalpy of both the outside air and return air. The system will control the system dampers adjust the outside quantity based on the two readings.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity, Retrofit
End Use: HVAC
Measure Type: Controls
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impacts

$$\Delta kWh = (kBtu/h)\left(\frac{1\,Ton}{12\,kBtu/h}\right)(SAVE_{kWh})$$

$$\Delta kW = (kBtu/h)\left(\frac{1\,Ton}{12\,kBtu/h}\right)(SAVE_{kW})$$

Where:
kBtu/h = Capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h).
$SAVE_{kWh}$ = Average annual kWh reduction per ton of cooling capacity: 289 kWh/ton[499]
$SAVE_{kW}$ = Average kW reduction per ton of cooling capacity: 0.289 kW/ton[500]

Baseline Efficiency

The baseline efficiency case for this measure assumes the relevant HVAC equipment is operating with a fixed dry-bulb economizer.

High Efficiency

The high efficiency case is the installation of an outside air economizer utilizing two enthalpy sensors, one for outdoor air and one for return air.

[499] Patel, Dinesh (2001). *Energy Analysis: Dual Enthalpy Control*. Prepared for Eversource (NSTAR).
[500] Ibid.

Hours

Not applicable.

Measure Life

The measure life is 10 years for lost-opportunity applications.[501] The measure life is 7 years for retrofit installations.[502]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
DEEC	NB, EUL	National Grid	1.00	1.00	1.00	1.00	0.40	0.00	n/a	n/a
DEEC	NB, EUL	Eversource (NSTAR)	1.00	1.01	1.09	1.57	0.45	0.00	n/a	n/a
DEEC	NB, EUL	CLC	1.00	1.01	1.09	1.57	0.55	0.00	n/a	n/a
DEEC	NB, EUL	Unitil	1.00	1.00	1.00	1.00	0.332	0.00	n/a	n/a
DEEC	NB, EUL	Eversource (WMECO)	1.00	0.91	1.09	1.57	0.45	0.00	0.00	0.00

In-Service Rates
All installations have 100% in service rate since PA programs include verification of equipment installations.

Realization Rates
- National Grid RRs are 1.0 since there have been no impact evaluations of the prescriptive savings calculations.
- Eversource (NSTAR) & CLC energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations[503]
- Unitil realization rates same as Unitary AC.
- Eversource (WMECO): Energy RRs are from 2007/2008 Large C&I Programs impact evaluation[504], demand realization rates from impact evaluation NSTAR 2006 HVAC installations.

Coincidence Factors
- All PAs on-peak CFs based 2011 NEEP C&I Unitary AC Loadshape Project[505].
- Eversource (WMECO): seasonal peak values set to 0.00 based on assumption that no DEEC savings occur during seasonal peak periods.

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[501] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1
[502] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Table 2.
[503] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.
[504] KEMA, Inc. (2011). *2007/2008 Large C&I Programs,*
[505] KEMA (2011). C&I Unitary AC LoadShape Project – Final Report. Prepared for the Regional Evaluation, Measurement & Verification Forum.

HVAC – ECM Fan Motors

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: This measure promotes the installation of electronically commutated motors (ECMs) on fan powered terminal boxes, fan coils, and HVAC supply fans on small unitary equipment.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC
Measure Type: Motors
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Electric Energy Impact

$$\Delta kWh = (Design\,CFM)(Box\,Size\,Factor)(\%Flow_{ANNUAL})(Hours)$$
$$\Delta kW_{SP} = (Design\,CFM)(Box\,Size\,Factor)(\%Flow_{SP})$$
$$\Delta kW_{WP} = (Design\,CFM)(Box\,Size\,Factor)(\%Flow_{WP})$$

Where:

Design CFM	=	Capacity of the VAV box in cubic feet per minute
Box Size Factor	=	Savings factor in Watts/CFM. See table below for values.
$\%Flow_{ANNUAL}$	=	Average % of design flow over all operating hours. See table below for values.
$\%Flow_{SP}$	=	Average % of design flow during summer peak period. See table below for values.
$\%Flow_{WP}$	=	Average % of design flow during summer peak period. See table below for values.
Hours	=	Annual operating hours for VAV box fans

ECM Fan Motor Savings Factors [506]

Factor	Box Size	Value	Units
Box Size Factor	< 1000 CFM	0.32	Watts/CFM
Box Size Factor	≥ 1000 CFM	0.21	Watts/CFM
$\%Flow_{ANNUAL}$	All	0.52	-
$\%Flow_{SP}$	All	0.63	-
$\%Flow_{WP}$	All	0.33	-

[506] Factors based on engineering analysis developed at National Grid.

Baseline Efficiency

The baseline efficiency case for this measure assumes the VAV box fans are powered by a single speed fractional horsepower permanent split capacitor (PSC) induction motor.

High Efficiency

The high efficiency case must have a motor installed on new, qualifying HVAC equipment.

Hours

The annual operating hours for ECMs on VAV box fans are site-specific and should be determined on a case-by-case basis.

Measure Life

The measure life is 20 years for lost opportunity applications.[507]

Algorithms for Calculating Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
ECM Fan Motors	NB, EUL	National Grid	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
ECM Fan Motors	NB, EUL	Eversource (NSTAR), CLC	1.00	1.01	1.09	1.57	0.82	0.05	n/a	n/a
ECM Fan Motors	NB, EUL	Unitil	1.00	1.00	1.00	1.00	1.00	0.82	n/a	n/a
ECM Fan Motors	NB, EUL	Eversource (WMECO)	1.00	1.31	1.09	1.57	0.82	0.05	0.72	0.00

<u>**In-Service Rates**</u>
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

<u>**Realization Rates**</u>
- National Grid: RRs based on engineering estimates
- Eversource (NSTAR), CLC: energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations[508]
- Unitil: energy and demand RRs are 100% for all C&I New Construction projects based on no evaluations
- Eversource (WMECO): Energy RRs are from 2007/2008 Large C&I Programs impact evaluation[509], demand realization rates from impact evaluation of NSTAR 2006 HVAC installations referenced above.

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507 Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
508 RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for Eversource (NSTAR) Electric and Gas; Table 17.
509 KEMA, Inc. (2011). *2007/2008 Large C&I Programs,*

Coincidence Factors

- National Grid: CFs based on engineering estimates.
- Eversource (NSTAR), CLC, Unitil, Eversource (WMECO): on-peak CFs based on standard assumptions.
- Eversource (WMECO): seasonal peak values from 2005 coincidence factor study[510]

[510] RLW Analytics (2007). *Final Report, 2005 Coincidence Factor Study*. Prepared for Connecticut Energy Conservation Management Board, United Illuminating and Connecticut Light & Power.

HVAC – Energy Management System

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The measure is the installation of a new building energy management system (EMS) or the expansion of an existing energy management system for control of non-lighting electric and gas end-uses in an existing building on existing equipment.
Primary Energy Impact: Electric
Secondary Energy Impact: Gas, Oil
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC
Measure Type: Controls
Core Initiative: C&I New Construction, C&I Existing Building Retrofit, C&I Small Business

Algorithms for Calculating Primary Energy Impacts

Gross energy and demand savings for energy management systems (EMS) are custom calculated using the PA's EMS savings calculation tools. These tools are used to calculate energy and demand savings based on project-specific details including hours of operation, HVAC system equipment and efficiency and points controlled.[511]

Baseline Efficiency

The baseline for this measure assumes the relevant HVAC equipment has no control.

High Efficiency

The high efficiency case is the installation of a new EMS or the expansion of an existing EMS to control additional non-lighting electric or gas equipment. The EMS must be installed in an existing building on existing equipment.

Hours

Not applicable.

Measure Life

For lost-opportunity applications, the measure life is 15 years.[512] For retrofit applications, the measure life is 10 years.[513]

[511] Descriptions of the EMS savings calculation tools are included in the TRM Library "C&I Spreadsheet Tools" folder.
[512] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[513] Ibid.

Secondary Energy Impacts

Heating Impacts: Gas and oil heat impacts are counted for EMS measures for reduction in space heating. If the heating system impacts are not calculated in the EMS savings calculation tool, they can be approximated using the interaction factors described below:

Measure	Energy Type	Impact (MMBtu/ΔkWh)[514]
EMS	C&I Gas Heat	0.001277
EMS	Oil	0.002496

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
EMS	Large Retrofit	National Grid	1.00	1.04	1.03	1.03	custom	custom	n/a	n/a
EMS	Large Retrofit	Eversource (NSTAR)	1.00	1.01	1.09	1.57	0.82	0.05	n/a	n/a
EMS	Large Retrofit, Small Retrofit	Unitil	1.00	1.00	1.00	1.00	0.82	0.05	n/a	n/a
EMS	Large Retrofit	Eversource (WMECO)	1.00	0.57	1.09	1.57	0.82	0.05	custom	custom
EMS	Large Retrofit, Small Retrofit	CLC	1.00	1.01	1.09	1.57	0.82	0.05	n/a	n/a

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
- National Grid RRs derived from a 1994 study of HVAC and process cooling equipment.[515]
- Eversource (NSTAR), CLC energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations[516]
- Unitil: energy and demand RRs are 100% for all C&I New Construction projects based on no evaluations
- Eversource (WMECO): Energy RRs are based on end use from 2007/2008 Large C&I Programs impact evaluation[517], demand RRs from impact evaluation of NSTAR 2006 HVAC installations referenced above.

Coincidence Factors
- National Grid: CFs are custom calculated.
- Eversource (NSTAR), CLC, Unitil, Eversource (WMECO): on-peak CFs based on standard assumptions.
- Eversource (WMECO): seasonal CFs are custom calculated.

[514] Optimal Energy, Inc. (2008). *MEMO: Non-Electric Benefits Analysis Update*. Prepared for Eversource (NSTAR). Final savings values calculated in spreadsheet analysis as noted on pg 5 of the memo.
[515] The Fleming Group (1994). *Persistence of Commercial/Industrial Non-Lighting Measures, Volume 3, Energy Management Control Systems*. Prepared for New England Power Service Company.
[516] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.
[517] KEMA, Inc. (2011). *2007/2008 Large C&I Program Final Report.* Prepared for Western Massachusetts Electric Company.

HVAC – High Efficiency Chiller

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: This measure promotes the installation of efficient water-cooled and air-cooled water chilling packages for comfort cooling applications. Eligible chillers include air-cooled, water cooled rotary screw and scroll, and water cooled centrifugal chillers for single chiller systems or for the lead chiller only in multi-chiller systems.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC
Measure Type: Cooling
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impacts

Gross energy and demand savings for chiller installations may be custom calculated using the PA's Chillers savings calculation tool. These tools are used to calculated energy and demand savings based on site-specific chiller plant details including specific chiller plan equipment, operational staging, operating load profile and load profile.[518]

Alternatively, the energy and demand savings may be calculated using the following algorithms and inputs. Please note that consistent efficiency types (FL or IPLV) must be used between the baseline and high efficiency cases. It is recommended that IPLV be used over FL efficiency types when possible.

Air-Cooled Chillers:

$$\Delta kWh = (Tons)\left(\frac{12}{EER_{BASE}} - \frac{12}{EER_{EE}}\right)(Hours)$$

$$\Delta kW = (Tons)\left(\frac{12}{EER_{BASE}} - \frac{12}{EER_{EE}}\right)$$

[518] Descriptions of the Chiller savings calculation tools are included in the TRM Library "C&I Spreadsheet Tools" folder.

Water-Cooled Chillers:

$$\Delta kWh = (Tons)(kW / ton_{BASE} - kW / ton_{EE})(Hours)$$

$$\Delta kW = (Tons)(kW / ton_{BASE} - kW / ton_{EE})(LF)$$

Where:

Tons	=	Rated capacity of the cooling equipment
EER_{BASE}	=	Energy Efficiency Ratio of the baseline equipment. See table below for values.
EER_{EE}	=	Energy Efficiency Ratio of the efficient equipment. Site-specific.
kW/ton_{BASE}	=	Energy efficiency rating of the baseline equipment. See table below for values.
kW/ton_{EE}	=	Energy efficiency rating of the efficient equipment. Site-specific.
Hours	=	Equivalent full load hours for chiller operation

Baseline Efficiency

The baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. As described in Chapter 13 of the aforementioned document, energy efficiency must be met via compliance with the International Energy Conservation Code (IECC) 2012. The table below details the specific efficiency requirements by equipment type and capacity.

Chiller - Minimum Efficiency Requirements[519]

Equipment Type	Size Category (Tons)	Units	Path A		Path B	
			Full Load	IPLV	Full Load	IPLV
Air-cooled chillers	< 150	EER	9.562	12.5	NA	NA
	≥ 150	EER	9.562	12.75	NA	NA
Water cooled, electrically operated, positive displacement (rotary screw and scroll)	< 75	kW/ton	0.780	0.63	0.800	0.600
	≥ 75 and < 150	kW/ton	0.775	0.615	0.790	0.586
	≥ 150 and < 300	kW/ton	0.680	0.580	0.718	0.540
	≥ 300	kW/ton	0.620	0.540	0.639	0.490
Water cooled, electrically operated, centrifugal	< 150	kW/ton	0.634	0.596	0.639	0.450
	≥ 150 and < 300	kW/ton	0.634	0.596	0.639	0.450
	≥ 300 and < 600	kW/ton	0.576	0.549	0.600	0.400
	≥ 600	kW/ton	0.570	0.539	0.590	0.400

Note: Compliance with this standard may be obtained by meeting the minimum requirements of Path A or B, however, both the Full Load and IPLV must be met to fulfill the requirements of Path A or B.

High Efficiency

The high efficiency scenario assumes water chilling packages that exceed the efficiency levels required by Massachusetts State Building Code and meet the minimum efficiency requirements as stated in the New Construction HVAC energy efficiency rebate forms.

[519] International Code Council (2009). *2009 International Energy Conservation Code*;.Table 503.2.3(7). NOTE: values equal to IECC 2012 values: International Code Council (2012). *2012 International Energy Conservation Code*; Page C-46, Table C403.2.3(7).

Hours

The equivalent full load hours of operation for water chilling packages are site-specific and should be determined on a case-by-case basis. If site-specific EFLH is unavailable, default EFLHs of 1,361 should be used.[520]

Measure Life

The measure life is 23 years.[521]

Secondary Energy Impacts

There are no secondary energy impacts counted for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Chillers – IPLV used	NB, EUL	National Grid, Unitil, CLC	1.00	1.20	1.00	1.00	0.49	0.06	0.42	0.04
	NB, EUL	Eversource	1.00	1.00	1.00	1.00	0.42	0.20	0.30	0.15
Chillers – FL used	NB, EUL	All	1.00	2.63	1.00	1.00	0.86	0.10	0.71	0.08

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
- National Grid, Unitil, CLC: RRs based on statewide prospective results from 2015 prescriptive chiller study.[522] Prospective results are to be used in parallel with updated savings factors, as described above, from the same study.
- Eversource: RRs based on retrospective results from 2015 prescriptive chiller study.[523] Retrospective results are applicable to the Eversource Chiller Calculation Tool.

Coincidence Factors
- National Grid, Unitil, CLC: CFs based on prospective statewide results from 2015 prescriptive chiller study.[524]
- Eversource: Note that values stored in the CF fields are actually retrospective demand RRs for Eversource from the 2015 prescriptive chiller study.[525]

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520 DNV GL (2015). *Impact Evaluation of Prescriptive Chiller and Compressed Air Installations*. Prepared for the MA PAs and EEAC.
521 GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.
522 DNV GL (2015). *Impact Evaluation of Prescriptive Chiller and Compressed Air Installations*. Prepared for the MA PAs and EEAC.
523 Ibid.
524 Ibid.
525 Ibid.

HVAC – Hotel Occupancy Sensors

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The measure is to the installation of hotel occupancy sensors (HOS) to control packaged terminal AC units (PTACs) with electric heat, heat pump units and/or fan coil units in hotels that operate all 12 months of the year.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC
Measure Type: Controls
Core Initiative: C&I Existing Building Retrofit, C&I Small Business

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on evaluation results:

$$\Delta kWh = SAVE_{kWh}$$
$$\Delta kW = SAVE_{kW}$$

Where:

Unit	=	Installed hotel room occupancy sensor
$SAVE_{kWh}$	=	Average annual kWh reduction per unit: 438 kWh[526]
$SAVE_{kW}$	=	Average annual kWh reduction per unit: 0.09 kW[527]

Baseline Efficiency

The baseline efficiency case assumes the equipment has no occupancy based controls.

High Efficiency

The high efficiency case is the installation of controls that include (a) occupancy sensors, (b) window/door switches for rooms that have operable window or patio doors, and (c) set back to 65 F in the heating mode and set forward to 78°F in the cooling mode when occupancy detector is in the unoccupied mode. Sensors controlled by a front desk system are not eligible.

[526] MassSave (2010). *Energy Analysis: Hotel Guest Occupancy Sensors*. Prepared for National Grid and Eversource (NSTAR).
[527] Ibid.

Hours

Not applicable.

Measure Life

For retrofit applications, the measure life is 10 years.[528]

Secondary Energy Impacts

There are no secondary energy impacts.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
HOS	Large Retrofit	National Grid	1.00	1.00	1.00	1.00	0.30	0.70	n/a	n/a
HOS	Large Retrofit	Eversource (NSTAR), CLC	1.00	1.01	1.09	1.57	0.82	0.05	n/a	n/a
HOS	Large Retrofit	Unitil	1.00	1.00	1.00	1.00	0.82	0.05	n/a	n/a
HOS	Large Retrofit	Eversource (WMECO)	1.00	0.91	1.09	1.57	0.82	0.05	0.00	0.00
HOS	Small Retrofit	CLC	1.00	1.01	1.09	1.57	0.82	0.05	n/a	n/a

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
- National Grid: RRs based on engineering estimates.
- Eversource (NSTAR), CLC energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations[529]
- Unitil: Energy and demand RRs are 100% based on no evaluations.
- Eversource (WMECO): Energy RRs are based on end use from 2007/2008 Large C&I Programs impact evaluation[530], demand RRs from impact evaluation of NSTAR 2006 HVAC installations referenced above.

Coincidence Factors
- National Grid: CFs based on engineering estimates.
- Eversource (NSTAR), CLC, Unitil, Eversource (WMECO): on-peak CFs based on standard assumptions.
- Eversource (WMECO): seasonal CFs set to 0.00 based on assumption that no savings occur during seasonal peak periods.

[528] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1; Measure life is assumed to be the same as for EMS retrofit measure.
[529] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.
[530] KEMA, Inc. (2011). *2007/2008 Large C&I Programs,*

HVAC – Programmable Thermostats

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: This measure involves the installation of a programmable thermostat for cooling and/or heating systems in spaces with either no or erratic existing control.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC
Measure Type: Controls
Core Initiative: C&I Small Business

Algorithms for Calculating Primary Energy Impacts

$$\Delta kWh = (SQFT)(SAVE_{kWh})$$
$$\Delta kW = (SQFT)(SAVE_{kW})$$

Where:
SQFT = Square feet of controlled space
$SAVE_{kWh}$ = Average kW reduction per SQFT of controlled space. See table below.
$SAVE_{kW}$ = Average annual kWh reduction per SQFT of controlled. See table below.

Savings Factors (Save)[531]

Equipment Type	$SAVE_{kWh}$ (kWh/SQFT)	$SAVE_{kW}$ (kW/SQFT)
Cool Only No Existing Control	0.539	0.00
Cool Only Erratic Existing Control	0.154	0.00
Heat Only No Existing Control	0.418	0.00
Heat Only Erratic Existing Control	0.119	0.00
Cool and Heat No Existing Control	0.957	0.00
Cool and Heat Erratic Existing Control	0.273	0.00
Heat Pump No Existing Control	0.848	0.00
Heat Pump Erratic Existing Control	0.242	0.00

Baseline Efficiency

The baseline efficiency case includes spaces with either no or erratic heating and/or cooling control as indicated in the equipment type selection.

[531] Massachusetts common assumptions.

High Efficiency

The high efficiency case includes control of the space cooling and/or heating system as indicated in the equipment type selection.

Hours

Not applicable.

Measure Life

For retrofit applications, the measure life is 8 years.[532]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Thermostats	Small Retrofit	National Grid	1.00	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Thermostats	Small Retrofit	Eversource (NSTAR), CLC	1.00	0.91	0.92	0.92	0.00	0.00	n/a	n/a
Thermostats	Small Retrofit	Unitil	1.00	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Thermostats	Small Retrofit	Eversource (WMECO)	1.00	1.00	0.92	0.92	0.00	0.00	0.00	0.00

In-Service Rates
All installations have 100% in service rate since PA programs include verification of equipment installations.

Realization Rates
- National Grid, Unitil: RRs set to 100% based on no evaluations.
- Eversource (NSTAR), CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
- Eversource (WMECO): Energy RRs from impact evaluation of 2008 small retrofit program[533], demand RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.

Coincidence Factors
- All PAs CFs set to zero since no savings are expected during peak periods.

532 Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
533 The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008*. Prepared for Western Massachusetts Electric Company.

Refrigeration – Door Heater Controls

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of controls to reduce the run time of door and frame heaters for freezers and walk-in or reach-in coolers. The reduced heating results in a reduced cooling load.[534]
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Refrigeration
Measure Type: Controls
Core Initiative: C&I Small Business, C&I Existing Building Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = kW_{DH} * \%OFF * 8760$$
$$\Delta kW = kW_{DH} * \%OFF$$

Where:

kW_{DH}	=	Total demand of the door heater, calculated as Volts * Amps / 1000
8760	=	Door heater annual run hours before controls
%OFF		Door heater Off time[535]: 46% for freezer door heaters or 74% for cooler door heaters)

Baseline Efficiency

The baseline efficiency case is a cooler or freezer door heater that operates 8,760 hours per year without any controls.

High Efficiency

The high efficiency case is a cooler or freezer door heater connected to a heater control system, which controls the door heaters by measuring the ambient humidity and temperature of the store, calculating the dew point, and using pulse width modulation (PWM) to control the anti-sweat heater based on specific algorithms for freezer and cooler doors. Door temperature is typically maintained about 5^{o}F above the store air dew point temperature.[536]

[534] The assumptions and algorithms used in this section are specific to NRM products.
[535] The value is an estimate by NRM based on hundreds of downloads of hours of use data from Door Heater controllers. These values are also supported by Select Energy Services, Inc. (2004). *Cooler Control Measure Impact Spreadsheet User's Manual*. Prepared for NSTAR.
[536] Select Energy Services, Inc. (2004). *Analysis of Cooler Control Energy Conservation Measures*. Prepared for NSTAR.

Hours

Pre-retrofit hours are 8,760 hours per year. After controls are installed, the door heaters in freezers are on for an average 4,730 hours/year (46% off time) and the door heaters for coolers are on for an average 2,278 hours/year (74% off time).

Measure Life

The measure life for cooler and freezer door heater controls is 10 years.[537]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Door Heater Control	Small Retrofit	National Grid	1.00	1.00	1.00	1.00	0.50	1.00	n/a	n/a
Door Heater Control	Small Retrofit	Eversource (NSTAR)	1.00	0.91	0.92	0.92	0.50	1.00	n/a	n/a
Door Heater Control	Small Retrofit	Unitil	1.00	1.00	1.00	1.00	0.50	1.00	n/a	n/a
Door Heater Control	Small Retrofit	Eversource (WMECO)	1.00	0.86	0.92	0.92	0.50	1.00	0.10	0.10
Door Heater Control	Small Retrofit, Large Retrofit	CLC	1.00	0.91	0.92	0.92	0.50	1.00	n/a	n/a

In-Service Rates
All installations have 100% in service rate since all PAs' programs include verification of equipment installations.

Realization Rates
- National Grid: energy RR based on staff estimates.
- Eversource (NSTAR), CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
- Unitil: RRs set to 100% based on no evaluations.
- Eversource (WMECO): Energy RRs from impact evaluation of 2008 small retrofit program,[538] demand RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.

Coincidence Factors
- All PAs: on-peak CFs from the 1995 HEC study of walk-in cooler anti-sweat door heater controls.[539]
- Eversource (WMECO): seasonal CFs based on staff estimates.

[537] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[538] The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008*. Prepared for Western Massachusetts Electric Company.
[539] HEC, Inc. (1995). *Analysis of Door Master Walk-In Cooler Anti-Sweat Door Heater Controls Installed at Ten Sites in Massachusetts*. Prepared for New England Power Service Company; Table 9. Adjusted to account for updated RR.

Refrigeration – Novelty Cooler Shutoff

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of controls to shut off a facility's novelty coolers for non-perishable goods based on pre-programmed store hours. Energy savings occur as coolers cycle off during facility unoccupied hours.[540]
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Refrigeration
Measure Type: Controls
Core Initiative: C&I Small Business, C&I Existing Building Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = (kW_{NC})(DC_{AVG})(HoursOFF)$$
$$\Delta kW = 0$$

Where:

ΔkW	=	0 since savings are assumed to occur during evening hours and are therefore not coincident with either summer or winter peak periods.
kW_{NC}	=	Power demand of novelty cooler calculated from equipment nameplate data and estimated 0.85 power factor[541]
HoursOFF	=	Potential hours off every night per year, estimated as one less than the number of hours the store is closed per day
DC_{AVG}	=	Weighted average annual duty cycle: 48.75%[542]

Baseline Efficiency

The baseline efficiency case is the novelty coolers operating 8,760 hours per year.

High Efficiency

The high efficiency case is the novelty coolers operating fewer than 8,760 hours per year since they are controlled to cycle each night based on pre-programmed facility unoccupied hours.

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[540] The assumptions and algorithms used in this section are specific to NRM products.
[541] Conservative value based on 15 years of NRM field observations and experience.
[542] Ibid; the estimated duty cycles for Novelty Coolers are supported by Select Energy Services, Inc. (2004). *Cooler Control Measure Impact Spreadsheet Users' Manual*. Prepared for NSTAR. The study gives a less conservative value than used by NRM.

Hours

Hours reduced per day are estimated on a case-by-case basis, and are typically calculated as one less than the number of hours per day that the facility is closed each day.

Measure Life

The measure life is 10 years.[543]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Novelty Cooler Shutoff	Small Retrofit	National Grid	1.00	1.00	1.00	1.00	0.00	0.00
Novelty Cooler Shutoff	Small Retrofit	Eversource (NSTAR)	1.00	0.91	0.92	0.92	0.00	0.00
Novelty Cooler Shutoff	Small Retrofit, Large Retrofit	CLC	1.00	0.91	0.92	0.92	0.00	0.00
Novelty Cooler Shutoff	Small Retrofit	Unitil	1.00	1.00	1.00	1.00	0.00	0.00
Novelty Cooler Shutoff	Small Retrofit	Eversource (WMECO)	1.00	0.86	0.92	0.92	0.00	0.00

In-Service Rates
All installations have 100% in service rate since all PAs' programs include verification of equipment installations.

Realization Rates
- National Grid: energy RR based on staff estimates.
- Eversource (NSTAR), CLC: RRs based on NSTAR 2002-2004 small retrofit impact evaluations.
- Unitil: RRs set to 100% based on no evaluations.
- Eversource (WMECO): Energy RRs from impact evaluation of 2008 small retrofit program[544], demand RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.

Coincidence Factors
Coincidence factors are set to zero since demand savings typically occur during off-peak hours.

[543] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[544] The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008*. Prepared for Western Massachusetts Electric Company.

Refrigeration – ECM Evaporator Fan Motors for Walk–in Coolers and Freezers

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of various sizes of electronically commutated motors (ECMs) in walk-in coolers and freezers to replace existing evaporator fan motors.[545]
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Refrigeration
Measure Type: Motors
Core Initiative: C&I Small Business, C&I Existing Building Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = \Delta kWh_{Fan} + \Delta kWh_{Heat}$$
$$\Delta kWh_{Fan} = kW_{Fan} * LRF * Hours$$
$$\Delta kWh_{Heat} = \Delta kWh_{Fan} * 0.28 * Eff_{RS}$$
$$\Delta kW = \Delta kWh / 8{,}760$$

Where:

ΔkWh_{Fan}	=	Energy savings due to increased efficiency of evaporator fan motor
ΔkWh_{Heat}	=	Energy savings due to reduced heat from the evaporator fans
kW_{Fan}	=	Power demand of evaporator fan calculated from equipment nameplate data and estimated 0.55 power factor/adjustment[546]: Amps x Voltage x PF x √Phase
LRF	=	Load reduction factor for motor replacement (65%)[547]
Hours	=	Annual fan operating hours.
0.28	=	Conversion factor between kW and tons: 3,413 Btuh/kW divided by 12,000 Btuh/ton
Eff_{RS}	=	Efficiency of typical refrigeration system: 1.6 kW/ton[548]
ΔkW	=	Average demand savings
8,760	=	Hours per year

[545] The assumptions and algorithms used in this section are specific to NRM products.
[546] Conservative value based on 15 years of NRM field observations and experience.
[547] Load factor is an estimate by NRM based on several pre- and post-meter readings of installations; the value is supported by RLW Analytics (2007). *Small Business Services Custom Measure Impact Evaluation.* Prepared for National Grid.
[548] Assumed average refrigeration efficiency for typical installations. Conservative value based on 15 years of NRM field observations and experience. Value supported by Select Energy (2004). *Cooler Control Measure Impact Spreadsheet Users' Manual*. Prepared for NSTAR.

Baseline Efficiency

The baseline efficiency case is an existing evaporator fan motor.

High Efficiency

The high efficiency case is the replacement of existing evaporator fan motors with ECMs.

Hours

The annual operating hours are assumed to be 8,760 * (1-%OFF), where %OFF = 0 if the facility does not have evaporator fan controls or %OFF = 46% if the facility has evaporator fan controls (4,030 hours). See section: Refrigeration – Evaporator Fan Controls for more on %OFF value.

Measure Life

The measure life is 15 years.[549]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings[550]

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Evap Fan ECMs	Small Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Evap Fan ECMs	Small Retrofit	Eversource (NSTAR)	1.00	0.91	0.92	0.92	1.00	1.00	n/a	n/a
Evap Fan ECMs	Small Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Evap Fan ECMs	Small Retrofit	Eversource (WMECO)	1.00	0.86	0.92	0.92	1.00	1.00	1.00	1.00
Evap Fan ECMs	Small Retrofit, Large Retrofit	CLC	1.00	0.91	0.92	0.92	1.00	1.00	n/a	n/a

<u>**In-Service Rates**</u>
All installations have 100% in service rate since PA programs include verification of equipment installations.

<u>**Realization Rates**</u>

- National Grid: RRs set to 100% since changes to calculation methodology made based on 2005 Custom SBS program evaluation. [551]
- Eversource (NSTAR), CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
- Unitil: RRs set to 100% based on no evaluations.

[549] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; 15-year measure life for retrofit motor installations.
[550] RLW Analytics (2007). *Small Business Services Custom Measure Impact Evaluation.* Prepared for National Grid.
[551] RLW Analytics (2007). *Impact Evaluation Analysis of the 2005 Custom SBS Program*. Prepared for National Grid.

- Eversource (WMECO): Energy RRs from impact evaluation of 2008 small retrofit program[552], demand RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.

Coincidence Factors

Coincident factors are set to 1 since demand savings is average.

[552] The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008*. Prepared for Western Massachusetts Electric Company.

Refrigeration – Case Motor Replacement

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of electronically commutated motors (ECMs) in multi-deck and freestanding coolers and freezers, typically on the retail floor of convenience stores, liquor stores, and grocery stores.[553]
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Refrigeration
Measure Type: Motors
Core Initiative: C&I Small Business

Algorithms for Calculating Primary Energy Impacts

$$\Delta kWh = \Delta kWh_{Motor} + \Delta kWh_{Heat}$$
$$\Delta kWh_{motor} = kW_{Motor} * LRF * Hours$$
$$\Delta kWh_{heat} = \Delta kWh_{Motor} * 0.28 * Eff_{RS}$$
$$\Delta kW = \Delta kWh / 8{,}760$$

Where:

ΔkWh_{Motor}	=	Energy savings due to increased efficiency of case motor
ΔkWh_{Heat}	=	Energy savings due to reduced heat from evaporator fans
kW_{motor}	=	Metered load of case motor
LRF	=	Load reduction factor: 53% when shaded pole motors are replaced, 29% when PSC motors are replaced[554]
Hours	=	Average runtime of case motors (8,500 hours)[555]
0.28	=	Conversion of kW to tons: 3,413 Btuh/kW divided by 12,000 Btuh/ton.
Eff_{RS}	=	Efficiency of typical refrigeration system (1.6 kW/ton) [556]
ΔkW	=	Average demand savings
8,760	=	Hours per year

[553] The assumptions and algorithms used in this section are specific to NRM products.
[554] Load factor is an estimate by NRM based on several pre- and post-meter readings of installations
[555] Conservative value based on 15 years of NRM field observations and experience.
[556] Assumed average refrigeration efficiency for typical installations. Conservative value based on 15 years of NRM field observations and experience. Value supported by Select Energy (2004). *Cooler Control Measure Impact Spreadsheet Users' Manual*. Prepared for NSTAR.

Baseline Efficiency

The baseline efficiency case is the existing case motor.

High Efficiency

The high efficiency case is the replacement of the existing case motor with an ECM.

Hours

Hours are the annual operating hours of the case motors.

Measure Life

The measure life is 15 years.[557]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Case ECMs	Small Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Case ECMs	Small Retrofit	Eversource (NSTAR), CLC	1.00	0.91	0.92	0.92	1.00	1.00	n/a	n/a
Case ECMs	Small Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Case ECMs	Small Retrofit	Eversource (WMECO)	1.00	0.86	0.92	0.92	1.00	1.00	1.00	1.00

In-Service Rates
All installations have 100% in service rate since all PAs' programs include verification of equipment installations.

Realization Rates

- National Grid: set to 100% since changes to calculation methodology based on 2005 Custom SBS evaluation. [558]
- Unitil: RRs set to 100% based on no evaluations.
- Eversource (NSTAR), CLC: RRs based on NSTAR 2002-2004 small retrofit impact evaluations.
- Eversource (WMECO): Energy RRs from impact evaluation of 2008 small retrofit program[559] and demand RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.

Coincidence Factors
All PAs set coincident factors to 1.00 since demand savings are average.

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[557] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; 15-year measure life for retrofit motor installations.
[558] RLW Analytics (2007). *Impact Evaluation Analysis of the 2005 Custom SBS Program*. Prepared for National Grid.
[559] The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008*. Prepared for Western Massachusetts Electric Company.

Refrigeration – Cooler Night Covers

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of retractable aluminum woven fabric covers for open-type refrigerated display cases, where the covers are deployed during the facility unoccupied hours in order to reduce refrigeration energy consumption.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Refrigeration
Measure Type: Night Cover
Core Initiative: C&I Small Business

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = (Width)(Save)(Hours)$$
$$\Delta kW = (Width)(Save)$$

Where:
ΔkWh = Energy savings
ΔkW = Connected load reduction
Width = Width of the opening that the night covers protect (ft)
Save = Savings factor based on the temperature of the case (kW/ft). See table below.
Hours = Annual hours that the night covers are in use

Savings Factors[560]

Cooler Case Temperature	Savings Factor
Low Temperature (-35 F to -5 F)	0.03 kW/ft
Medium Temperature (0 F to 30 F)	0.02 kW/ft
High Temperature (35 F to 55 F)	0.01 kW/ft

Baseline Efficiency

The baseline efficiency case is the annual operation of open-display cooler cases.

[560] CL&P Program Savings Documentation for 2011 Program Year (2010). Factors based on Southern California Edison (1997). *Effects of the Low Emissive Shields on Performance and Power Use of a Refrigerated Display Case.*

High Efficiency

The high efficiency case is the use of night covers to protect the exposed area of display cooler cases during unoccupied hours.

Hours

Hours represent the number of annual hours that the night covers are in use, and should be determined on a case-by-case basis.

Measure Life

The measure life is 10 years.[561]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Cooler Night Cover	Small Retrofit	National Grid	1.00	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Cooler Night Cover	Small Retrofit	Eversource (NSTAR), CLC	1.00	0.91	0.92	0.92	0.00	0.00	n/a	n/a
Cooler Night Cover	Small Retrofit	Unitil	1.00	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Cooler Night Cover	Small Retrofit	Eversource (WMECO)	1.00	0.86	0.92	0.92	0.00	0.00	0.00	0.00

In-Service Rates
All installations have 100% in service rate since all PAs' programs include verification of equipment installations.

Realization Rates
- National Grid, Unitil: RRs set to 100% based on no evaluations.
- Eversource (NSTAR), CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
- Eversource (WMECO): Energy RRs from impact evaluation of 2008 small retrofit program.[562] Demand RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.

Coincidence Factors
Coincidence factors are set to zero since demand savings typically occur during off-peak hours.

561 Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Page 4-5 to 4-6.
562 The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008*. Prepared for Western Massachusetts Electric Company.

Refrigeration – Electronic Defrost Control

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: A control mechanism to skip defrost cycles when defrost is unnecessary.[563]
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Refrigeration
Measure Type: Controls
Core Initiative: C&I Small Business, C&I Existing Building Retrofit

Algorithms for Calculating Primary Energy Impacts

$$\Delta kWh = \Delta kWh_{Defrost} + \Delta kWh_{Heat}$$
$$\Delta kWh_{Defrost} = kW_{Defrost} * Hours * DRF$$
$$\Delta kWh_{Heat} = \Delta kWh_{Defrost} * 0.28 * Eff_{RS}$$
$$\Delta kW = \Delta kWh / 8{,}760$$

Where:

$\Delta kWh_{Defrost}$	=	Energy savings resulting from an increase in operating efficiency due to the addition of electronic defrost controls.
ΔkWh_{Heat}	=	Energy savings due to reduced heat from reduced number of defrosts.
$kW_{Defrost}$	=	Load of electric defrost.
Hours	=	Number of hours defrost occurs over a year without the defrost controls.
DRF	=	Defrost reduction factor- percent reduction in defrosts required per year (35%)[564]
0.28	=	Conversion of kW to tons: 3,413 Btuh/kW divided by 12,000 Btuh/ton.
Eff_{RS}	=	Efficiency of typical refrigeration system (1.6 kW/ton)[565]
ΔkW	=	Average demand savings
8,760	=	Hours per year

Baseline Efficiency

The baseline efficiency case is an evaporator fan electric defrost system that uses a time clock mechanism to initiate defrost.

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563 The assumptions and algorithms used in this section are specific to NRM products.
564 Ibid; supported by 3rd party evaluation: Independent Testing was performed by Intertek Testing Service on a Walk-in Freezer that was retrofitted with Smart Electric Defrost capability.
565 Assumed average refrigeration efficiency for typical installations. Conservative value based on 15 years of NRM field observations and experience. Value supported by Select Energy (2004). *Cooler Control Measure Impact Spreadsheet Users' Manual*. Prepared for NSTAR.

High Efficiency

The high efficiency case is an evaporator fan defrost system with electric defrost controls.

Hours

The number of defrost cycles is estimated to decrease by 35% from an average number of defrost cycles of 1460 defrosts/year at 40 minutes each for a total of 973 hours/year.[566] The number of defrost cycles with the defrost controls is 949 cycles/year, or 633 hours/year.

Measure Life

The measure life is 10 years.[567]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Defrost Control	Small Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Defrost Control	Small Retrofit	Eversource (NSTAR)	1.00	0.91	0.92	0.92	1.00	1.00	n/a	n/a
Defrost Control	Small Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Defrost Control	Small Retrofit	Eversource (WMECO)	1.00	0.86	0.92	0.92	1.00	1.00	1.00	1.00
Defrost Control	Small Retrofit, Large Retrofit	CLC	1.00	0.91	0.92	0.92	1.00	1.00	n/a	n/a

In-Service Rates
All installations have 100% in service rate since all PAs' programs include verification of equipment installations.

Realization Rates
- National Grid, Unitil: RRs set to 100% based on no evaluations.
- Eversource (NSTAR), CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
- Eversource (WMECO): Energy RRs from impact evaluation of 2008 small retrofit program[568], demand RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.

Coincidence Factors
All PAs set coincident factors to 1.00 since demand savings are average.

[566] Conservative value based on 15 years of NRM field observations and experience.
[567] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities.
[568] The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008*. Prepared for Western Massachusetts Electric Company.

Refrigeration – Evaporator Fan Controls

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of controls to modulate the evaporator fans based on temperature control. Energy savings include: fan energy savings from reduced fan operating hours, refrigeration energy savings from reduced waste heat, and compressor energy savings resulting from the electronic temperature control. Electronic controls allow less fluctuation in temperature, thereby creating savings.[569]
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Refrigeration
Measure Type: Controls
Core Initiative: C&I Small Business, C&I Existing Building Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = \Delta kWh_{Fan} + \Delta kWh_{Heat} + \Delta kWh_{Control}$$
$$\Delta kWh_{Fan} = kW_{Fan} * 8760 * \%OFF$$
$$\Delta kWh_{Heat} = \Delta kWh_{Fan} * 0.28 * Eff_{RS}$$
$$\Delta kWh_{Control} = \left[kW_{CP} * Hours_{CP} + kW_{Fan} * 8760 * (1 - \%Off)\right] * 5\%$$
$$\Delta kW = \Delta kWh / 8760$$

Where:

ΔkWh_{Fan}	=	Energy savings due to evaporator being shut off
ΔkWh_{Heat}	=	Energy savings due to reduced heat from the evaporator fans
$\Delta kWh_{Control}$	=	Energy savings due to the electronic controls on compressor and evaporator
kW_{Fan}	=	Power demand of evaporator fan calculated from equipment nameplate data and estimated 0.55 power factor/ adjustment[570]: Amps x Voltage x PF x √Phase
%OFF	=	Percent of annual hours that the evaporator is turned off: 46%[571]
0.28	=	Conversion of kW to tons: 3,413 Btuh/kW divided by 12,000 Btuh/ton.
Eff_{RS}	=	Efficiency of typical refrigeration system: 1.6 kW/ton[572]
kW_{CP}	=	Total power demand of compressor motor and condenser fan calculated from equipment

[569] The assumptions and algorithms used in this section are specific to NRM products.
[570] Conservative value based on 15 years of NRM field observations and experience.
[571] The value is an estimate by NRM based on hundreds of downloads of hours of use data. These values are also supported by Select Energy Services, Inc. (2004). *Cooler Control Measure Impact Spreadsheet User's Manual*. Prepared for NSTAR.
[572] Assumed average refrigeration efficiency for typical installations. Conservative value based on 15 years of NRM field observations and experience. Value supported by Select Energy (2004). *Cooler Control Measure Impact Spreadsheet Users' Manual*. Prepared for NSTAR.

		nameplate data and estimated 0.85 power factor[573]: Amps x Voltage x PF x √Phase
$Hours_{CP}$	=	Equivalent annual full load hours of compressor operation: 4,072 hours[574]
5%	=	Reduced run-time of compressor and evaporator due to electronic temperature controls[575]
ΔkW	=	Average demand savings
8,760	=	Hours per year

Baseline Efficiency

The baseline efficiency case assumes evaporator fans that run 8,760 annual hours with no temperature control.

High Efficiency

The high efficiency case is the use of an energy management system to control evaporator fan and compressor operation based on temperature.

Hours

The operation of the fans is estimated to be reduced by 46% from the 8,760 hours in the base case scenario.

Measure Life

The measure life is 10 years[576].

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

[573] This value is an estimate by NRM based on hundreds of downloads of hours of use data from the electronic controller.
[574] Conservative value based on 15 years of NRM field observations and experience.
[575] Conservative estimate supported by less conservative values given by several utility-sponsored 3rd Party studies including: Select Energy Services, Inc. (2004). *Analysis of Cooler Control Energy Conservation Measures*. Prepared for NSTAR.
[576] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Evap Fan Control	Small Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Evap Fan Control	Small Retrofit	Eversource (NSTAR)	1.00	0.91	0.92	0.92	1.00	1.00	n/a	n/a
Evap Fan Control	Small Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Evap Fan Control	Small Retrofit	Eversource (WMECO)	1.00	0.86	0.92	0.92	1.00	1.00	1.00	1.00
Evap Fan Control	Small Retrofit, Large Retrofit	CLC	1.00	0.91	0.92	0.92	1.00	1.00	n/a	n/a

In-Service Rates
All installations have 100% in service rate since all PAs' programs include verification of equipment installations.

Realization Rates
- National Grid set to 100% after small retrofit RRs from 1996 savings analysis[577] suggestions for more accurate calculations adopted.
- Eversource (NSTAR), CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
- Unitil: RRs set to 100% based on no evaluations.
- Eversource (WMECO): Energy RRs from impact evaluation of 2008 small retrofit program[578], demand RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.

Coincidence Factors
All PAs set coincident factors to 1.00 since demand savings are average.

[577] HEC, Inc. (1996). *Analysis of Savings from Walk-In Cooler Air Economizers and Evaporator Fan Controls*. Prepared for New England Power Service Company.
[578] The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008*. Prepared for Western Massachusetts Electric Company.

Refrigeration – Vending Misers

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Controls can significantly reduce the energy consumption of vending machine lighting and refrigeration systems. Qualifying controls must power down these systems during periods of inactivity but, in the case of refrigerated machines, must always maintain a cool product that meets customer expectations. This measure applies to refrigerated beverage vending machines, non-refrigerated snack vending machines, and glass front refrigerated coolers. This measure should not be applied to ENERGY STAR® qualified vending machines, as they already have built-in controls.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Refrigeration
Measure Type: Controls
Core Initiative: C&I Existing Building Retrofit, C&I Small Business

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms and assumptions:

$$\Delta kWh = (kW_{RATED})(Hours)(SAVE)$$
$$\Delta kW = \Delta kWh / Hours$$

Where:

kW_{rated} = Rated kW of connected equipment. See for default rated kW by connected equipment type.
Hours = Operating hours of the connected equipment: default of 8,760 hours
SAVE = Percent savings factor for the connected equipment. See table below for values.

Vending Machine and Cooler Controls Savings Factors [579]

Equipment Type	kWRATED	SAVE (%)	ΔkW	ΔkWh
Refrigerated Beverage Vending Machines	0.40	46	0.184	1612
Non-Refrigerated Snack Vending Machines	0.085	46	0.039	343
Glass Front Refrigerated Coolers	0.46	30	0.138	1208

[579] USA Technologies Energy Management Product Sheets (2006). http://www.usatech.com/energy_management/energy_productsheets.php. Accessed 9/1/09.

Baseline Efficiency

The baseline efficiency case is a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler without a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

High Efficiency

The high efficiency case is a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler with a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

Hours

It is assumed that the connected equipment operates 24 hours per day, 7 days per week for a total annual operating hours of 8,760.

Measure Life

The measure life is 5 years.[580]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Vending Misers	Large Retrofit	National Grid	1.00	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Vending Misers	Large Retrofit	Eversource (NSTAR), CLC	1.00	0.85	0.41	0.24	0.00	0.00	n/a	n/a
Vending Misers	Large Retrofit	Unitil	1.00	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Vending Misers	Large Retrofit	Eversource (WMECO)	1.00	0.91	0.41	0.24	0.00	0.00	0.00	0.00
Vending Misers	Small Retrofit	National Grid	1.00	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Vending Misers	Small Retrofit	Eversource (NSTAR), CLC	1.00	0.91	0.92	0.92	0.00	0.00	n/a	n/a
Vending Misers	Small Retrofit	Unitil	1.00	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Vending Misers	Small Retrofit	Eversource (WMECO)	1.00	0.86	0.92	0.92	0.00	0.00	0.00	0.00

<u>**In-Service Rates**</u>
All installations have 100% in service rate since all PAs' programs include verification of equipment installations.

[580] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.

Realization Rates

- National Grid, Unitil: RRs set to 100% since savings estimated are based on study results.
- Eversource (NSTAR), CLC: C&I Existing Building Retrofit RRs from impact evaluation of NSTAR 2006 refrigeration installations[581]; small retrofit RRs from impact evaluation of 2002 program year[582]
- Eversource (WMECO): Energy RRs from impact evaluation of 2008 small retrofit program[583]; C&I Existing Building Retrofit energy RRs are based on end use from 2007/2008 Large C&I Programs impact evaluation[584], C&I Existing Building Retrofit demand RRs from impact evaluation of NSTAR 2006 refrigeration installations, small retrofit demand RRs from NSTAR impact evaluation of 2002 program year

Coincidence Factors

CFs based on staff estimates- assumed that savings occur during off peak hours.

[581] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.
[582] RLW Analytics (2003). *Small Business Solutions Program Year 2002 Impact Evaluation - Final Report*. Prepared for NSTAR.
[583] The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008*. Prepared for Western Massachusetts Electric Company.
[584] KEMA, Inc. (2011). *2007/2008 Large C&I Programs,*

Food Service – Commercial Electric Ovens

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a qualified ENERGY STAR® commercial convection oven or commercial combination oven. ENERGY STAR® commercial ovens save energy during preheat, cooking and idle times due to improved cooking efficiency, and preheat and idle energy rates. Combination ovens can be used either as convection ovens or as steamers.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial
Market: Lost Opportunity
End Use: Food Service
Measure Type: Cooking Equipment
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on the Energy Star Commercial Kitchen Equipment Savings Calculator and the Food Services Technology Center Life Cycle Cost Calculator:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kWh / Hours$$

Where:
ΔkWh = gross annual kWh savings from the measure. See table below.
ΔkW = gross average kW savings from the measure. See table below.
Hours = Annual hours of operation. See Hours section below.

Energy Savings for Commercial Ovens[585]

Equipment Type	ΔkW	ΔkWh
Full Size Convection Oven	0.44	1,661
Combination Oven	1.40	5,271

Baseline Efficiency

The baseline efficiency case is a convection oven with a cooking energy efficiency of 65%, production capacity of 90 pounds per hour, and idle energy rate of 2.0 kW. The baseline efficiency case for a combination oven is a commercial combination oven with a convection cooking energy efficiency of 72%

[585] Savings Calculator for ENERGY STAR® Certified Commercial Kitchen Equipment: Oven Calcs. < http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx >. Tool downloaded August 10, 2015.

with a production capacity of 79 pounds per hour for convection mode and 49% steam cooking energy efficiency, with a production capacity of 126 pounds per hour for steam mode. Idle energy is assumed to be 1.3 kW for convection mode and 5.3 kW for steam mode.

High Efficiency

The high efficiency case is a convection oven with a cooking energy efficiency of 71%, production capacity of 90 pounds per hour, and idle energy rate of 1.6 kW. The high efficiency case for a combination oven is a commercial combination oven with a cooking energy efficiency of 76% with a production capacity of 119 pounds per hour for convection mode, and 55% cooking energy efficiency with a production capacity of 177 pounds per hour for steam mode, and idle energy rate of 1.3 kW for convection mode and 2.0 kW for steam mode.

Hours

Ovens assumed to operate 313 days per year[586] for 12 hours a day, or 3,756 hours.[587]

Measure Life

The measure life for a new commercial electric oven is 12 years.[588]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Electric Ovens	NB, EUL	All	1.00	1.00	1.00	1.00	0.90	0.90

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
100% realization rates are assumed because savings are based on researched assumptions by ENERGY STAR®.

Coincidence Factors
Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

586 The default value of 365 days per year seems excessive. Though many or most restaurants operate 7 days per week, many institutional kitchens do not. 6 day operation is assumed. 365 * 6/7 = 313 days/yr
587 Savings Calculator for ENERGY STAR® Certified Commercial Kitchen Equipment: Oven Calcs. < http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx >. Tool downloaded August 10, 2015.
588 Ibid.

Food Service – Commercial Electric Steam Cooker

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a qualified ENERGY STAR® commercial steam cooker. ENERGY STAR® steam cookers save energy during cooling and idle times due to improved cooking efficiency and idle energy rates.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Water, Wastewater
Sector: Commercial
Market: Lost Opportunity
End Use: Food Service
Measure Type: Cooking Equipment
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on the Energy Star Commercial Kitchen Equipment Savings Calculator:

$$\Delta kWh = (SAVE)(Quantity)(Hours)$$

$$\Delta kW = (SAVE)(Quantity)$$

Where:

ΔkWh	=	gross annual kWh savings from the measure. With default Quantity, average savings are 8,547 kWh.
ΔkW	=	average kW savings from the measure. With default Quantity, average savings are 2.28 kW
SAVE	=	Demand savings per pan: 0.76 kW/pan [589]
Quantity	=	Number of pans. Default of 3 pans.
Hours	=	Average annual equipment operating hours. See Hours section below.

Baseline Efficiency

The Baseline Efficiency case is an electric steam cooker with a cooking efficiency of 30%, pan production capacity of 23.3 pounds per hour, preheat energy of 1.5 kWh, and idle energy rate of 1.2 kW.

[589] Savings Calculator for ENERGY STAR® Certified Commercial Kitchen Equipment: Steam Cooker Calcs. < http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx > except for hours of operation, see Hours section below. Tool downloaded August 10, 2015.

High Efficiency

The High Efficiency case is an ENERGY STAR® electric steam cooker with a cooking energy efficiency of 50%, pan production capacity of 16.7 pounds per hour, preheat energy of 1.5 kWh, and an idle energy rate of 0.4 kW.

Hours

Steamers are assumed to operate 313 days per year.[590] The average steam cooker is assumed to operate 12 hours per day[591], or 3,756 hours per year.

Measure Life

The measure life for a new steamer is 12 years.[592]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Water and wastewater is saved due to the improved cooking efficiency of the high efficiency equipment.

Benefit Type	Description	Savings[593]
C&I Water	Annual water savings per unit	139,000 gallons/unit
C&I Waste Water	Annual wastewater savings per unit	139,000 gallons/unit

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Electric Steam Cooker	NB, EUL	1.00	1.00	1.00	1.00	0.90	0.90

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
100% realization rates are assumed because savings are based on researched assumptions by ENERGY STAR®.

Coincidence Factors
Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

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[590] The default value of 365 days per year seems excessive. Though many or most restaurants operate 7 days per week, many institutional kitchens do not. 6 day operation is assumed. 365 * 6/7 = 313 days/yr
[591] Savings Calculator for ENERGY STAR® Certified Commercial Kitchen Equipment: Steam Cooker Calcs. < *http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx* >. Tool downloaded August 10, 2015.
[592] Ibid.
[593] Ibid.

Food Service – Commercial Electric Griddle

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a qualified ENERGY STAR® griddle. ENERGY STAR® griddles save energy cooking and idle times due to improved cooking efficiency and idle energy rates.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial
Market: Lost Opportunity
End Use: Food Service
Measure Type: Cooking Equipment
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on the Energy Star Commercial Kitchen Equipment Savings Calculator:

$$\Delta kWh = (SAVE)(Width)(Hours)$$
$$\Delta kW = (SAVE)(Width)$$

Where:

ΔkWh	=	gross annual kWh savings from the measure. With default Width, average savings are 1,637 kWh.
ΔkW	=	gross average kW savings from the measure. With default Width, average savings are 0.44 kW.
SAVE	=	Savings per foot of griddle width: 0.15 kW/ft[594]
Width	=	Width of griddle in feet. Default of 3 feet.
Hours	=	Average annual equipment operating hours, see Hours section below.

Baseline Efficiency

The baseline efficiency case is a typically sized, 6 sq. ft. commercial griddle with a cooking energy efficiency of 65%, production capacity of 35 pounds per hour, and idle energy rate of 400 W/sq. ft.

594 Savings Calculator for ENERGY STAR® Certified Commercial Kitchen Equipment: Griddle Calcs. < http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx >. Tool downloaded August 10, 2015.

High Efficiency

The high efficiency case is a typically sized, 6 sq. ft. commercial griddle with a cooking energy efficiency of 70%, production capacity of 40 pounds per hour, and idle energy rate of 320 W/sq. ft.

Hours

Griddles are assumed to operate 313 days per year.[595] The average griddle is assumed to operate 12 hours per day[596], or 3,756 hours per year.

Measure Life

The measure life for a new griddle is 12 years.[597]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Electric Griddle	NB, EUL	1.00	1.00	1.00	1.00	1.00	1.00

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
100% realization rates are assumed because savings are based on researched assumptions by ENERGY STAR®.

Coincidence Factors
Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

595 The default value of 365 days per year seems excessive. Though many or most restaurants operate 7 days per week, many institutional kitchens do not. 6 day operation is assumed. 365 * 6/7 = 313 days/yr
596 Savings Calculator for ENERGY STAR® Certified Commercial Kitchen Equipment: Griddle Calcs. < http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx >. Tool downloaded August 10, 2015.
597 PG&E calculator: http://www.fishnick.com/saveenergy/tools/calculators/egridcalc.php

Food Service – Low Temperature Commercial Dishwasher

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a qualified ENERGY STAR® low temperature commercial dishwasher in a facility with electric hot water heating. Low temperature dishwashers use the hot water supplied by the kitchen's existing water heater and use a chemical sanitizing agent in the final rinse cycle and sometimes a drying agent.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Water
Sector: Commercial
Market: Lost Opportunity
End Use: Food Service
Measure Type: Cleaning Equipment
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on the Energy Star Commercial Kitchen Equipment Savings Calculator:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kWh / Hours$$

Where:
ΔkWh = gross annual kWh savings from the measure. See table below.
ΔkW = gross average kW savings from the measure. See table below.
Hours = Average annual equipment operating hours, see Hours section below.

Energy Savings for Low Temperature Commercial Dishwashers[598]

Equipment Type	ΔkW	ΔkWh
Under Counter	0.39	2,178
Door Type	2.46	13,851
Single Tank Conveyor	2.07	11,685
Multi Tank Conveyor	2.86	16,131

598 Savings Calculator for ENERGY STAR® Certified Commercial Kitchen Equipment: Dishwasher Calcs. < http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx >. Tool downloaded August 10, 2015. Default values used except for days operated per year. See Hours section below.

Baseline Efficiency

The baseline efficiency case is a commercial dishwasher with idle energy rates and water consumption as follows:

Dishwasher Type	Idle Energy Rate (kW)	Water Consumption (gal/rack)
Under Counter	0.50	1.73
Door Type	0.60	2.10
Single Tank Conveyor	1.60	1.31
Multi Tank Conveyor	2.00	1.04

High Efficiency

The high efficiency case is a commercial dishwasher with idle energy rates and water consumption following ENERGY STAR efficiency requirements as follows:

Dishwasher Type	Max Idle Energy Rate (kW)	Max Water Consumption (gal/rack)
Under Counter	0.50	1.19
Door Type	0.60	1.18
Single Tank Conveyor	1.60	0.79
Multi Tank Conveyor	2.00	0.54

Hours

Dishwashers are assumed to operate 313 days per year.[599] The average dishwasher is assumed to operate 18 hours per day[600], or 5,634 hours per year.

Measure Life

The measure life for a new low temperature dishwasher is given by type below:[601]

Dishwasher Type	Life (years)
Under Counter	10
Door Type	15
Single or Multi Tank Conveyor	20

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

[599] The default value of 365 days per year seems excessive. Though many or most restaurants operate 7 days per week, many institutional kitchens do not. 6 day operation is assumed. 365 * 6/7 = 313 days/yr
[600] Savings Calculator for ENERGY STAR® Certified Commercial Kitchen Equipment: Dishwasher Calcs. < http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx >. Tool downloaded August 10, 2015.
[601] Ibid.

Non-Energy Impacts

There are water savings associated with this measure:[602]

Dishwasher Type	Annual water savings (Gal/Unit)	Annual wastewater savings per unit (Gal/Unit)
Under Counter	12,677	12,677
Door Type	80,629	80,629
Single Tank Conveyor	65,104	65,104
Multi Tank Conveyor	93,900	93,900

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Low Temperature Dishwasher	NB, EUL	1.00	1.00	1.00	1.00	0.90	0.90

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
100% realization rates are assumed because savings are based on researched assumptions by ENERGY STAR®.

Coincidence Factors
Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

602 Ibid.

Food Service – High Temperature Commercial Dishwasher

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a qualified ENERGY STAR® high temperature commercial dishwasher in a building with gas domestic hot water. High temperature dishwashers use a booster heater to raise the rinse water temperature to 180^0 F – hot enough to sterilize dishes and assist in drying. Electric savings are achieved through savings to the electric booster.
Primary Energy Impact: Electric
Secondary Energy Impact: Gas
Non-Energy Impact: Water
Sector: Commercial
Market: Lost Opportunity
End Use: Food Service
Measure Type: Cleaning Equipment
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on the Energy Star Commercial Kitchen Equipment Savings Calculator:

$$\Delta kWh = \Delta kWh$$

$$\Delta kW = \Delta kWh / Hours$$

Where:

ΔkWh = gross annual kWh savings from the measure. See table below
ΔkW = gross average kW savings from the measure. See table below
Hours = Average annual equipment operating hours, see Hours section below.

Energy Savings for High Temperature Commercial Dishwashers[603]

Equipment Type	ΔkW	ΔkWh
Under Counter	0.32	1,791
Door Type	0.74	4,151
Single Tank Conveyor	0.75	4,243
Multi Tank Conveyor	1.71	9,630
Pot, Pan, and Utensil	0.18	1,032

[603] Savings Calculator for ENERGY STAR® Certified Commercial Kitchen Equipment: Dishwasher Calcs. < http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx >. Tool downloaded August 10, 2015. Default values used except for days operated per year. See Hours section below.

Baseline Efficiency

The baseline efficiency case is a commercial dishwasher with idle energy rates and water consumption as follows:

Dishwasher Type	Idle Energy Rate (kW)	Water Consumption (gal/rack)
Under Counter	0.76	1.09
Door Type	0.87	1.29
Single Tank Conveyor	1.93	0.87
Multi Tank Conveyor	2.59	0.97
Pot, Pan, and Utensil	1.20	0.70

High Efficiency

The high efficiency case is a commercial dishwasher with idle energy rates and water consumption following ENERGY STAR® Efficiency Requirements as follows:

Dishwasher Type	Idle Energy Rate (kW)	Water Consumption (gal/rack)
Under Counter	0.50	0.86
Door Type	0.70	0.89
Single Tank Conveyor	1.50	0.70
Multi Tank Conveyor	2.25	0.54
Pot, Pan, and Utensil	1.20	0.58

Hours

Dishwashers are assumed to operate 313 days per year.[604] The average dishwasher is assumed to operate 18 hours per day[605], or 5,634 hours per year.

Measure Life

The measure life for a new high temperature dishwasher is given by type below:[606]

Dishwasher Type	Life (years)
Under Counter	10
Door Type	15
Single or Multi Tank Conveyor	20
Pot, Pan, and Utensil	10

[604] The default value of 365 days per year seems excessive. Though many or most restaurants operate 7 days per week, many institutional kitchens do not. 6 day operation is assumed. 365 * 6/7 = 313 days/yr
[605]Savings Calculator for ENERGY STAR® Certified Commercial Kitchen Equipment: Dishwasher Calcs. < *http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx* >. Tool downloaded August 10, 2015.
[606] Ibíd.

Secondary Energy Impacts

There are gas savings for this measure.

Dishwasher Type	Savings (therms)
Under Counter	39
Door Type	252
Single Tank Conveyor	153
Multi Tank Conveyor	580
Pot, Pan, and Utensil	76

Non-Energy Impacts

There are water savings associated with this measure:[607]

Dishwasher Type	Annual water savings (gal/unit)	Annual wastewater savings (gal/unit)
Under Counter	5,399	5,399
Door Type	35,056	35,056
Single Tank Conveyor	21,284	21,284
Multi Tank Conveyor	80,754	80,754
Pot, Pan, and Utensil	10,517	10,517

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
High Temperature Dishwasher	NB, EUL	1.00	1.00	1.00	1.00	0.90	0.90

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
100% realization rates are assumed because savings are based on researched assumptions by ENERGY STAR®.

Coincidence Factors
Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

[607] Ibid.

Food Service – Commercial Ice Machine

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a qualified ENERGY STAR® commercial ice machine. Commercial ice machines meeting the ENERGY STAR® specifications are on average 15 percent more energy efficient and 10 percent more water-efficient than standard models. ENERGY STAR® qualified equipment includes ice-making head (IMH), self-contained (SCU), and remote condensing units (RCU).
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Water
Sector: Commercial
Market: Lost Opportunity
End Use: Food Service
Measure Type: Ice Machines
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on the Energy Star Commercial Kitchen Equipment Savings Calculator:

$$\Delta kWh = \Delta kWh$$

$$\Delta kW = \Delta kWh / Hours$$

Where:
ΔkWh = gross annual kWh savings from the measure. See table below.
ΔkW = gross average kW savings from the measure. See table below.
Hours = Average annual equipment operating hours, see Hours section below.

Energy Savings for Commercial Ice Machine[608]

Equipment Type	ΔkW	ΔkWh
Ice Making Head	0.08	665
Self Contained Unit	0.02	205
Remote Condensing Unit (Batch)	0.07	630
Remote Condensing Unit (Continuous)	0.14	1,196

[608] Savings Calculator for ENERGY STAR® Certified Commercial Kitchen Equipment: Ice Machine Calcs. < http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx >. Tool downloaded August 10, 2015. Except for duty cycle of machines- ES tool uses 75% duty cycle, which is thought to be too high. Duty cycle of 40% used instead.

Baseline Efficiency

The baseline efficiency case is a non-ENERGY STAR® commercial ice machine.

High Efficiency

The high efficiency case is a commercial ice machine meeting the ENERGY STAR® Efficiency Requirements.

Hours

Ice making machines are assumed to operate 365 days per year. The average ice making machine is assumed to operate 18 hours per day[609], or 5,634 hours per year.

Measure Life

The measure life for a new ice making machine is assumed to be 8 years.[610]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There is water savings associated with this measure:[611]

Dishwasher Type	Annual water savings (gal/unit)	Annual wastewater savings (gal/unit)
Ice Making Head	3,322	3,322
Self Contained Unit	3,526	3,526
Remote Condensing Unit (Batch)	2,631	2,631
Remote Condensing Unit (Continuous)	0	0

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Ice Making Machine	NB, EUL	1.00	1.00	1.00	1.00	1.00	1.00

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
100% realization rates are assumed because savings are based on researched assumptions by ENERGY STAR®.

Coincidence Factors
Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

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609 Savings Calculator for ENERGY STAR® Certified Commercial Kitchen Equipment: Ice Machine Calcs. < *http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx* >. Tool downloaded August 10, 2015.
610 Ibíd.
611 Ibid.

Food Service – Commercial Fryers

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a qualified ENERGY STAR® standard or large vat commercial fryer. ENERGY STAR® commercial fryers save energy during cooking and idle times due to improved cooking efficiency and idle energy rates.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial
Market: Lost Opportunity
End Use: Food Service
Measure Type: Cooking Equipment
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on the Energy Star Commercial Kitchen Equipment Savings Calculator:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW / Hours$$

Where:
ΔkWh = gross annual kWh savings from the measure per table below
ΔkW = gross average kW savings from the measure per table below
Hours = Annual hours of operation. See Hours section below.

Energy Savings for Commercial Fryer[612]

Equipment Type	ΔkW	ΔkWh
Standard Vat	0.16	610
Large Vat	0.58	2,175

Baseline Efficiency

The baseline efficiency case for a standard sized fryer is a deep-fat fryer with a cooking energy efficiency of 75%, shortening capacity of up to 65 pounds, and idle energy rate of 1.05 kW.

[612] ENERGY STAR® Commercial Kitchen Equipment Savings Calculator: Fryer Calcs. < http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xls>. Tool downloaded August 10, 2015. Default assumptions used except for operating hours, see Hours section, and food cooked per day. Standard sized fryer food cooked per day reduced by 25% to 112 lb/day reflect the 25% reduction in operating hours

The baseline efficiency case for a large sized fryer is a deep-fat fryer with a cooking energy efficiency of 70%, shortening capacity of up to 100 pounds, and idle energy rate of 1.35 kW.

High Efficiency

The high efficiency case for a standard sized fryer is a deep-fat fryer with a cooking energy efficiency of 80%, shortening capacity of up to 70 pounds, and idle energy rate of no more than 1.0 kW. For large-capacity fryers (shortening capacity exceeds 70 pounds), the idle energy rate may be up to 1.1 kW.

Hours

Fryers assumed to operate 313 days per year.[613] Fryers assumed to operate 12 hours a day, or 3,756 hours per year.[614]

Measure Life

The measure life for a new commercial electric fryer is 12 years[615].

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Electric Fryer	NB, EUL	All	1.00	1.00	1.00	1.00	1.00	0.90	0.90

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
100% realization rates are assumed because savings are based on researched assumptions by ENERGY STAR®.

Coincidence Factors
Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

[613] The default value of 365 days per year seems excessive. Though many or most restaurants operate 7 days per week, many institutional kitchens do not. 6 day operation is assumed. 365 * 6/7 = 313 days/yr
[614] Default hours of 16 seem excessive by staff estimates and compared to other commercial equipment operation hours. Twelve hours used as more reasonable estimate.
[615] Pacific Gas & Electric Company – Customer Energy Efficiency Department (2007). *Work Paper PGECOFST101, Commercial Convection Oven, Revision #0.*

Food Service – Food Holding Cabinets

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a qualified ENERGY STAR® hot food holding cabinet (HFHC). ENERGY STAR® hot food holding cabinets are 70 percent more energy efficient than standard models. Models that meet this requirement incorporate better insulation, reducing heat loss, and may also offer additional energy saving devices such as magnetic door gaskets, auto-door closures, or dutch doors. The insulation of the cabinet also offers better temperature uniformity within the cabinet from top to bottom. Offering full size, ¾ size, and ½ half size HFHC.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial
Market: Lost Opportunity
End Use: Food Service
Measure Type: Storage Equipment
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on the Energy Star Commercial Kitchen Equipment Savings Calculator:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kWh / Hours$$

Where:
ΔkWh = gross annual kWh savings from the measure: See table below.
ΔkW = gross average kW savings from the measure: See table below.
Hours = Annual hours of operation. See Hours section below.

Energy Savings for Commercial Hot Food Holding Cabinets[616]

Equipment Type	ΔkW	ΔkWh
Full Size – 20 ft^3	0.51	2,376
¾ Size – 12 ft^3	0.22	1,042
½ Size – 8 ft^3	0.15	695

[616] ENERGY STAR® Commercial Kitchen Equipment Savings Calculator: HFHC Calcs. < http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xls>. Tool downloaded August 10, 2015. Default assumptions used except for hours of operation and volume of HFHC. See Hours section below.

Baseline Efficiency

The baseline efficiency idle energy rate for a HFHC is 40 W for all sizes.

High Efficiency

The high efficiency idle energy rate for HFHC is 294 W for full size, 258 W for ¾ size, and 172 W for ½ size.

Hours

Hot food holding cabinets assumed to operate 313 days per year[617] for 15 hours a day, or 4,695 hours per year.[618]

Measure Life

The measure life for a new commercial HFHC is 12 years[619].

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
HFHC	NB, EUL	All	1.00	1.00	1.00	1.00	1.00	0.90	0.90

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
100% realization rates are assumed because savings are based on researched assumptions by ENERGY STAR®.

Coincidence Factors
Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

[617] The default value of 365 days per year seems excessive. Though many or most restaurants operate 7 days per week, many institutional kitchens do not. 6 day operation is assumed. 365 * 6/7 = 313 days/yr
[618] Default hours of 16 seem excessive by staff estimates and compared to other commercial equipment operation hours. Twelve hours used as more reasonable estimate.
[619] Pacific Gas & Electric Company – Customer Energy Efficiency Department (2007). *Work Paper PGECOFST101, Commercial Convection Oven, Revision #0.*

Compressed Air – High Efficiency Air Compressors

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Covers the installation of oil flooded, rotary screw compressors with Load/No Load, Variable Speed Drive, or Variable Displacement capacity control with properly sized air receiver. Efficient air compressors use various control schemes to improve compression efficiencies at partial loads. When an air compressor fitted with Load/No Load, Variable Speed Drive, or Variable Displacement capacity controls is used in conjunction with a properly-sized air receiver, considerable amounts of energy can be saved.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity, Retrofit
End Use: Compressed Air
Measure Type: Air Compressors
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impacts

$$\Delta kWh = (HP_{COMPRESSOR})(SAVE)(Hours)$$
$$\Delta kW = (HP_{COMPRESSOR})(SAVE)$$

Where:

$HP_{COMPRESSOR}$	=	Nominal rated horsepower of high efficiency air compressor.
Save	=	Air compressor kW reduction per HP: 0.189. [620]
Hours	=	Annual operating hours of the air compressor.

Baseline Efficiency

The baseline efficiency case is a typical load/unload compressor.

High Efficiency

The high efficient case is an oil-flooded, rotary screw compressor with Variable Speed Drive or Variable Displacement capacity control with a properly sized air receiver. Air receivers are designed to provide a supply buffer to meet short-term demand spikes which can exceed the compressor capacity. Installing a larger receiver tank to meet occasional peak demands can allow for the use of a smaller compressor.

[620] DNV GL (2015). Impact Evaluation of Prescriptive Chiller and Compressed Air Installations. Prepared for the MA PAs and EEAC. Result for VSD 25-75 HP used since "All" result includes savings from load/unload compressors, which are now baseline.

Hours

The annual hours of operation for air compressors are site-specific and should be determined on a case-by-case basis.

Measure Life

For lost-opportunity installations, the lifetime for this measure is 15 years.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Air Compressor	NB, EUL, Large Retrofit	All	1.00	1.39	1.00	1.00	1.17	0.98	1.29	1.00

In-Service Rates
All installations have 100% in service rate since PA programs include verification of equipment installations.

Realization Rates

- All PAs: RR from the prospective results of the 2015 study of prescriptive compressed air. The RR adjusts for differences in operating hours between PA tracking assumptions and on site findings. The RR must be coupled with the updated kW/HP results from the same study.[621]

Coincidence Factors

- All PAs: CFs from the prospective results of the 2015 study of prescriptive compressed air.[622]

[621] DNV GL (2015). *Impact Evaluation of Prescriptive Chiller and Compressed Air Installations*. Prepared for the MA PAs and EEAC.
[622] Ibid.

Compressed Air – Refrigerated Air Dryers

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The installation of cycling or variable frequency drive (VFD)-equipped refrigerated compressed air dryers. Refrigerated air dryers remove the moisture from a compressed air system to enhance overall system performance. An efficient refrigerated dryer cycles on and off or uses a variable speed drive as required by the demand for compressed air instead of running continuously. Only properly sized refrigerated air dryers used in a single-compressor system are eligible.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: Compressed Air
Measure Type: Refrigerated Air Dryers
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = (CFM_{DRYER})(SAVE)(Hours)$$
$$\Delta kW = (CFM_{DRYER})(SAVE)$$

Where:

CFM_{DRYER}	=	Full flow rated capacity of the refrigerated air dryer in cubic feet per minute (CFM). Obtain from equipment's Compressed Air Gas Institute Datasheet.
Save	=	Refrigerated air dryer kW reduction per dryer full flow rated CFM: 0.00554. [623]
Hours	=	Annual operating hours of the refrigerated air dryer.

Baseline Efficiency

The baseline efficiency case is a non-cycling refrigerated air dryer.

High Efficiency

The high efficiency case is a cycling refrigerated dryer or a refrigerated dryer equipped with a VFD.

[623] DNV GL (2015). *Impact Evaluation of Prescriptive Chiller and Compressed Air Installations*. Prepared for the MA PAs and EEAC.

Hours

The annual hours of operation for compressed air dryers are site-specific.

Measure Life

The measure life is 15 years.[624]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Refrigerated Air Dryers	NB, EUL	All	1.00	1.56	1.00	1.00	1.17	0.98	1.29	1.00

<u>In-Service Rates</u>
All installations have 100% in service rate since PA programs include verification of equipment installations.

<u>Realization Rates</u>
RR from the prospective results of the 2015 study of prescriptive compressed air. The RR adjusts for differences in operating hours between PA tracking assumptions and on site findings. The RR must be coupled with the updated kW/CFM results from the same study.[625]

<u>Coincidence Factors</u>
CFs from the prospective results of the 2015 study of prescriptive compressed air.[626]

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[624] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[625] DNV GL (2015). *Impact Evaluation of Prescriptive Chiller and Compressed Air Installations*. Prepared for the MA PAs and EEAC.
[626] Ibid.

Compressed Air – Low Pressure Drop Filters

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Filters remove solids and aerosols from compressed air systems. Low pressure drop filters have longer lives and lower pressure drops than traditional coalescing filters resulting in higher efficiencies.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity & Retrofit
End Use: Compressed Air
Measure Type: Low Pressure Drop Filters
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life, C&I Existing Building Retrofit

Algorithms for Calculating Primary Energy Impacts[627]

$$\Delta kWh = (Quantity)(HP_{COMP})(0.7457)(\%Savings)(Hours)$$
$$\Delta kW = (Quantity)(HP_{COMP})(0.7457)(\%Savings)$$

Where:

ΔkWh	=	Energy savings
ΔkW	=	Demand savings
Quantity	=	Number of filters installed
HP_{COMP}	=	Average compressor load
0.7457	=	Conversion from HP to kW
% Savings	=	Percent change in pressure drop. Site specific.
Hours	=	Annual operating hours of the lower pressure drop filter.

Baseline Efficiency

The baseline efficiency case is a standard coalescing filter with initial drop of between 1 and 2 pounds per sq inch (psi) with an end of life drop of 10 psi.

High Efficiency

The high efficiency case is a low pressure drop filter with initial drop not exceeding 1 psi over life and 3 psi at element change. Filters must be deep-bed, “mist eliminator” style and installed on a single operating compressor rated 15 – 75 HP.

[627] Formula adapted from savings calculation tool developed by Lenticular Solutions Inc.

Hours

The annual hours of operation are site specific and will be determined on a case by case basis.

Measure Life

For lost-opportunity installations, the lifetime for this measure is 5 years. For retrofit projects, the lifetime is 3 years.[628]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings[629]

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
LP Drop Filter	NB, EUL, Large Retrofit	National Grid	1.00	1.00	1.00	1.00	0.80	0.54	0.77	0.54
LP Drop Filter	NB, EUL, Large Retrofit	Eversource (NSTAR), CLC	1.00	1.25	0.95	0.80	0.88	0.69	n/a	n/a
LP Drop Filter	NB, EUL, Large Retrofit	Unitil	1.00	1.00	1.00	1.00	0.80	0.54	0.77	0.54
LP Drop Filter	NB, EUL, Large Retrofit	Eversource (WMECO)	1.00	0.90	0.95	0.80	0.88	0.69	custom	custom

<u>In-Service Rates</u>
All installations have 100% in service rate since PA programs include verification of equipment installations.

<u>Realization Rates</u>
- National Grid, Unitil: RRs based on impact evaluation of PY 2004 compressed air installations.[630]
- Eversource (NSTAR), CLC: energy and demand RRs from impact evaluation of NSTAR 2006 compressed air installations[631]
- Eversource (WMECO): energy RRs from 2011 WMECO C&I impact evaluation.[632], demand RRs from impact evaluation of NSTAR 2006 compressed air installations referenced above.

[628] Based on typical replacement schedules for low pressure filters (Eversource (NSTAR) staff estimates).
[629] This measure was included in the 2015 DNV GL study of Prescriptive compressed air measures, however, no sites with low pressure drop filters were selected in the sample.
[630] DMI (2006). *Impact Evaluation of 2004 Compressed Air Prescriptive Rebates*. Prepared for National Grid; results analyzed in RLW Analytics (2006). *Sample Design and Impact Evaluation Analysis for Prescriptive Compressed Air Measures in the Energy Initiative and Design 2000 Programs*. Prepared for National Grid.
[631] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.
[632] KEMA (2011). 2007/2008 Large C&I Programs. Prepared for Western Massachusetts Electric Company.

Coincidence Factors

- National Grid, Unitil: CFs based on impact evaluation of PY 2004 compressed air installations.633
- Eversource (NSTAR), CLC, Eversource (WMECO): on-peak CFs based on standard assumptions.
- Eversource (WMECO): seasonal CFs are custom calculated

[633] DMI (2006). *Impact Evaluation of 2004 Compressed Air Prescriptive Rebates*. Prepared for National Grid; results analyzed in RLW Analytics (2006). *Sample Design and Impact Evaluation Analysis for Prescriptive Compressed Air Measures in the Energy Initiative and Design 2000 Programs*. Prepared for National Grid.

Compressed Air – Zero Loss Condensate Drains

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Drains remove water from a compressed air system. Zero loss condensate drains remove water from a compressed air system without venting any air, resulting in less air demand and consequently greater efficiency.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity & Retrofit
End Use: Compressed Air
Measure Type: Zero Loss Condensate Drains
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life, C&I Existing Building Retrofit

Algorithms for Calculating Primary Energy Impacts

$$\Delta kWh = (CFM_{pipe})(CFM_{saved})(SAVE)(Hours)$$
$$\Delta kW = (CFM_{pipe})(CFM_{save})(SAVE)$$

Where:

ΔkWh	=	Energy Savings
ΔkW	=	Demand savings
CFM_{pipe}	=	CFM capacity of piping. Site specific.
CFM_{saved}	=	Average CFM saved per CFM of piping capacity: 0.049
Save	=	Average savings per CFM: 0.24386 kW/CFM[634]
Hours	=	Annual operating hours of the zero loss condensate drain.

Baseline Efficiency

The baseline efficiency case is installation of a standard condensate drain on a compressor system.

High Efficiency

The high efficiency case is installation of a zero loss condensate drain on a single operating compressor rated ≤ 75 HP.

Hours

The annual hours of operation are site specific and will be determined on a case by case basis.

[634] Based on Eversource (NSTAR) analysis assuming a typical timed drain settings discharge scenario.

Measure Life

For lost-opportunity installations, the lifetime for this measure is 15 years. For retrofit projects, the lifetime is 13 years.[635]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings[636]

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CFSSP	CFWSP
Zero Loss Drain	NB, EUL, Large Retrofit	National Grid	1.00	1.00	1.00	1.00	0.80	0.54	0.77	0.54
Zero Loss Drain	NB, EUL, Large Retrofit	Eversource (NSTAR), CLC	1.00	1.25	0.95	0.80	0.88	0.69	n/a	n/a
Zero Loss Drain	NB, EUL, Large Retrofit	Unitil	1.00	1.00	1.00	1.00	0.80	0.54	0.77	0.54
Zero Loss Drain	NB, EUL, Large Retrofit	Eversource (WMECO)	1.00	0.90	0.95	0.80	0.88	0.69	custom	custom

In-Service Rates
All installations have 100% in service rate since PA programs include verification of equipment installations.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates

- National Grid, Unitil: RRs based on impact evaluation of PY 2004 compressed air installations.[637]
- Eversource (NSTAR), CLC: energy and demand RRs from impact evaluation of NSTAR 2006 compressed air installations[638]
- Eversource (WMECO): energy RRs from 2011 WMECO C&I impact evaluation.[639], demand RRs from impact evaluation of NSTAR 2006 compressed air installations referenced above.

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[635] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1. Drains not expected to change during life of compressor.
[636] This measure was included in the 2015 DNV GL study of Prescriptive compressed air measures, however, there were not a statistically significant number of sites with this measure selected in the sample, so no impact updates have been made.
[637] DMI (2006). *Impact Evaluation of 2004 Compressed Air Prescriptive Rebates*. Prepared for National Grid; results analyzed in RLW Analytics (2006). *Sample Design and Impact Evaluation Analysis for Prescriptive Compressed Air Measures in the Energy Initiative and Design 2000 Programs*. Prepared for National Grid.
[638] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.
[639] KEMA (2011). 2007/2008 Large C&I Programs. Prepared for Western Massachusetts Electric Company.

Coincidence Factors

- National Grid, Unitil: CFs based on impact evaluation of PY 2004 compressed air installations.[640]
- Eversource (NSTAR), CLC, Eversource (WMECO): on-peak CFs based on standard assumptions.
- Eversource (WMECO): seasonal CFs are custom calculated.

[640] DMI (2006). *Impact Evaluation of 2004 Compressed Air Prescriptive Rebates*. Prepared for National Grid; results analyzed in RLW Analytics (2006). *Sample Design and Impact Evaluation Analysis for Prescriptive Compressed Air Measures in the Energy Initiative and Design 2000 Programs*. Prepared for National Grid.

Motors/Drives – Variable Frequency Drives

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: This measure covers the installation of variable speed drives according to the terms and conditions stated on the statewide worksheet. The measure covers multiple end use types and building types. The installation of this measure saves energy since the power required to rotate a pump or fan at lower speeds requires less power than when rotated at full speed.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity, Retrofit
End Use: Motors/Drives
Measure Type: Variable Speed Drive
Core Initiative: C&I New Buildings & Major Renovations and C&I Initial Purchase & End of Useful Life, C&I Existing Building Retrofit, C&I Small Business

Algorithms for Calculating Primary Energy Impacts

$$\Delta kWh = (HP)\left(\frac{1}{\eta_{motor}}\right)(kWh / HP)$$

$$\Delta kW = (HP)\left(\frac{1}{\eta_{motor}}\right)(kW / HP)_{SP}$$

Where:

HP	=	Rated horsepower for the impacted motor.
η_{motor}	=	Motor efficiency
kWh/HP	=	Annual electric energy reduction based on building and equipment type. See table below.
kW/HP_{SP}	=	Summer demand reduction based on building and equipment type. See table below.
kW/HP_{WP}	=	Winter demand reduction based on building and equipment type. See table below.

Savings Factors for C&I VFDs (kWh/HP[641] and kW/HP[642])

	Building Exhaust Fan	Cooling Tower Fan	Chilled Water Pump	Boiler Feed Water Pump	Hot Water Circulating. Pump	MAF - Make-up Air Fan	Return Fan	Supply Fan	WS Heat Pump Circulating Loop
Annual Energy Savings Factors (kWh/HP)									
University/College	3,641	449	745	2,316	2,344	3,220	1,067	1,023	3,061
Elm/H School	3,563	365	628	1,933	1,957	3,402	879	840	2,561
Multi-Family	3,202	889	1,374	2,340	2,400	3,082	1,374	1,319	3,713
Hotel/Motel	3,151	809	1,239	2,195	2,239	3,368	1,334	1,290	3,433
Health	3,375	1,705	2,427	2,349	2,406	3,002	1,577	1,487	3,670
Warehouse	3,310	455	816	2,002	2,087	3,229	1,253	1,205	2,818
Restaurant	3,440	993	1,566	1,977	2,047	2,628	1,425	1,363	3,542
Retail	3,092	633	1,049	1,949	2,000	2,392	1,206	1,146	2,998
Grocery	3,126	918	1,632	1,653	1,681	2,230	1,408	1,297	3,285
Offices	3,332	950	1,370	1,866	1,896	3,346	1,135	1,076	3,235
Summer Demand Savings Factors (kW/HP_{SP})									
University/College	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Elm/H School	0.377	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Multi-Family	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Hotel/Motel	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Health	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Warehouse	0.109	-0.023	0.174	0.457	0.091	0.261	0.287	0.274	0.218
Restaurant	0.261	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Retail	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Grocery	0.261	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Offices	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Winter Demand Savings Factors (kW/HP_{WP})									
University/College	0.377	-0.006	0.184	0.457	0.210	0.109	0.260	0.252	0.282
Elementary/High School	0.457	-0.006	0.184	0.457	0.210	0.109	0.260	0.252	0.282
Multi-Family	0.109	-0.006	0.184	0.355	0.210	0.109	0.260	0.252	0.282
Hotel/Motel	0.109	-0.006	0.184	0.418	0.210	0.109	0.260	0.252	0.282
Health	0.377	-0.006	0.184	0.275	0.210	0.109	0.260	0.252	0.282
Warehouse	0.377	-0.006	0.184	0.178	0.210	0.261	0.260	0.252	0.282
Restaurant	0.109	-0.006	0.184	0.355	0.210	0.109	0.260	0.252	0.282
Retail	0.109	-0.006	0.184	0.275	0.210	0.109	0.260	0.252	0.282
Grocery	0.457	-0.006	0.184	0.418	0.210	0.109	0.260	0.252	0.282
Offices	0.457	-0.006	0.184	0.418	0.210	0.109	0.260	0.252	0.282

[641] Chan, Tumin (2010). *Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR*. Prepared for NSTAR.
[642] For Chilled Water Pump, Hot Water Circ. Pump, Return Fan, Supply Fan, and WSHP Circ. Loop: kW/HP estimates derived from Cadmus (2012). *Variable Speed Drive Loadshape Project.* Prepared for the NEEP Regional Evaluation, Measurement & Verification Forum. Other drive type kW/HP savings estimates based on Chan, Tumin (2010). *Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR*. Prepared for NSTAR.

Baseline Efficiency

The baseline efficiency case measure varies with equipment type. All baselines assume either a constant or 2-speed motor. Air or water volume/temperature is controlled using valves, dampers, and/or reheats.

High Efficiency

In the high efficiency case, pump flow or fan air volume is directly controlled using downstream information. The pump or fan will automatically adjust its speed based on inputted set points and the downstream feedback it receives.

Hours

Hours vary by end use and building type.

Measure Life

For lost-opportunity installations, the lifetime is 15 years. For retrofit projects, the lifetime is 13 years.[643]

Secondary Energy Impacts

There are no secondary energy impacts.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
VFD	NB, EUL	All	1.00	0.94	1.00	1.00	1.00	1.00	1.00	1.00
VFD	Large Retrofit	All	1.00	0.94	1.00	1.00	1.00	1.00	1.00	1.00
VFD	Small Retrofit	CLC	1.00	0.94	1.00	1.00	1.00	1.00	1.00	1.00
VFD	Small Retrofit	Eversource (NSTAR)	1.00	0.94	1.00	1.00	1.00	1.00	1.00	1.00
VFD	Small Retrofit	Eversource (WMECO)	1.00	0.94	1.00	1.00	1.00	1.00	1.00	1.00

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Energy RRs for all PAs based on impact evaluation of 2011-2012 prescriptive VSD projects.[644] Demand RRs from study not used due to low precision of demand results. Demand RRs for Chilled Water Pump, Hot Water Circ. Pump, Return Fan, Supply Fan, and WSHP Circ. Loop set to 1 since savings based on NEEP VSD Loadshape study.

Coincidence Factors
CFs for all PAs set to 1.0 since summer and winter demand savings are based on evaluation results.

[643] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[644] KEMA, Inc. and DMI, Inc. (2013). *2011-2012 Massachusetts Prescriptive VSD Impact Evaluation.* Prepared for the Massachusetts Program Administrators and the Massachusetts Energy Efficiency Advisory Council.

Motors/Drives – Motor and Variable Frequency Drives

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: This measure covers the installation of a high efficiency motor with a variable speed drives according to the terms and conditions stated on the statewide worksheet. The measure covers multiple end use types and building types. The installation of this measure saves energy since the power required to rotate a pump or fan at lower speeds requires less power than when rotated at full speed.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity, Retrofit
End Use: Motors/Drives
Measure Type: Variable Speed Drive
Core Initiative: C&I Existing Building Retrofit, C&I Small Business

Algorithms for Calculating Primary Energy Impacts

$$\Delta kWh = (HP)\left(\frac{1}{\eta_{motor}}\right)(kWh/HP)$$

$$\Delta kW = (HP)\left(\frac{1}{\eta_{motor}}\right)(kW/HP)_{SP}$$

Where:

HP	=	Rated horsepower for the impacted motor.
η_{motor}	=	Motor efficiency
kWh/HP	=	Annual electric energy reduction based on building and equipment type. See table below.
kW/HP_{SP}	=	Summer demand reduction based on building and equipment type. See table below.
kW/HP_{WP}	=	Winter demand reduction based on building and equipment type. See table below.

Savings Factors for C&I VFDs with Motor Replacement (kWh/HP[645] and kW/HP[646])

	Building Exhaust Fan	Cooling Tower Fan	Chilled Water Pump	Boiler Feed Water Pump	Hot Water Circulating. Pump	MAF - Make-up Air Fan	Return Fan	Supply Fan	WS Heat Pump Circulating Loop
Annual Energy Savings Factors (kWh/HP)									
University/College	3,802	486	780	2,415	2,442	3,381	1,143	1,100	3,194
Elm/H School	3,721	396	657	2,015	2,040	3,561	941	903	2,673
Multi-Family	3,368	954	1,435	2,443	2,504	3,248	1,466	1,412	3,879
Hotel/Motel	3,317	866	1,294	2,291	2,335	3,534	1,425	1,381	3,585
Health	3,541	1,815	2,535	2,453	2,510	3,168	1,676	1,586	3,835
Warehouse	3,476	496	853	2,098	2,183	3,396	1,342	1,294	2,952
Restaurant	3,606	1,066	1,636	2,067	2,138	2,794	1,519	1,457	3,703
Retail	3,258	685	1,097	2,036	2,087	2,558	1,288	1,229	3,133
Grocery	3,292	1,001	1,710	1,724	1,753	2,396	1,498	1,386	3,434
Offices	3,498	1,014	1,432	1,947	1,977	3,512	1,210	1,151	3,379
Summer Demand Savings Factors (kW/HP_{SP})									
University/College	0.257	(0.004)	0.465	0.952	0.190	0.257	0.679	0.706	0.582
Elm/H School	1.187	(0.006)	0.697	1.428	0.286	0.385	1.019	1.058	0.699
Multi-Family	0.385	(0.006)	0.697	1.428	0.286	0.385	1.019	1.058	0.873
Hotel/Motel	0.257	(0.004)	0.465	0.952	0.190	0.257	0.679	0.706	0.582
Health	0.128	(0.002)	0.232	0.476	0.095	0.128	0.340	0.353	0.291
Warehouse	0.770	(0.012)	1.394	2.855	0.571	1.677	2.038	2.117	1.745
Restaurant	0.839	(0.006)	0.697	1.428	0.286	0.385	1.019	1.058	0.722
Retail	0.514	(0.008)	0.930	1.904	0.381	0.514	1.358	1.411	1.163
Grocery	0.280	(0.002)	0.232	0.476	0.095	0.128	0.340	0.353	0.241
Offices	0.257	(0.004)	0.465	0.952	0.190	0.257	0.679	0.706	0.582
Winter Demand Savings Factors (kW/HP_{WP})									
University/College	0.791	(0.001)	0.384	0.952	0.437	0.257	0.563	0.544	0.587
Elementary/High School	1.428	(0.002)	0.575	1.428	0.655	0.385	0.844	0.816	0.881
Multi-Family	0.385	(0.002)	0.575	1.123	0.661	0.385	0.844	0.816	0.893
Hotel/Motel	0.257	(0.001)	0.384	0.874	0.438	0.257	0.563	0.544	0.590
Health	0.396	(0.001)	0.192	0.294	0.223	0.128	0.281	0.272	0.302
Warehouse	2.374	(0.003)	1.151	1.181	1.384	1.677	1.688	1.632	1.872
Restaurant	0.385	(0.002)	0.575	1.123	0.661	0.385	0.844	0.816	0.893
Retail	0.514	(0.002)	0.767	1.178	0.893	0.514	1.125	1.088	1.208
Grocery	0.476	(0.001)	0.192	0.437	0.219	0.128	0.281	0.272	0.295
Offices	0.952	(0.001)	0.384	0.874	0.438	0.257	0.563	0.544	0.590

Baseline Efficiency

In the baselines, air or water volume/temperature is controlled using valves, dampers, and/or reheats.

645 Chan, Tumin (2010). *Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at Eversource (NSTAR)*. Prepared for NSTAR.
646 For Chilled Water Pump, Hot Water Circ. Pump, Return Fan, Supply Fan, and WSHP Circ. Loop: kW/HP estimates derived from Cadmus (2012). *Variable Speed Drive Loadshape Project.* Prepared for the NEEP Regional Evaluation, Measurement & Verification Forum. Other drive type kW/HP savings estimates based on Chan, Tumin (2010). *Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR*. Prepared for NSTAR.

High Efficiency

In the high efficiency case, pump flow or fan air volume is directly controlled using downstream information. The pump or fan will automatically adjust its speed based on inputted set points and the downstream feedback it receives.

Hours

Hours vary by end use and building type.

Measure Life

For retrofit projects, the lifetime is 13 years.[647]

Secondary Energy Impacts

There are no secondary energy impacts.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
VFD	Large Retrofit	All	1.00	0.94	1.00	1.00	1.00	1.00	1.00	1.00
VFD	Small Retrofit	CLC	1.00	0.94	1.00	1.00	1.00	1.00	1.00	1.00
VFD	Small Retrofit	Eversource (NSTAR)	1.00	0.94	1.00	1.00	1.00	1.00	1.00	1.00
VFD	Small Retrofit	Eversource (WMECO)	1.00	0.94	1.00	1.00	1.00	1.00	1.00	1.00

In-Service Rates
All installations have 100% in service rate since all PAs programs include verification of equipment installations.

Realization Rates
Energy RRs for all PAs based on impact evaluation of 2011-2012 prescriptive VSD projects.[648] Demand RRs from study not used due to low precision of demand results. Demand RRs for Chilled Water Pump, Hot Water Circ. Pump, Return Fan, Supply Fan, and WSHP Circ. Loop set to 1 since savings based on NEEP VSD Loadshape study.

Coincidence Factors
CFs for all PAs set to 1.0 since summer and winter demand savings are based on evaluation results.

[647] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[648] KEMA, Inc. and DMI, Inc. (2013). *2011-2012 Massachusetts Prescriptive VSD Impact Evaluation.* Prepared for the Massachusetts Program Administrators and the Massachusetts Energy Efficiency Advisory Council.

Whole Building - Building Operator Certification

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Building Operator Certification (BOC) is a nationally recognized training program designed to educate facilities personnel in the energy and resource efficient operation and maintenance of building systems. Savings include only operations, maintenance and controls savings.
Primary Energy Impact: Electric
Secondary Energy Impact: Project Specific
Non-Energy Impact: Project Specific
Sector: Commercial & Industrial
Market: Retrofit
End Use: All
Measure Type: Custom
Core Initiative: C&I Existing Building Retrofit

Algorithms for Calculating Primary Energy Impact

Savings are deemed based on study results[649]

Savings for Building Operator Certification

Measure Name	ΔkWh/SF/Student
BOC – O&M Only	0.178
BOC – O&M plus Capital Upgrades	0.364

Baseline Efficiency

No BOC training

High Efficiency

Completion and certification in a BOC level I or level II training course.

Measure Life

Measure life of 5 years.[650]

Secondary Energy Impacts

There are no secondary energy impacts.

[649] Navigant Consulting (2015). *Comprehensive Review of Non-Residential Training and Education Programs, with a Focus on Building Operator Certification.* Prepared for the Massachusetts Program Administrators and the Energy Efficiency Advisory Council
[650] Ibid.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
BOC Training	Large Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	1.00

In-Service Rates
n/a

Realization Rates
Realization rates are set to 100% since savings are based off of evaluation results.

Coincidence Factors
Coincident factors are set to 1.0.

Code Compliance Support Initiative (CCSI) - Commercial

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The MassSave Code Compliance Support Initiative (CCSI) is focused on improving the energy code compliance rates of residential and commercial buildings in the state. The initiative includes trainings, technical support, and the development of compliance documentation tools. This effort will support code officials, as well as design and construction professionals.
Primary Energy Impact: Electric & Gas
Secondary Energy Impact: N/A
Non-Energy Impact: N/A
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: All
Measure Type: Whole Building
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = GTP * \frac{(1 - NC) - BC}{1 - BC} * AF * ARF$$

Where:

GTP = Gross Technical Potential - Commercial energy savings (kWh and Therms) through building simulations described below under Baseline Efficiency. The gross technical potential for C&I is the difference between site observed energy measures and buildings modelled as 100% compliant with 2012 IECC requirements multiplied by the total square feet of new commercial buildings in MA

NC = Non-Compliance - The percentage of potential energy savings not realized at the end of an energy code cycle due to buildings on average not fully meeting code requirements: the difference between 100% and actual compliance at the end of the energy code cycle

BC = Baseline Compliance - The percentage of energy savings realized at the beginning of a new code cycle

AF = Attribution Factor - The percentage of potential energy savings above the normal compliance level, on average, at the end of a typical energy code cycle attributable to PA CCSI efforts[651]

ARF = Annual Ramp Factor - Factor used to simulate how quickly the CCSI reaches the target compliance goal across years. That is, since it takes time for the education efforts of the CCSI to take hold only a portion of the attributable savings are claimed each year during the

[651] A deemed rate of 35% is used.

initiative and ramped up to 100% over the entire three year term[652]

Baseline Efficiency

The baseline efficiency case assumes energy consumption using a measured compliance level[653]. The baseline for the commercial building sector was determined as buildings that meet 100% of the 2012 IECC code, and were then compared to non-compliant buildings that were surveyed during the 2012 code baseline study[654] (commercial buildings on average were 80% compliant with the 2006/2009 codes at the time of the study in terms of energy savings). New Buildings Institute conducted building modeling simulations for five building types based on data collected during the 2012 code baseline study. Energy Use Intensities (EUI) for offices, schools, multifamily, retail and refrigerated warehouses were created both for 100% compliant conditions and for those when compliance was not met. The EUIs were then multiplied by the forecasted number of square feet of new construction commercial buildings in MA using the online Dodge Database.

High Efficiency

The high efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code.

Hours

Not Applicable.

Measure Life

20 years.

Secondary Energy Impacts

Not Applicable.

Non-Energy Impacts

Not Applicable.

Impact Factors for Calculating Adjusted Gross Savings

Measure	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Code Compliance Support Initiative	ALL	1.00	1.00	1.00	1.00	N/A	N/A	N/A	N/A

Note: Unless otherwise stated, PA's use Statewide results.

[652] The 2016 – 2018 term includes savings from 2015 – 2018 where the Annual Ramp Factor is 20% for 2015, 30% for 2016, 50% for 2017, and 100% for 2018.
[653] DNV-GL, ERS, APPRISE (2015). *Massachusetts Commercial New Construction Energy Code Compliance Follow-Up Study, Final Report,* Prepared for: Massachusetts Program Administrators and Energy Efficiency Advisory Council.
[654] DNV-KEMA, ERS, APPRISE (2012). *Final Report, Project 11, Code Compliance Baseline Study*, Prepared for: Massachusetts Energy Efficiency Program Administrators.

In-Service Rates
All PAs use 100% in service rate.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
All PAs use 100% realization rates as all adjustments are made via the factors listed in the algorithm above.

Coincidence Factors
Not applicable as only energy savings are counted.

Custom Measures (Large C&I)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The Custom project track is offered for energy efficiency projects involving complex site-specific applications that require detailed engineering analysis and/or projects which do not qualify for incentives under any of the prescriptive rebate offering. Projects offered through the custom approach must pass a cost-effectiveness test based on project-specific costs and savings.
Primary Energy Impact: Electric
Secondary Energy Impact: Project Specific
Non-Energy Impact: Project Specific
Sector: Commercial & Industrial
Market: Lost Opportunity, Retrofit
End Use: All
Measure Type: Custom
Core Initiative: C&I New Buildings & Major Renovations and C&I Initial Purchase & End of Useful Life, C&I Existing Building Retrofit

Notes

In 2011 the PAs agreed on the following set of categories for Large C&I custom projects. All Large C&I Custom projects will be assigned to one of the following categories for future statewide impact evaluation.

Custom Category	Description
Comprehensive Design	New construction projects which address multiple end-uses, reach 20%+ total energy savings, and use whole-building simulations for ex-ante savings estimates and Retrofit projects which address multiple end-uses, reach 15%+ electric energy savings, and do not require whole-building simulations.
Compressed Air	New construction and/or retrofit projects for compressed air systems.
CHP	Combined Heat and Power projects.
HVAC	New construction and/or retrofit projects for HVAC system equipment and controls.
Lighting	New construction and/or retrofit projects for lighting system equipment and controls.
Motor	New construction and/or retrofit projects for motor installations or controls.
Other	New construction and/or retrofit projects that do not fit in with other categories.
Process	New construction and/or retrofit projects for process system equipment and controls.
Refrigeration	New construction and/or retrofit projects for refrigeration system equipment and controls.
Verified Savings	Retrofit “Pay-for-Performance” projects for which savings are estimated based on post-installation measurement and verification.

Algorithms for Calculating Primary Energy Impact

Gross energy and demand savings estimates for custom projects are calculated using engineering analysis with project-specific details. Custom analyses typically include a weather dependent load bin analysis, whole building energy model simulation, end-use metering or other engineering analysis and include estimates of savings, costs, and an evaluation of the projects' cost-effectiveness.

Baseline Efficiency

For lost opportunity projects, the baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code or industry accepted standard practice. For retrofit projects, the baseline efficiency case is the same as the existing, or pre-retrofit, case for the facility.

High Efficiency

The high efficiency scenario is specific to the custom project and may include one or more energy efficiency measures. Energy and demand savings calculations are based on projected or measured changes in equipment efficiencies and operating characteristics and are determined on a case-by-case basis. The project must be proven cost-effective in order to qualify for energy efficiency incentives.

Hours

All hours for custom savings analyses should be determined on a case-by-case basis.

Measure Life

For both lost-opportunity and retrofit custom applications, the measure life is determined based on specific project using the common custom measure life recommendations.[655]

Secondary Energy Impacts

All secondary energy impacts should be determined on a case-by-case basis.

Non-Energy Impacts

All non-energy impacts should be determined on a case-by-case basis.

[655] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-2.

Impact Factors for Calculating Adjusted Gross Savings

Measure	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Comprehensive Design	Eversource (NSTAR), CLC, Unitil, Eversource (WMECO)	1.00	0.91	0.64	0.60	custom	custom	custom	custom
	National Grid	1.00	0.97	0.64	0.55	custom	custom	n/a	n/a
Compressed Air	All	1.00	0.85	0.76	0.74	custom	custom	custom	custom
CHP	Eversource (NSTAR)	1.00	1.10	1.44	1.01	custom	custom	custom	custom
	National Grid	1.00	0.91	1.09	1.05	custom	custom	custom	custom
	Unitil	1.00	0.84	1.38	0.00	custom	custom	custom	custom
HVAC	Unitil	1.00	0.88	0.88	0.85	custom	custom	custom	custom
	National Grid	1.00	0.75	0.70	0.67	custom	custom	n/a	n/a
	Eversource (NSTAR)	1.00	0.91	0.94	0.88	custom	custom	n/a	n/a
	Eversource (WMECO)	1.00	0.88	0.88	0.85	custom	custom	custom	custom
	CLC	1.00	0.88	0.88	0.85	custom	custom	n/a	n/a
Lighting	National Grid	1.00	0.98	1.16	0.85	custom	custom	n/a	n/a
	Eversource (NSTAR)	1.00	1.02	0.85	0.84	custom	custom	n/a	n/a
	CLC	1.00	0.98	0.94	0.92	custom	custom	n/a	n/a
	Unitil	1.00	0.98	0.94	0.92	custom	custom	n/a	n/a
	Eversource (WMECO)	1.00	0.98	0.85	0.84	custom	custom	custom	custom
LED Street Lighting	CLC	1.00	1.00	1.00	1.00	custom	custom	custom	custom
Motor	National Grid	1.00	0.89	0.89	0.74	custom	custom	n/a	n/a
	Eversource (NSTAR), CLC	1.00	0.91	0.90	0.76	custom	custom	n/a	n/a
	Unitil	1.00	1.00	1.00	1.00	custom	custom	n/a	n/a
	Eversource (WMECO)	1.00	0.91	0.90	0.76	custom	custom	custom	custom
Other	National Grid	1.00	0.31	0.34	0.33	custom	custom	custom	custom
Process	National Grid	1.00	0.68	0.96	0.82	custom	custom	n/a	n/a
	Eversource (NSTAR)	1.00	1.04	0.80	1.11	custom	custom	n/a	n/a
	CLC	1.00	0.76	0.82	0.88	custom	custom	n/a	n/a
	Unitil	1.00	0.76	0.82	0.88	custom	custom	n/a	n/a
	Eversource (WMECO)	1.00	0.76	0.80	1.11	custom	custom	custom	custom
Refrigeration	National Grid	1.00	1.19	1.21	1.20	custom	custom	n/a	n/a
	Eversource (NSTAR), CLC	1.00	1.13	1.38	1.10	custom	custom	n/a	n/a
	Unitil	1.00	1.11	1.21	1.14	custom	custom	n/a	n/a
	Eversource (WMECO)	1.00	1.11	1.21	1.14	custom	custom	custom	custom
Verified Savings[656]	Statewide	1.00	1.00	1.00	1.00	custom	custom	custom	custom

Note: Unless otherwise stated, PA's use Statewide results.

[656] The PAs assume 100% realization rates for verified savings projects because gross savings assumptions are based on post-installation verification and analysis. This custom category is new in 2011 and has not been evaluated.

In-Service Rates

All installations have 100% in service rate since all PA programs include verification of equipment installations.

Realization Rates

- Comprehensive: Realization rates from statewide impact evaluation completed in 2011. National Grid uses PA specific values, all other PA's use statewide values due to small sample size. [657]
- HVAC: Realization rates from statewide impact evaluation completed in 2015. National Grid and Eversource (NSTAR) use PA specific values, all other PA's use statewide values due to small sample size.[658]
- CHP: National Grid, Eversource (NSTAR) and Unitil CHP RRs from a Massachusetts CHP impact evaluation of 2011-2012 CHP projects.[659]
- Compressed Air: Realization rates from statewide impact evaluation completed in 2012.[660] All PA's use statewide values due to poor precision on a PA level.
- Process: Realization rates from statewide impact evaluation completed in 2012.[661] National Grid and Eversource (NSTAR) use PA specific values, all other PA's use statewide values due to small sample size.
- Lighting: Realization rates from statewide impact evaluation completed in 2012.[662] National Grid and Eversource (NSTAR) use PA specific values, all other PA's use statewide values due to small sample size.
- Refrigeration, Motors, and Other: Realization rates from statewide impact evaluation completed in 2012. National Grid uses PA specific values for each end use, All other PAs use statewide values due to small sample size. In the case of Eversource (NSTAR), the statewide rate for Custom Motors was used due to small sample size and the PA specific number for Refrigeration.[663]

Coincidence Factors

For all PAs, gross summer and winter peak coincidence factors are custom-calculated for each custom project based on project-specific information. The actual or measured coincidence factors are included in the summer and winter demand realization rates.

[657] KEMA, Inc. and SBW (2011). *Impact Evaluation of 2008 and 2009 Custom CDA Installations*. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council.
[658] DNV GL (2015). *Impact Evaluation of 2012 Custom HVAC Installations*. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council.
[659] KEMA (2013). *Massachusetts Combined Heat and Power Program Impact Evaluation 2011-2012*. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council
[660] KEMA (2012). *Impact Evaluation of 2010 Custom Process and Compressed Air Installations*. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council.
[661] Ibid.
[662] KEMA (2012). *Impact Evaluation of the 2010 Custom Lighting Installations*. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council.
[663] KEMA, Inc. and SBW (2013). *Impact Evaluation of 2011 Custom Refrigeration, Motor, and Other Installations*. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council.

Custom Measures (Small C&I)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The Custom project track is offered for energy efficiency projects involving complex site-specific applications that require detailed engineering analysis and/or projects which do not qualify for incentives under any of the prescriptive rebate offering. Projects offered through the custom approach must pass a cost-effectiveness test based on project-specific costs and savings.
Primary Energy Impact: Electric
Secondary Energy Impact: Project Specific
Non-Energy Impact: Project Specific
Sector: Commercial & Industrial
Market: Retrofit
End Use: All
Measure Type: Custom
Core Initiative: C&I Small Business

Algorithms for Calculating Primary Energy Impact

Gross energy and demand savings estimates for custom projects are calculated using engineering analysis with project-specific details. Custom analyses typically include a weather dependent load bin analysis, whole building energy model simulation, end-use metering or other engineering analysis and include estimates of savings, costs, and an evaluation of the projects' cost-effectiveness.

Baseline Efficiency

For Lost Opportunity projects, the baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code or industry accepted standard practice. For retrofit projects, the baseline efficiency case is the same as the existing, or pre-retrofit, case for the facility.

High Efficiency

The high efficiency scenario is specific to the custom project and may include one or more energy efficiency measures. Energy and demand savings calculations are based on projected or measured changes in equipment efficiencies and operating characteristics and are determined on a case-by-case basis. The project must be proven cost-effective in order to qualify for energy efficiency incentives.

Hours

All hours for custom savings analyses should be determined on a case-by-case basis.

Measure Life

For both lost-opportunity and retrofit custom applications, the measure life is determined based on specific project using the common custom measure life recommendations.[664]

Secondary Energy Impacts

All secondary energy impacts should be determined on a case-by-case basis.

Non-Energy Impacts

All non-energy impacts should be determined on a case-by-case basis.

Impact Factors for Calculating Adjusted Gross Savings

Measure	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Lighting	National Grid	1.00	1.04	1.02	1.13	custom	custom	n/a	n/a
Refrigeration	National Grid	1.00	1.60	1.49	0.69	custom	custom	n/a	n/a
Other	National Grid	1.00	0.81	0.77	0.53	custom	custom	n/a	n/a
Lighting Systems	Eversource (NSTAR)	1.00	1.02	0.99	0.99	custom	custom	n/a	n/a
Lighting Controls	Eversource (NSTAR)	1.00	0.42	0.92	0.92	custom	custom	n/a	n/a
VSD	Eversource (NSTAR)	1.00	0.94	1.00	1.00	custom	custom	n/a	n/a
Other Non-Lighting Systems	Eversource (NSTAR), CLC	1.00	0.91	0.92	0.92	custom	custom	n/a	n/a
LED Street Lighting	CLC	1.00	1.00	1.00	1.00	custom	custom	n/a	n/a
Lighting Controls	CLC	1.00	0.42	0.92	0.92	custom	custom	n/a	n/a
Lighting Systems	CLC	1.00	1.02	0.99	0.99	custom	custom		
Lighting	Unitil	1.00	1.08	0.99	0.99	custom	custom	n/a	n/a
Non-Lighting	Unitil	1.00	1.08	1.00	1.00	custom	custom	n/a	n/a
Lighting Systems	Eversource (WMECO)	1.00	1.02	0.99	0.99	custom	custom	0.67	0.58
Lighting Controls	Eversource (WMECO)	1.00	0.42	0.92	0.92	custom	custom	0.67	0.58
VSD	Eversource (WMECO)	1.00	0.94	1.00	1.00	custom	custom	custom	custom
Other	Eversource (WMECO)	1.00	1.00	0.92	0.92	custom	custom	custom	custom

In-Service Rates
All installations have 100% in service rate since all PA programs include verification of equipment installations.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
- National Grid RRs derived from impact evaluation of 2005 SBS program[665]
- Eversource (NSTAR) VSD rates from impact evaluation of C&I 2006 programs[666]

[664] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-2.
[665] RLW Analytics (2007). *Small Business Services Custom Measure Impact Evaluation*. Prepared for National Grid; Table 4.

- Eversource (NSTAR), Eversource (WMECO), and CLC: lighting RRs from the 2011 Small C&I Non-Controls Lighting impact evaluation.[667] Lighting Controls from a lighting control pre/post installation impact evaluation.[668] Other non-lighting energy and all demand RRs based on NSTAR 2002–2004 small retrofit impact evaluations
- Unitil RRs from Small Business program impact evaluation.[669]

Coincidence Factors

For all PAs, gross summer and winter peak coincidence factors are custom-calculated for each custom project based on project-specific information. The actual or measured coincidence factors are included in the summer and winter demand realization rates.

[666] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Tables 14-18

[667] Cadmus Group (2011). *Non-Controls Lighting Evaluation for the Massachusetts Small Commercial Direct Install Program*. Prepared for Massachusetts Utilities.

[668] Cadmus Group (2012). *Small Business Direct Install Program: Pre/Post Lighting Occupancy Sensor Study*. Prepared for Prepared for Massachusetts Program Administrators.

[669] Summit Blue Consulting, LLC (2008). *Multiple Small Business Services Programs Impact Evaluation 2007 – Final Report Update*. Prepared for Cape Light Compact, National Grid, NSTAR, Unitil and Western Massachusetts Electric Company.

Custom Measures (Multifamily C&I)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Vendors install a variety of measures at multifamily facilities. Measures include lighting, HVAC, and domestic hot water equipment and measures.
Primary Energy Impact: Electric
Secondary Energy Impact: Project Specific
Non-Energy Impact: Yes
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC, Lighting, Hot Water
Measure Type: Custom
Core Initiative: C&I Multifamily

Algorithms for Calculating Primary Energy Impact

Gross energy and demand savings estimates for C&I Multifamily projects are calculated by approved vendors with project-specific details. Vendors currently use algorithms (described in the Residential section of this document) to calculate savings.

Baseline Efficiency

For retrofit projects, the baseline efficiency case is the same as the existing, or pre-retrofit, case for the facility.

High Efficiency

The high efficiency scenario is specific to the facility and may include one or more energy efficiency measures. Energy and demand savings calculations are based on projected or measured changes in equipment efficiencies and operating characteristics and are determined on a case-by-case basis.

Hours

See Residential Section of this document.

Measure Life

See Residential Section of this document.

Secondary Energy Impacts

See Residential Section of this document.

Non-Energy Impacts

All non-energy impacts should be determined on a case-by-case basis.

Impact Factors for Calculating Adjusted Gross Savings

Measure	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Lighting	National Grid	1.00	0.98	1.16	0.85	custom	custom	n/a	n/a
	Eversource	1.00	1.02	0.85	0.84	custom	custom	custom	custom
	CLC	1.00	0.98	0.94	0.92	custom	custom	n/a	n/a
	Unitil	1.00	0.98	0.94	0.92	custom	custom	n/a	n/a
HVAC	National Grid	1.00	0.75	0.70	0.67	custom	custom	n/a	n/a
	Eversource	1.00	0.91	0.94	0.88	custom	custom	custom	custom
	CLC	1.00	0.88	0.88	0.85	custom	custom	n/a	n/a
	Unitil	1.00	0.88	0.88	0.85	custom	custom	n/a	n/a
Hot Water	National Grid	1.00	0.68	0.96	0.82	custom	custom	n/a	n/a
	Eversource	1.00	1.00	0.92	0.92	custom	custom	custom	custom
	CLC	1.00	0.91	0.92	0.92	custom	custom	n/a	n/a
	Unitil	1.00	1.08	1.00	1.00	custom	custom	n/a	n/a

In-Service Rates
All installations have 100% in service rate since all PA programs include verification of equipment installations.

Realization Rates
- Lighting: All PAs use realization rates from the large commercial custom lighting statewide impact evaluation completed in 2012.[670]
- HVAC: All PAs use realization rates from the large commercial custom HVAC impact evaluation completed in 2015.[671]
- Hot Water: National Grid RRs derived from the large commercial electric process evaluation.[672] Eversource and CLC energy RRs and all demand RRs based on Eversource (NSTAR) 2002–2004 small retrofit impact evaluations, Unitil RRs from Small Business program impact evaluation.[673]

Coincidence Factors
For all PAs, gross summer and winter peak coincidence factors are custom-calculated for each custom project based on project-specific information. The actual or measured coincidence factors are included in the summer and winter demand realization rates.

[670] KEMA (2012). Impact Evaluation of the 2010 Custom Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council.
[671] DNV GL (2015). Impact Evaluation of 2012 Custom HVAC Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council.
[672] KEMA (2012). *Impact Evaluation of 2010 Custom Process and Compressed Air Installations*. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council.
[673] Summit Blue Consulting, LLC (2008). *Multiple Small Business Services Programs Impact Evaluation 2007 – Final Report Update*. Prepared for Cape Light Compact, National Grid, NSTAR, Unitil and Western Massachusetts Electric Company.

Prescriptive Measures (C&I Multifamily)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Vendors install a variety of measures at multifamily facilities. Measures include lighting, HVAC, and domestic hot water equipment and measures.
Primary Energy Impact: Electric
Secondary Energy Impact: Project Specific
Non-Energy Impact: Yes
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC, Lighting, Hot Water
Measure Type: Varied, see Residential Section
Core Initiative: C&I Multifamily

Algorithms for Calculating Primary Energy Impact

The prescriptive measures, algorithms, and deemed savings claimed in the C&I Multifamily Retrofit program are identical to those claimed through the Residential Multifamily programs. Please reference the appropriate measure in the residential section of this TRM for all savings algorithms and deemed savings numbers.

Baseline Efficiency

See Residential Section of this document for measure specific detail.

High Efficiency

See Residential Section of this document for measure specific detail.

Hours

See Residential Section of this document for measure specific detail.

Measure Life

See Residential Section of this document for measure specific detail.

Secondary Energy Impacts

See Residential Section of this document for measure specific detail.

Non-Energy Impacts

See Residential Section of this document for measure specific detail.

Impact Factors for Calculating Adjusted Gross Savings

Measure	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Lighting	All	0.97	0.60	0.60	0.60	*	*	*	*
HVAC	All	1.00	0.60	0.60	0.60	*	*	*	*
Hot Water	All	1.00	0.60	0.60	0.60	*	*	*	*

In-Service Rates

- Lighting: In Service Rate from the MF Retrofit: MF Retrofit: 2012 MF Impact Analysis[674]
- HVAC and Hot Water: All installations have 100% in service rate since all PA programs include verification of equipment installations.

Realization Rates

- All PAs use realization rates from common assumptions.
- HVAC: National Grid uses realization rates from the All PAs use realization rates from the large commercial custom HVAC impact evaluation completed in 2015. [675]
- Hot Water: National Grid RRs derived from impact evaluation of 2005 SBS program.[676] Eversource and CLC energy RRs and all demand RRs based on NSTAR 2002–2004 small retrofit impact evaluations, Unitil RRs from Small Business program impact evaluation.[677]

Coincidence Factors

See Residential Section of this document for measure specific detail.

674 The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.
675 DNV GL (2015). Impact Evaluation of 2012 Custom HVAC Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council.
676 RLW Analytics (2007). *Small Business Services Custom Measure Impact Evaluation*. Prepared for National Grid; Table 4.
677 Summit Blue Consulting, LLC (2008). *Multiple Small Business Services Programs Impact Evaluation 2007 – Final Report Update*. Prepared for Cape Light Compact, National Grid, NSTAR, Unitil and Western Massachusetts Electric Company.

Commercial and Industrial Gas Efficiency Measures

Food Service – Commercial Ovens

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of High Efficiency Gas Ovens
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: Water
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: Food Service
Measure Type: Cooking Equipment
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed:

Measure Name	ΔMMBtu
Convection Oven	12.9[678]
Combination Oven	112.0 [679]
Conveyer Oven	88.4[680]
Rack Oven	211.3[681]

Baseline Efficiency

The baseline efficiency case is a standard efficiency oven.

Measure Name	Baseline Efficiency
Convection Oven	44%
Combination Oven	35%
Conveyer Oven	20% Heavy Load
Rack Oven	30%

High Efficiency

High efficiency case is an oven that meets or exceeds the high efficiency ratings per oven type shown in table below.

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[678] Energy Star Commercial Kitchen Equipment Saving Calculator http://www.energystar.gov/products/certified-products/detail/commercial-food-service-equipment. Default values used. Accessed on 10/2/2015
[679] Food Service Technology Center (2015). *Gas Combination Oven Life-Cycle Cost Calculator*. http://www.fishnick.com/saveenergy/tools/calculators/gcombicalc.php. Default values used. Accessed 10/2/2015
[680] Food Service Technology Center (2015). *Gas Conveyor Oven Life-Cycle Cost Calculator*. http://www.fishnick.com/saveenergy/tools/calculators/gconvovencalc.php. Default values used. Accessed 10/2/2015
[681] Food Service Technology Center (2015). *Gas Rack Oven Life-Cycle Cost Calculator*. http://www.fishnick.com/saveenergy/tools/calculators/grackovencalc.php. Default values used. 10/2/2015

Measure Name	Efficiency Requirement
Convection Oven	>= 46%
Combination Oven	>= 44%
Conveyer Oven	>= 42%
Rack Oven	>= 50%

Hours

Not applicable.

Measure Life

The measure life is 12 years for all commercial ovens.[682]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

65,700 Gallons of water[683] for the combination oven

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Convection Oven	NB, EUL	All	1.00	1.00	n/a	n/a	n/a	n/a
Combination Oven	NB, EUL	All	1.00	1.00	n/a	n/a	n/a	n/a
Conveyer Oven	NB, EUL	All	1.00	1.00	n/a	n/a	n/a	n/a
Rack Oven	NB, EUL	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

[682] Food Service Technology Center (2015). *Oven Life-Cycle Cost Calculators*
[683] Food Service Technology Center (2015). *Gas Combination Oven Life-Cycle Cost Calculator*. http://www.fishnick.com/saveenergy/tools/calculators/gcombicalc.php. Accessed 10/2/2015

Food Service – Commercial Griddle

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a gas griddle with efficiency of 38%.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: Food Service
Measure Type: Cooking Equipment
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[684].

Savings for Commercial Griddles

Measure Name	ΔMMBtu
Griddle	13.1

Baseline Efficiency

The baseline efficiency case is a standard efficiency (32% efficient) gas griddle.

High Efficiency

The high efficiency case is a gas griddle with an efficiency of 38%.

Hours

Not applicable.

Measure Life

The measure life is 12 years.[685]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

[684] Energy Star Commercial Kitchen Equipment Saving Calculator http://www.energystar.gov/products/certified-products/detail/commercial-food-service-equipment. Default values used. Accessed on 10/2/2015
[685] Ibid.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Griddle	NB, EUL	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

Food Service – Commercial Fryer

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The installation of a natural-gas fired fryer that is either ENERGY STAR® rated or has a heavy-load cooking efficiency of at least 50%. Qualified fryers use advanced burner and heat exchanger designs to use fuel more efficiently, as well as increased insulation to reduce standby heat loss.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: Food Service
Measure Type: Cooking Equipment
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed[686]

Savings for Commercial Fryers

Measure Name	ΔMMBtu
Fryer	50.8

Baseline Efficiency

The baseline efficiency case is a non-Energy Star qualified fryer.

High Efficiency

The high efficiency case is an Energy Star qualified fryer.

Hours

Not applicable.

Measure Life

The measure life is 12 years.[687]

[686] Energy Star Commercial Kitchen Equipment Saving Calculator http://www.energystar.gov/products/certified-products/detail/commercial-food-service-equipment. Default values used. Accessed on 10/2/2015
[687] Ibid.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Fryer	NB, EUL	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

Food Service – Commercial Steamer

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The installation of an ENERGY STAR® rated natural-gas fired steamer, either connectionless or steam-generator design, with heavy-load cooking efficiency of at least 38%. Qualified steamers reduce heat loss due to better insulation, improved heat exchange, and more efficient steam delivery systems.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: Water, Wastewater
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: Food Service
Measure Type: Cooking Equipment
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed[688].

Savings for Commercial Steamers

Measure Name	ΔMMBtu
Steamer	105.4

Baseline Efficiency

The baseline efficiency case is a non-energy star steamer

High Efficiency

The high efficiency case is an ENERGY STAR® qualified gas-fired steamer.

Hours

The deemed savings assumes 4,380 annual operating hours (12 hours a day * 365 days/year).[689]

Measure Life

The measure life is 12 years.[690]

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688 Energy Star Commercial Kitchen Equipment Saving Calculator http://www.energystar.gov/products/certified-products/detail/commercial-food-service-equipment. Default values used. Accessed on 10/2/2015
689 Ibid
690 Ibid.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings[691]
C&I Water	C&I Water Savings	162,060 gallons/unit
C&I Wastewater	C&I Wastewater Savings	162,060 gallons/unit

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Steamer	NB, EUL	All	1.00	1.00	1.00	1.00	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

[691] Ibid.

HVAC – Boilers

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The installation of a high efficiency natural gas fired condensing hot water boiler. High-efficiency condensing boilers can take advantage of improved design, sealed combustion and condensing flue gases in a second heat exchanger to achieve improved efficiency.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC
Measure Type: Heating
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[692].

Savings for Boilers

Measure Name	ΔMMBtu
Condensing Boiler <= 300 mbh (.90 AFUE)	30.6
Condensing Boiler 301-499 mbh (.90 TE)	58.4
Condensing Boiler 500-999 mbh (.90 TE)	107.3
Condensing Boiler 1000-1700 mbh (.90 TE)	197.2
Condensing Boiler 1701+ mbh (.90 TE)	345.1
Condensing Boiler <= 300 mbh (.95 AFUE)	27.8

Baseline Efficiency

The baseline efficiency assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. The deemed savings methodology for this measure does not require specific baseline data, but the baseline information is provided here for use in the future when this is converted to a deemed calculated measure.

As described in Chapter 13 of the Massachusetts State Building Code, energy efficiency must be met via compliance with the International Energy Conservation Code (IECC) 2012. The table below details the specific efficiency requirements by equipment type and capacity. Baseline requirements for 2017 and on have not been finalized.

[692] KEMA (2013). *Impact Evaluation of 2011 Prescriptive Gas Measures*. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council; Page 1-2.

Baseline Efficiency Requirements for C&I Gas-Fired Boilers[693]

Equipment Type	Subcategory	Size Category (Input)	Minimum Efficiency (2016)[a]	Test Procedure
Boilers, Hot water	Gas-Fired	<300,000 Btu/h	82% AFUE	10 CFR Part 430
		>=300,000 Btu/h and <=2,500,000 Btu/h[b]	80% E_t	10 CFR Part 431
		>2,500,000 Btu/h[c]	82% E_c	

a. Annual Fuel Utilization Efficiency (AFUE), Thermal efficiency (Et), Combustion efficiency (Ec)
b. Maximum capacity – min. and max. ratings as provided for and allowed by the units controls
c. These requirements apply to boilers with rated input of 8 MMBtu/h or less that are not packaged boilers and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers

High Efficiency

The high efficiency scenario assumes a gas-fired boiler that exceeds the efficiency levels required by Massachusetts State Building Code or federal code whichever has a higher value

Hours

Not applicable.

Measure Life

The measure life is 25 years.[694]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Condensing Boiler <= 300 mbh (.90 TE)	NB, EUL	All	1.00	1.00	n/a	n/a	n/a	n/a
Condensing Boiler 301-499 mbh (.90 TE)	NB, EUL	All	1.00	1.00	n/a	n/a	n/a	n/a
Condensing Boiler 500-999 mbh (.90 TE)	NB, EUL	All	1.00	1.00	n/a	n/a	n/a	n/a
Condensing Boiler 1000-1700 mbh (.90 TE)	NB, EUL	All	1.00	1.00	n/a	n/a	n/a	n/a
Condensing Boiler 1701+ mbh (.90 TE)	NB, EUL	All	1.00	1.00	n/a	n/a	n/a	n/a
Condensing Boiler <= 300 mbh (.95 TE)	NB, EUL	All	1.00	1.00	n/a	n/a	n/a	n/a

[693] Adapted from 2012 International Energy Conservation Code; Table C403.2.3(5).
[694] ASHRAE Applications Handbook (2003); Page 36.3.

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

HVAC – Boiler Reset Controls

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Boiler Reset Controls are devices that automatically control boiler water temperature based on outdoor or return water temperature using a software program.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC
Measure Type: Heating
Core Initiative: C&I Existing Building Retrofit, C&I Small Business

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[695].

Savings for Boiler Reset Controls

Measure Name	ΔMMBtu
Boiler Reset Control	35.5

Baseline Efficiency

The baseline efficiency case is a boiler without reset controls.

High Efficiency

The high efficiency case is a boiler with reset controls.

Hours

Not applicable.

Measure Life

The measure life is 15 years.[696]

[695] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks; the GDS Study assumes 710.46 MMBTU base use with 5% savings factor.
[696] ACEEE (2006). *Emerging Technologies Report: Advanced Boiler Controls*. Prepared for ACEEE; Page 2

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Boiler Reset Controls	Large Retrofit, Small Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

HVAC – Combo Water Heater/Boiler

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: This measure promotes the installation of a combined high-efficiency boiler and water heating unit. Combined boiler and water heating systems are more efficient than separate systems because they eliminate the standby heat losses of an additional tank.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC, Hot Water
Measure Type: Heating
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[697].

Savings for Combo Condensing Boiler/Water Heater

Measure Name	ΔMMBtu
Combo Condensing Boiler/Water Heater 90%	24.6
Combo Condensing Boiler/Water Heater 95%	31.8

Baseline Efficiency

The baseline efficiency case is a standard efficiency gas-fired storage tank hot water heater with a separate standard efficiency boiler for space heating purposes.

High Efficiency

The high efficiency case is either a condensing, integrated water heater/boiler with an AFUE of >=90% or AFUE>=95%.

Hours

Not applicable.

Measure Life

The measure life is 20 years.[698]

[697] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Combo Condensing Boiler/Water Heater 90%	NB, EUL	All	1.00	1.00	n/a	n/a	n/a	n/a
Combo Condensing Boiler/Water Heater 95%	NB, EUL	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

[698] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks.

HVAC – Condensing Unit Heaters

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a condensing gas-fired unit heater for space heating with capacity up to 300 MBH and minimum combustion efficiency of 90%.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC
Measure Type: Heating
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[699].

Savings for Condensing Unit Heater

Measure Name	ΔMMBtu
Condensing Unit Heater <= 300 mbh	40.9

Baseline Efficiency

The baseline efficiency case is a standard efficiency gas fired unit heater with minimum combustion efficiency of 80%, interrupted or intermittent ignition device (IID), and either power venting or an automatic flue damper.[700] As a note, the baseline efficiency referenced applies to 2016. Baseline requirements for 2017 and on have not been finalized.

High Efficiency

The high efficiency case is a condensing gas unit heater with 90% AFUE or greater.

Hours

Not applicable.

[699] NYSERDA Deemed Savings Database (Rev 11); Measure Name: A.UNIT-HEATER-COND.<300000.CI._._.N. The database provides savings of 204.6 MMBtu per million BTU/hr of heater input capacity. Assume average unit size of 200,000 BTU capacity.
[700] 2012 International Energy Conservation Code

Measure Life

The measure life is 18 years.[701]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Condensing Unit Heater <= 300 mbh	NB, EUL	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

[701] Ecotrope, Inc. (2003). *Natural Gas Efficiency and Conservation Measure Resource Assessment for the Residential and Commercial Sectors*. Prepared for the Energy Trust of Oregon.

HVAC – Furnaces

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The installation of a high efficiency natural gas warm air furnace with an electronically commutated motor (ECM) for the fan. High efficiency furnaces are better at converting fuel into direct heat and better insulated to reduce heat loss. ECM fan motors significantly reduce fan motor electric consumption as compared to both shaped-pole and permanent split capacitor motors.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: Electric
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC
Measure Type: Heating
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[702].

Savings for Furnaces

Measure Name	ΔMMBtu
Furnace w/ECM 95%	5.7
Furnace w/ECM 97%	6.7

Baseline Efficiency

The baseline efficiency assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. The deemed savings methodology for this measure does not require specific baseline data, but the baseline information is provided here for use in the future if this is converted to a deemed calculated measure.

As described in the Massachusetts State Building Code, energy efficiency must be met via compliance with the relevant International Energy Conservation Code (IECC) 2012. The table below details the specific efficiency requirements by equipment type and capacity. Baseline requirements for 2017 and on have not been finalized.

[702] DNV-GL (2015). *Recalculation of Prescriptive Program Gas Furnace Savings Using New Baseline.* Prepared for Massachusetts Energy Efficiency Program Administrators & Massachusetts Energy Efficiency Advisory Council.

Baseline Efficiency Requirements for Gas-Fired Furnaces[703]

Equipment Type	Size Category (Input)	Minimum Efficiency (2016)
Warm air furnaces, gas fired	< 225,000 Btu/h	85% AFUE

High Efficiency

The high efficiency scenario assumes either a gas-fired furnace equal or higher than 95% AFUE or 97 AFUE.

Hours

Not applicable.

Measure Life

The measure life is 18 years.[704]

Secondary Energy Impacts

High efficiency furnaces equipped with ECM fan motors also save electricity from reduced fan energy requirements. The reduction of electric use is 168 kWh and 0.124 kW[705]. See HVAC – Furnace Fan Motors (ECM) in the Residential section.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Furnace w/ECM 95%	NB, EUL	All	1.00	1.00	1.00	1.00	0.00	0.16
Furnace w/ECM 97%	NB, EUL	All	1.00	1.00	1.00	1.00	0.00	0.16

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

[703] Agreed upon value with EEAC consultants
[704] ASHRAE Applications Handbook (2003); Page 36.3.
[705] The Cadmus Group, Inc. (2012). *Brushless Fan Motors Impact Evaluation*. Prepared for: The Electric and Gas Program Administrators of Massachusetts

HVAC – Infrared Heaters

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The installation of a gas-fired low intensity infrared heating system in place of unit heater, furnace, or other standard efficiency equipment. Infrared heating uses radiant heat as opposed to warm air to heat buildings. In commercial environments with high air exchange rates, heat loss is minimal because the space's heat comes from surfaces rather than air.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC
Measure Type: Heating
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[706].

Savings for Infrared Heaters

Measure Name	ΔMMBtu
Infrared Heaters	12.0

Baseline Efficiency

The baseline efficiency case is a standard efficiency gas-fired unit heater with combustion efficiency of 80%.

High Efficiency

The high efficiency case is a gas-fired low-intensity infrared heating unit.

Hours

Not applicable.

Measure Life

The measure life is 17 years.[707]

[706] KEMA (2013). *Impact Evaluation of 2011 Prescriptive Gas Measures.* Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council; Page 1-5.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Infrared Heaters	NB, EUL	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

[707] Nexant (2006). *DSM Market Characterization Report*. Prepared for Questar Gas.

HVAC – Thermostats

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a programmable thermostat with the ability to adjust heating or air-conditioning operating times according to a pre-set schedule to meet occupancy needs and minimize redundant HVAC operation.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC
Measure Type: Controls
Core Initiative: C&I Existing Building Retrofit, C&I Small Business, C&I Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[708,709]

Savings for Programmable Thermostats

Measure Name	Core Initiative	PA	ΔMMBtu
Programmable Thermostat	Large Retrofit	All	3.2
Programmable Thermostat	Small Retrofit	All	3.2
Programmable Thermostat	C&I MF Retrofit	All	2.3

Baseline Efficiency

The baseline efficiency case is an HVAC system using natural gas to provide space heating without a programmable thermostat.

High Efficiency

The high efficiency case is an HVAC system using natural gas to provide space heating with a 7-day programmable thermostat installed.

Hours

Not applicable.

[708] DNV GL (2015) *2013 Massachusetts Prescriptive Gas Thermostat Evaluation Study & Programmable Thermostat Decision Memo.* Prepared for the Massachusetts Energy Efficiency Program Administrators..
[709] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis. Page 18-2* Prepared for Massachusetts Program Administrators

Measure Life

The measure life is 15 years.[710]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Programmable Thermostat	Large Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Programmable Thermostat	Small Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Programmable Thermostat	C&I MF Retrofit	All	1.00	0.60	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

[710] Environmental Protection Agency (2010). *Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat*.

HVAC – Duct Sealing and Insulation

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: For existing ductwork in non-conditioned spaces, seal and insulate ductwork. This could include replacing un-insulated flexible duct with rigid insulated ductwork or sealing leaky fixed ductwork with mastic or aerosol and installing 1" – 2" of duct-wrap insulation.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC
Measure Type: Ducting
Core Initiative: C&I Existing Building Retrofit, C&I Small Business, C&I Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu * Unit$$

Where:

Unit	=	Number of square feet of ductwork treated
ΔMMBtu	=	Average annual MMBtu savings per unit: 0.13[711]

Baseline Efficiency

The baseline efficiency case is existing, non-sealed (leaky) and un-insulated ductwork in unconditioned spaces (e.g. attic or basement)

High Efficiency

The high efficiency condition is air sealed and insulated ductwork in unconditioned spaces.

Hours

Not Applicable.

Measure Life

The measure life is 20 years.[712]

[711] National Grid Staff Estimate (2010) MA SBS-DI Duct Sealing and Insulation Scenario and Deemed Savings.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Duct Sealing and Insulation	Large Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Duct Sealing and Insulation	Small Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Duct Sealing and Insulation	C&I MF Retrofit	All	1.00	0.60	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

[712] National Grid Staff Estimate (2010). MA SBS-DI Duct Sealing and Insulation Scenario and Deemed Savings.

HVAC – Pipe Wrap (Heating)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Install insulation on steam piping located in non-conditioned spaces.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC
Measure Type: Insulation
Core Initiative: C&I Existing Building Retrofit, C&I Small Business, C&I Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[713,714]

Savings for Steam Pipe Insulation

Measure Name	Core Initiative	PA	ΔMMBtu per linear foot
Steam Pipe Insulation, <=1.5"	Large Retrofit, Small Retrofit	All	0.21
Steam Pipe Insulation, 3"	Large Retrofit, Small Retrofit	All	0.37
Pipe Wrap (Heating)	C&I MF Retrofit	All	0.16

Baseline Efficiency

The baseline efficiency case is un-insulated steam piping in unconditioned space.

High Efficiency

The high efficiency condition is steam piping in unconditioned space with insulation installed.

Hours

Not Applicable.

Measure Life

The measure life is 15 years[715].

[713] National Grid Staff Calculation (2010). Pipe insulation for SBS DI measures 2010 Excel Workbook
[714] Savings assumptions from National Grid program vendor for Multifamily.
[715] GDS Associates, Inc (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks; table B-2a, measure

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Steam Pipe Insulation, <=1.5"	Large Retrofit, Small Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Steam Pipe Insulation, 3"	Large Retrofit, Small Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Pipe Wrap (Heating)	C&I MF Retrofit	All	1.00	0.60	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

Process – Steam Traps

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Repair or replace malfunctioning steam traps.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC
Measure Type: Steam Traps
Core Initiative: C&I Existing Building Retrofit, C&I Small Business

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[716]:

Savings for Steam Traps

Measure Name	ΔMMBtu
Steam Trap - Prescriptive	25.7

Baseline Efficiency

The baseline efficiency case is a failed steam trap.

High Efficiency

The high efficiency case is a repaired or replaced steam trap.

Hours

Not applicable.

Measure Life

The measure life is 6 years.[717]

[716] National Grid (2008). National Grid 2008 Steam Trap Savings Calculation. Based on historical steam trap surveys steam losses in lbs/hr are found using "Boiler Efficiency Institute (1987). *Steam Efficiency Improvement*.; Page 34, Table 4.1 under Steam Leak Rate Through Holes. Average loss rate for all trap sizes 1/32" to 1/4" for low steam pressures (5 psig and 10 psig) and high pressures (50 psig and 100 psig). Assume trap failure effective for 540 EFLH per year. Determine to equivalent therms per year and factor for frequency encountered = [80% * (78.50 + 111.46)/2] + [20% * (1,108.04 + 1,982.18)/2] = 385.01 BTU/trap-year. Assume that 50% of traps fail in the open position and savings is grossed up by the efficiency of the boiler supplying the steam of (inverse of 75%). Net savings is 257 therms per trap.
[717] DNV GL (2015) *Massachusetts 2013 Prescriptive Gas Impact Evaluation – Steam Trap Evaluation Phase I.* Prepared for Massachusetts Energy Efficiency Program Administrators & Massachusetts Energy Efficiency Advisory Council.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Steam Trap - Prescriptive	Large Retrofit, Small Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

Water Heating – Pipe Wrap (Water Heating)

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Install insulation on hot water located in non-conditioned spaces.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC
Measure Type: Insulation
Core Initiative: C&I Existing Building Retrofit, C&I Small Business, C&I Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[718,719]

Savings for Hot Water Insulation

Measure Name	Core Initiative	PA	ΔMMBtu per linear foot
Hot Water Pipe Insulation, <=1.5"	Large Retrofit, Small Retrofit	All	0.21
Hot Water Pipe Insulation, 2"	Large Retrofit, Small Retrofit	All	0.36
Pipe Wrap (Water Heating)	C&I MF Retrofit	All	1.14

Baseline Efficiency

The baseline efficiency case is un-insulated hot water piping in unconditioned space.

High Efficiency

The high efficiency condition is hot water piping in unconditioned space with insulation installed.

Hours

Not Applicable.

Measure Life

The measure life is 15 years[720].

[718] National Grid Staff Calculation (2010). Pipe insulation for SBS DI measures 2010 Excel Workbook
[719] The Cadmus Group (2012). *Massachusetts Multifamily Program Impact Analysis July 2012 – Revised May 2013.* Prepared for Massachusetts Program Administrators.
[720] GDS Associates, Inc (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks; table B-2a, measure

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Hot Water Pipe Insulation, <=1.5"	Large Retrofit, Small Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Hot Water Pipe Insulation, 2"	Large Retrofit, Small Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Pipe Wrap (Water Heating)	C&I MF Retrofit	All	1.00	0.60	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

Water Heating – Indirect Water Heater

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Indirect water heaters use a storage tank that is heated by the main boiler. The energy stored by the water tank allows the boiler to turn off and on less often, saving considerable energy.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: Hot Water
Measure Type: Water Heater
Core Initiative: C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[721].

Savings for Indirect Water Heaters

Measure Name	ΔMMBtu
Indirect Water Heater - Upstream	19.0

Baseline Efficiency

The baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. As described in the MA State Building Code, energy efficiency must be met via compliance with the relevant International Energy Conservation Code (IECC) 2012. The assumed efficiency slightly exceeds the minimum required by code to reflect the typical baseline unit available in the marketplace. Baseline requirements for 2017 and on have not been finalized.

For indirect water heaters the baseline is a hot water boiler operating at 78% recovery efficiency. Additionally a baseline storage water heater was assumed for purposed of estimating standby losses.[722]

High Efficiency

The high efficiency scenario is an indirect water heater with a Combined Appliance Efficiency (CAE) of 85% or greater.

[721] KEMA (2013). *Impact Evaluation of 2011 Prescriptive Gas Measures.* Prepared for Massachusetts Energy Efficiency Program Administrators; Page 1-6
[722] Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010; Energy Conservation standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters: Final Rule, Federal Register, 75 FR 20112, April 16, 2010.

Hours

Not applicable.

Measure Life

The measure life is 15 years[723].

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Indirect Water Heater	EUL	All	1.00	1.00	n/a	n/a	n/a	n/a

<u>In-Service Rates</u>
All installations have 100% in service rate since programs include verification of equipment installations.

<u>Realization Rates</u>
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

<u>Coincidence Factors</u>
Not applicable for this measure since no electric savings are claimed.

[723] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks; Appendix A-2.

Water Heating – Tankless Water Heater

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Tankless water heaters circulate water through a heat exchanger to be heated for immediate use, eliminating the standby heat loss associated with a storage tank.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: Hot water
Measure Type: Water Heater
Core Initiative: C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed[724].

Savings for Tankless Water Heaters

Measure Name	ΔMMBtu
Tankless Water Heater 0.82 - Upstream	6.6
Tankless Water Heater 0.94 - Upstream	9.0

Baseline Efficiency

The baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. As described in the MA State Building Code, energy efficiency must be met via compliance with the relevant International Energy Conservation Code (IECC) 2012. The assumed efficiency slightly exceeds the minimum required by code to reflect the typical baseline unit available in the marketplace. Baseline requirements for 2017 and on have not been finalized.

For on-demand tankless water heaters the baseline is a code-compliant gas-fired storage water heater with EF = 0.61.[725]

[724] Title 10, Code of Federal Regulations, Part 430-Energy Conservation Program for Consumer Products, Subpart C – Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010; Energy Conservation standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters; Final Rule, Federal Register, 75 FR 20112, April 16, 2010.
[725] Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010; Energy Conservation standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters: Final Rule, Federal Register, 75 FR 20112, April 16, 2010.

High Efficiency

The high efficiency equipment is either a gas-fired instantaneous hot water heater with an Energy Factor of at least 0.82 or 0.94.

Hours

Not applicable.

Measure Life

The measure life is 20 years[726].

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Tankless Water Heater 0.82 - Upstream	EUL	All	1.00	1.00	n/a	n/a	n/a	n/a
Tankless Water Heater 0.94 - Upstream	EUL	All	1.00	1.00	n/a	n/a	n/a	n/a

<u>In-Service Rates</u>
All installations have 100% in service rate since programs include verification of equipment installations.

<u>Realization Rates</u>
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

<u>Coincidence Factors</u>
Not applicable for this measure since no electric savings are claimed.

[726] Hewitt, D. Pratt, J. & Smith, G. (2005). *Tankless Gas Water Heaters: Oregon Market Status*. Prepared for the Energy Trust of Oregon.

Water Heating – Condensing Water Heater

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a high-efficiency gas-fired water heater.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: Hot Water
Measure Type: Water Heater
Core Initiative: C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed[727].

Savings for Condensing Water Heaters

Measure Name	ΔMMBtu
Condensing Water Heater 0.95 - Upstream	25.0

Baseline Efficiency

The baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. As described in the MA State Building Code, energy efficiency must be met via compliance with the relevant International Energy Conservation Code (IECC) 2012. The assumed efficiency slightly exceeds the minimum required by code to reflect the typical baseline unit available in the marketplace. Baseline requirements for 2017 and on have not been finalized.

For condensing stand-alone water heaters, the assumed baseline is a stand-alone tank water heater with a thermal efficiency of 80%.[728]

High Efficiency

The high efficiency case is a condensing stand alone commercial water heater with a thermal efficiency of 95% or greater and a capacity between 75,000 Btu and 300,000 Btu.

[727] Title 10, Code of Federal Regulations, Part 430-Energy Conservation Program for Consumer Products, Subpart C – Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010; Energy Conservation standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters; Final Rule, Federal Register, 75 FR 20112, April 16, 2010.
[728] Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010; Energy Conservation standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters: Final Rule, Federal Register, 75 FR 20112, April 16, 2010.

Hours

Not applicable.

Measure Life

The measure life is 15 years[729].

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Condensing Water Heater 0.94 - Upstream	EUL	All	1.00	1.00	n/a	n/a	n/a	n/a

<u>In-Service Rates</u>
All installations have 100% in service rate since programs include verification of equipment installations.

<u>Realization Rates</u>
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

<u>Coincidence Factors</u>
Not applicable for this measure since no electric savings are claimed.

[729] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks; Page 2 of Appendix B-2, measure GDS C-WH-4. The GDS study references "ACEEE (2004). *Emerging technologies and practices*; W1 - pg 46."

Water Heating – Stand Alone Water Heater

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a high-efficiency gas-fired water heater.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: Hot Water
Measure Type: Water Heater
Core Initiative: C&I Initial Purchase & End of Useful Life

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[730].

Savings for Stand Alone Water Heaters

Measure Name	ΔMMBtu
Stand Alone Water Heater 0.67 - Upstream	2.4

Baseline Efficiency

The baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. As described in the MA State Building Code, energy efficiency must be met via compliance with the relevant International Energy Conservation Code (IECC) 2012. The assumed efficiency slightly exceeds the minimum required by code to reflect the typical baseline unit available in the marketplace. Baseline requirements for 2017 and on have not been finalized.

For free-standing water heaters the baseline is a code-compliant gas-fired storage water heater with EF = 0.59.[731]

High Efficiency

The high efficiency case is an ENERGY STAR® gas-fired freestanding hot water heater with an Energy Factor of at least 0.67 and a nominal input of 75,000 BTU/hour or less.

[730] Title 10, Code of Federal Regulations, Part 430-Energy Conservation Program for Consumer Products, Subpart C – Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010; Energy Conservation standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters; Final Rule, Federal Register, 75 FR 20112, April 16, 2010.
[731] Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010; Energy Conservation standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters: Final Rule, Federal Register, 75 FR 20112, April 16, 2010.

Hours

Not applicable.

Measure Life

The measure life is 13 years[732].

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Stand Alone Water Heater 0.67 - Upstream	EUL	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

[732] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks; Appendix A-2.

Water Heating – Pre-Rinse Spray Valve

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Retrofitting existing standard spray nozzles in locations where service water is supplied by natural gas fired hot water heater with new low flow pre-rinse spray nozzles with an average flow rate of 1.6 GPM.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: C&I Water, C&I Sewer
Sector: Commercial, Industrial
Market: Retrofit
End Use: Hot Water
Measure Type: Flow Control
Core Initiative: C&I Existing Building Retrofit, C&I Small Business

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[733].

Savings for Pre-Rise Spray Valves

Measure Name	ΔMMBtu
Pre-Rinse Spray Valve	11.4

Baseline Efficiency

The baseline efficiency case is an existing efficiency spray valve.

High Efficiency

The high efficiency case is a low flow pre-rinse spray valve with an average flow rate of 1.6 GPM.

Hours

Not applicable.

Measure Life

The measure life is 8 years.[734]

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[733] DNV-GL (2014). *Impact Evaluation Massachusetts Prescriptive Gas Pre-Rinse Spray Valve*. Prepared for the MA Gas PAs and MA EEAC.
[734] Ibid.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings[735]
C&I Water	C&I water savings	6,410 gallons/unit
C&I Sewer	C&I sewer water savings	6,410 gallons/unit

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Pre-Rinse Spray Valve	Large Retrofit, Small Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

[735] Ibid.

Water Heating – Low-Flow Shower Heads

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a low flow showerhead with a flow rate of 1.5 GPM or less in a commercial setting with service water heated by natural gas.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: C&I Water, C&I Sewer
Sector: Commercial
Market: Retrofit
End Use: Hot water
Measure Type: Flow Control
Core Initiative: C&I Existing Building Retrofit, C&I Small Business, C&I Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed[736,737]

Savings for Low-Flow Shower Heads

Measure Name	Core Initiative	PA	ΔMMBtu
Low-Flow Showerhead	Large Retrofit	All	2.65
Low-Flow Showerhead	Small Retrofit	All	2.65
Low-Flow Showerhead	C&I MF Retrofit	All	1.14

Baseline Efficiency

The baseline efficiency case is a 2.5 GPM showerhead.

High Efficiency

The high efficiency case is a 1.5 GPM showerhead.

Hours

Not Applicable.

[736] Department of Energy Calculator for Faucets & Showerheads. http://energy.gov/eere/femp/energy-cost-calculator-faucets-and-showerheads-0. Subsequently revised for lower anticipated hot water use. Baseline values were used with the exception of hot water use. This was changed from 100% to 50%.
[737] The Cadmus Group (2012). *Massachusetts Multifamily Program Impact Analysis July 2012 – Revised May 2013.* Prepared for Massachusetts Program Administrators.

Measure Life

The measure life is 10 years in the Large Retrofit and Small Retrofit initiatives.[738] The measure life is 7 years in the C&I MF Retrofit initiative[739].

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Core Initiative	Description	Savings
C&I Water	Large Retrofit, Small Retrofit	C&I water savings	7,300 gallons/unit[740]
C&I Sewer	Large Retrofit, Small Retrofit	C&I sewer water savings	7,300 gallons/unit[741]
Residential Water	C&I MF Retrofit	Multifamily water savings for low-flow showerheads	2,165 Gallons/Unit[742]

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Low-Flow Showerhead	Large Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Low-Flow Showerhead	Small Retrofit	All	1.00	1.00	n/a	n/a	n/a	n/a
Low-Flow Showerhead	C&I MF Retrofit	All	1.00	0.60	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

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[738] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks; Table B-2a, measure C-WH-15.
[739] MA Common Assumptions
[740] Federal Energy Management Program (2011). Energy Cost Calculator for Faucets and Showerheads. Accessed on 10/12/2011.
[741] Federal Energy Management Program (2011). Energy Cost Calculator for Faucets and Showerheads. Accessed on 10/12/2011.
[742] Staff calculation based on methodology from The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts

Water Heating – Faucet Aerator

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Installation of a faucet aerator with a flow rate of 1.5 GPM or less on an existing faucet with high flow in a commercial setting with service water heated by natural gas.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: C&I Water, C&I Sewer
Sector: Commercial
Market: Retrofit
End Use: Hot water
Measure Type: Flow Control
Core Initiative: C&I Existing Building Retrofit, C&I Small Business, C&I Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results[743,744]

Savings for Faucet Aerators

Measure Name	Core Initiative	PA	ΔMMBtu
Faucet Aerator	Large Retrofit	All	1.7
Faucet Aerator	Small Retrofit	All	1.7
Faucet Aerator	C&I MF Retrofit	All	0.86

Baseline Efficiency

The baseline efficiency case is a 2.2 GPM faucet.

High Efficiency

The high efficiency case is a faucet with 1.5 GPM or less aerator installed.

Hours

The savings estimates for this measure are determined empirically in terms of units installed and so the equivalent heating full load hours are not directly used, however, the calculator used to determine the deemed savings uses a default operation of 30 minutes a day, 260 days a year.

[743] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks; Table B-2a, measure C-WH-16.
[744] The Cadmus Group (2012). *Massachusetts Multifamily Program Impact Analysis July 2012 – Revised May 2013*. Prepared for Massachusetts Program Administrators.

Measure Life

The measure life is 10 years in the Large Retrofit and Small Retrofit initiatives.745 The measure life is 7 years in the C&I MF Retrofit initiative[746].

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Core Initiative	Description	Savings[747]
C&I Water	Large Retrofit, Small Retrofit	C&I water savings	5,460 gallons/unit
C&I Sewer	Large Retrofit, Small Retrofit	C&I sewer water savings	5,460 gallons/unit
Residential Water	C&I MF Retrofit	Residential water savings for faucet aerators [748]	332 Gallons/Unit

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Faucet Aerator	Large Retrofit	All	1.00	1.00	1.00	1.00	n/a	n/a
Faucet Aerator	Small Retrofit	All	1.00	1.00	1.00	1.00	n/a	n/a
Faucet Aerator	C&I MF Retrofit	All	1.00	0.60	1.00	1.00	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates
All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

[745] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks; Table B-2a, measure C-WH-15.
[746] MA Common Assumptions
[747] Federal Energy Management Program (2011). Energy Cost Calculator for Faucets and Showerheads. Accessed on 10/12/2011.
[748] NMR Group, Inc., Tetra Tech (2011). *Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation,* Prepared for Massachusetts Program Administrators

Whole Building - Building Operator Certification

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: Building Operator Certification (BOC) is a nationally recognized training program designed to educate facilities personnel in the energy and resource efficient operation and maintenance of building systems. Savings include only operations, maintenance and controls savings.
Primary Energy Impact: Gas
Secondary Energy Impact: Project Specific
Non-Energy Impact: Project Specific
Sector: Commercial & Industrial
Market: Retrofit
End Use: All
Measure Type: Custom
Core Initiative: C&I Existing Building Retrofit

Algorithms for Calculating Primary Energy Impact

Savings are deemed based on study results[749]

Savings for Building Operator Certification

Measure Name	ΔMMBtu/SF/Student
BOC – O&M Only	0.0007
BOC – O&M plus Capital Upgrades	0.0011

Baseline Efficiency

No BOC training

High Efficiency

Completion and certification in a BOC level I or level II training course.

Measure Life

Measure life of 5 years[750]

Secondary Energy Impacts

There are no secondary energy impacts.

[749] Navigant Consulting (2015). *Comprehensive Review of Non-Residential Training and Education Programs, with a Focus on Building Operator Certification.* Prepared for the Massachusetts Program Administrators and the Energy Efficiency Advisory Council
[750] Ibid.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
BOC Training	Large Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	1.00

In-Service Rates
n/a

Realization Rates
Realization rates are set to 100% since savings are based off of evaluation results.

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

Custom Measures

Version Date and Revision History

Effective Date: 1/1/2016
End Date: TBD

Measure Overview

Description: The Custom project track is offered for energy efficiency projects involving complex site-specific applications that require detailed engineering analysis and/or projects which do not qualify for incentives under any of the prescriptive rebate offering. Projects offered through the custom approach must pass a cost-effectiveness test based on project-specific costs and savings.
Primary Energy Impact: Natural Gas (Heating, Water Heating, or All)
Secondary Energy Impact: Project Specific
Non-Energy Impact: Project Specific
Sector: Commercial & Industrial
Market: Lost Opportunity, Retrofit
End Use: All
Measure Type: Varies
Core Initiative: C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life, C&I Existing Building Retrofit, C&I Small Business, C&I Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

Gross therm savings estimates for custom projects are calculated using engineering analysis and project-specific details. Custom analyses typically include a weather dependent load bin analysis, whole building energy model simulation, or other engineering analysis and include estimates of savings, costs, and an evaluation of the project's cost-effectiveness.

Baseline Efficiency

For Lost Opportunity projects, the baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code or industry accepted standard practice.

For retrofit projects, the baseline efficiency case is the same as the existing, or pre-retrofit, case for the facility.

High Efficiency

The high efficiency scenario is specific to the custom project and may include one or more energy efficiency measures. Energy and demand savings calculations are based on projected changes in equipment efficiencies and operating characteristics and are determined on a case-by-case basis. The project must be proven cost-effective in order to qualify for energy efficiency incentives.

Hours

All hours for custom savings analyses should be determined on a case-by-case basis.

Measure Life

For both lost-opportunity and retrofit custom applications, the measure life is determined on a case-by-case basis.

Secondary Energy Impacts

All secondary energy impacts should be determined on a case-by-case basis.

Non-Energy Impacts

All non-energy impacts should be determined on a case-by-case basis.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Core Initiative	PA	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Custom	NB, EUL	Liberty, Berkshire, Unitil	1.00	0.883	n/a	n/a	n/a	n/a
Custom	NB, EUL	Eversource (NSTAR)	1.00	0.918	n/a	n/a	n/a	n/a
Custom	NB, EUL	National Grid	1.00	0.779	n/a	n/a	n/a	n/a
Custom	NB, EUL	Columbia Gas	1.00	0.727	n/a	n/a	n/a	n/a
Custom	Large Retrofit, Small Retrofit, C&I MF Retrofit	Liberty, Berkshire, Unitil	1.00	0.883	n/a	n/a	n/a	n/a
Custom	Large Retrofit, Small Retrofit, C&I MF Retrofit	Eversource (NSTAR)	1.00	0.918	n/a	n/a	n/a	n/a
Custom	Large Retrofit, Small Retrofit, C&I MF Retrofit	National Grid	1.00	0.779	n/a	n/a	n/a	n/a
Custom	Large Retrofit, Small Retrofit, C&I MF Retrofit	Columbia Gas	1.00	0.727	n/a	n/a	n/a	n/a

In-Service Rates
All installations have 100% in service rate since programs include verification of equipment installations.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
Eversource (NSTAR), National Grid, and Columbia Gas use PA-specific results while all other Pas use the statewide average.[751].

Coincidence Factors
Not applicable for this measure since no electric savings are claimed.

[751]DNV GL & ERS (2015) *Project 43 Impact Evaluation of PY2013 Custom Gas Installations.* Prepared for Massachusetts Energy Efficiency Program Administrators & Massachusetts Energy Efficiency Advisory Council.

Appendices

Appendix A: Common Lookup Tables

Table 1: Lighting Power Densities Using the Building Area Method[752]

Building Area Type	Lighting Power Density (W/ft^2)
Automotive Facility	0.9
Convention Center	1.2
Court House	1.2
Dining: Bar Lounge/Leisure	1.3
Dining: Cafeteria/Fast Food	1.4
Dining: Family	1.6
Dormitory	1.0
Fire Stations	0.8
Exercise Center	1.0
Gymnasium	1.1
Healthcare-Clinic	1.0
Hospital	1.2
Hotel	1.0
Library	1.3
Manufacturing Facility	1.3
Motel	1.0
Motion Picture Theatre	1.2
Multi-Family	0.7
Museum	1.1
Office	0.9
Parking Garage	0.3
Penitentiary	1.0
Performing Arts Theatre	1.6
Police/Fire Station	1.0
Post Office	1.1
Religious Building	1.3
Retail	1.4
School/University	1.2
Sports Arena	1.1
Town Hall	1.1
Transportation	1.0
Warehouse	0.6
Workshop	1.4

[752] IECC 2012 Interior Lighting Power Allowances: Building Area method, Table C405.5.2(1)

Table 2: Interior Lighting Power Allowances: Space-by-Space Method[753]

Space Type	Lighting Power Density (W/ft^2)
COMMON SPACE-BY-SPACE TYPES	
Atrium – First 40 feet in height	0.03 per ft. ht.
Atrium – Above 40 feet in height	0.02 per ft. ht.
Audience/seating area – permanent	
For Auditorium	0.9
For performing arts theater	2.6
For motion picture theater	1.2
Classroom/lecture/training	1.30
Conference/meeting/multipurpose	1.2
Corridor/transition	0.7
Dining Area	
Bar/lounge/leisure dining	1.40
Family dining area	1.40
Dressing/fitting room performing arts theater	1.1
Electrical/mechanical	1.10
Food preparation	1.20
Laboratory for classrooms	1.3
Laboratory for medical/industrial/research	1.8
Lobby	1.10
Lobby for performing arts theater	3.3
Lobby for motion picture theater	1.0
Locker room	0.80
Lounge recreation	0.8
Office – enclosed	1.1
Office – open plan	1.0
Restroom	1.0
Sales area	1.6
Stairway	0.70
Storage	0.8
Workshop	1.60
Courthouse/police station/penitentiary	
Courtroom	1.90
Confinement cells	1.1
Judge chambers	1.30
Penitentiary audience seating	0.5
Penitentiary classroom	1.3
Penitentiary dining	1.1
BUILDING SPECIFIC SPACE-BY-SPACE TYPES	
Automotive – service/repair	0.70
Bank/office – banking activity area	1.5
Dormitory living quarters	1.10
Gymnasium/fitness center	

[753] IECC 2012 Interior Lighting Power Allowances: Space-by-Space Method, Table C405.5.2(2)

Space Type	Lighting Power Density (W/ft^2)
Fitness area	0.9
Gymnasium audience/seating	0.40
Playing area	1.40
Healthcare clinic/hospital	
Corridors/transition	1.00
Exam/treatment	1.70
Emergency	2.70
Public and staff lounge	0.80
Medical Supplies	1.40
Nursery	0.9
Nurse Station	1.00
Physical Therapy	0.90
Patient room	0.70
Pharmacy	1.20
Radiology/imaging	1.3
Operating room	2.20
Recovery	1.2
Lounge/recreation	0.8
Laundry – washing	0.60
Hotel	
Dining area	1.30
Guest rooms	1.10
Hotel lobby	2.10
Highway lodging dining	1.20
Highway lodging guest rooms	1.10
Library	
Stacks	1.70
Card File and cataloguing	1.10
Reading area	1.20
Manufacturing	
Corridors/transition	0.40
Detailed manufacturing	1.3
Equipment room	1.0
Extra high bay (> 50-foot floor-ceiling height)	1.1
High bay (25 – 50-foot floor-ceiling height)	1.20
Low bay (< 25-foot floor-ceiling height)	1.2
Museum	
General Exhibition	1.00
Restoration	1.70
Parking Garage – garage areas	0.2
Convention Center	
Exhibit space	1.50
Audience/seating area	0.90
Fire Stations	
Engine Room	0.80
Sleeping quarters	0.30

Space Type	Lighting Power Density (W/ft^2)
Post Office	
Sorting area	0.90
Religious building	
Fellowship hall	0.60
Audience seating	2.40
Worship pulpit/choir	2.40
Retail	
Dressing/fitting area	0.9
Mall concourse	1.6
Sales area	1.6
Sports arena	
Audience seating	0.4
Court sports area – Class 4	0.7
Court sports area – Class 3	1.2
Court sports area – Class 2	1.9
Court sports area – Class 1	3.0
Ring sports area	2.7
Transportation	
Air/train/bus baggage area	1.00
Airport concourse	0.60
Terminal – ticket counter	1.50
Warehouse	
Fine material storage	1.40
Medium/bulky material	0.60

Table 3: MassSAVE New Construction Proposed Lighting Wattage Tables

2016 MassSAVE C&I Lighting Rated Wattage Tables developed by Lighting Worksheet Team

Device Code	Device Description	Rated Watts
T5 Systems		
1F14SSE	1L2’ 14W T5/ELIG	16
1F21SSE	1L3’ 21W T5/ELIG	24
1F24HSE	1L2’ 24W T5HO/ELIG	29
1F28SSE	1L4’ 28W T5/ELIG	32
1F39HSE	1L3’ 39W T5HO/ELIG	42
1F47HSE	1L4’ 47W T5HO/ELIG	53
1F50HSE	1L4’ 50W T5HO/ELIG	58
1F54HSE	1L4’ 54W T5HO/ELIG	59
2F14SSE	2L2’ 14W T5/ELIG	32
2F21SSE	2L3’ 21W T5/ELIG	47
2F24HSE	2L2’ 24W T5HO/ELIG	52
2F28SSE	2L4’ 28W T5/ELIG	63
2F39HSE	2L3’ 39W T5HO/ELIG	85
2F47HSE	2L4’ 47W T5HO/ELIG	103
2F50HSE	2L4’ 50W T5HO/ELIG	110
2F54HSE	2L4’ 54W T5HO/ELIG	117
3F14SSE	3L2’ 14W T5/ELIG	50
3F24HSE	3L4’ T5HO/ELIG	80
3F28SSE	3L4’ 28W T5/ELIG	95
3F47HSE	3L4’ 47W T5HO/ELIG	157
3F50HSE	3L4’ 50W T5HO/ELIG	168
3F54HSE	3L4’ 54W T5HO/ELIG	177
4F14SSE	4L2’ 14W T5/ELIG	68
4F28SSE	4L4’ 28W T5/ELIG	126
4F47HSE	4L4’ 47W T5HO/ELIG	200
4F50HSE	4L4’ 50W T5HO/ELIG	215
4F54ESH	4L4’ 54W T5HO/ELEE	218
4F54HSE	4L4’ 54W T5HO/ELIG	234
5F47HSE	5L4’ 47W T5HO/ELIG	260
5F50HSE	5L4’ 50W T5HO/ELIG	278
5F54HSE	5L4’ 54W T5HO/ELIG	294
6F28SSE	6L4’ 28W T5/ELIG	189
6F47HSE	6L4’ 47W T5HO/ELIG	303
6F50HSE	6L4’ 50W T5HO/ELIG	325
6F54HSE	6L4’ 54W T5HO/ELIG	351
8F54HSE	8L4’ 54W T5HO/ELIG	468
10F54HSE	10L4’ 54W T5HO/ELIG	585
Two Foot High Efficient T8 Systems		
1F17ESN	1L2’ 17W T8EE/ELEE	17
1F17ESH	1L2’ 17W T8EE/ELEE HIGH PWR	20
1F28BXE	1L2’ F28BX/ELIG	32

Device Code	Device Description	Rated Watts
Two Foot High Efficient T8 Systems (cont.)		
2F17ESL	2L2’ 17W T8EE/ELEE LOW PWR	27
2F17ESN	2L2’ 17W T8EE/ELEE	32
2F17ESH	2L2’ 17W T8EE/ELEE HIGH PWR	40
2F28BXE	2L2’ F28BX/ELIG	63
3F17ESL	3L2’ 17W T8EE/ELEE LOW PWR	39
3F17ESN	3L2’ 17W T8EE/ELEE	46
3F17ESH	3L2’ 17W T8EE/ELEE HIGH PWR	61
3F28BXE	3L2’ F28BX/ELIG	94
1F17ESL	1L2’ 17W T8EE/ELEE LOW PWR	14
Three Foot High Efficient T8 Systems		
1F25ESL	1L3’ 25W T8EE/ELEE LOW PWR	21
1F25ESN	1L3’ 25W T8EE/ELEE	24
1F25ESH	1L3’ 25W T8EE/ELEE HIGH PWR	30
2F25ESL	2L3’ 25W T8EE/ELEE LOW PWR	40
2F25ESN	2L3’ 25W T8EE/ELEE	45
2F25ESH	2L3’ 25W T8EE/ELEE HIGH PWR	60
3F25ESL	3L3’ 25W T8EE/ELEE LOW PWR	58
3F25ESN	3L3’ 25W T8EE/ELEE	67
3F25ESH	3L3’ 25W T8EE/ELEE HIGH PWR	90
Four Foot T8 High Efficient / Reduce Wattage Systems		
1F25EEH	1L4’ 25W T8EE/ELEE HIGH PWR	30
1F25EEE	1L4’ 25W T8EE/ELEE	22
1F25EEL	1L4’ 25W T8EE/ELEE LOW PWR	19
2F25EEH	2L4’ 25W T8EE/ELEE HIGH PWR	57
2F25EEE	2L4’ 25W T8EE/ELEE	43
2F25EEL	2L4’ 25W T8EE/ELEE LOW PWR	37
3F25EEH	3L4’ 25W T8EE/ELEE HIGH PWR	86
3F25EEE	3L4’ 25W T8EE/ELEE	64
3F25EEL	3L4’ 25W T8EE/ELEE LOW PWR	57
4F25EEH	4L4’ 25W T8EE/ELEE HIGH PWR	111
4F25EEE	4L4’ 25W T8EE/ELEE	86

Device Code	Device Description	Rated Watts
Four Foot T8 High Efficient / Reduce Wattage Systems (cont.)		
4F25EEL	4L4’ 25W T8EE/ELEE LOW PWR	75
1F28EEH	1L4’ 28W T8EE/ELEE HIGH PWR	33
1F28EEE	1L4’ 28W T8EE/ELEE	24
1F28EEL	1L4’ 28W T8EE/ELEE LOW PWR	22
2F28EEH	2L4’ 28WT8EE/ELEE HIGH PWR	64
2F28EEE	2L4’ 28W T8EE/ELEE	48
2F28EEL	2L4’ 28W T8EE/ELEE LOW PWR	42
3F28EEH	3L4’ 28W T8EE/ELEE HIGH PWR	96
3F28EEE	3L4’ 28W T8EE/ELEE	72
3F28EEL	3L4’ 28W T8EE/ELEE LOW PWR	63
4F28EEH	4L4’ 28W T8EE/ELEE HIGH PWR	126
4F28EEE	4L4’ 28W T8EE/ELEE	94
4F28EEL	4L4’ 28W T8EE/ELEE LOW PWR	83
1F30EEH	1L4’ 30W T8EE/ELEE HIGH PWR	36
1F30EEE	1L4’ 30W T8EE/ELEE	26
1F30EEL	1L4’ 30W T8EE/ELEE LOW PWR	24
2F30EEH	2L4’ 30WT8EE/ELEE HIGH PWR	69
2F30EEE	2L4’ 30W T8EE/ELEE	52
2F30EEL	2L4’ 30W T8EE/ELEE LOW PWR	45
3F30EEH	3L4’ 30W T8EE/ELEE HIGH PWR	103
3F30EEE	3L4’ 30W T8EE/ELEE	77
3F30EEL	3L4’ 30W T8EE/ELEE LOW PWR	68
4F30EEH	4L4’ 30W T8EE/ELEE HIGH PWR	133
4F30EEE	4L4’ 30W T8EE/ELEE	101
4F30EEL	4L4’ 30W T8EE/ELEE LOW PWR	89
1F32EEH	1L4’ 32W T8EE/ELEE HIGH PWR	38
1F32EEE	1L4’ 32W T8EE/ELEE	28
1F32EEL	1L4’ 32W T8EE/ELEE LOW PWR	25
1F32SSE	1L4’ 32W T8/ELIG	30
2F32SSE	2L4’ 32W T8/ELIG	60
5F32EEH	5L4’ 32W T8EE/ELEE HIGH PWR	182
6F28EEE	6L4’ 28W T8EE/ELEE	144

Device Code	Device Description	Rated Watts
Four Foot T8 High Efficient / Reduce Wattage Systems (cont.)		
6F28EEH	6L4’ 28W T8EE/ELEE HIGH PWR	192
6F28EEL	6L4’ 28W T8EE/ELEE LOW PWR	126
6F30EEE	6L4’ 30W T8EE/ELEE	154
6F30EEL	6L4’ 30W T8EE/ELEE LOW PWR	136
7F32EEH	7L4’ 32W T8EE/ELEE HIGH PWR	250
2F32EEH	2L4’ 32W T8EE/ELEE HIGH PWR	73
2F32EEE	2L4’ 32W T8EE/ELEE	53
2F32EEL	2L4’ 32W T8EE/ELEE LOW PWR	47
3F32EEH	3L4’ 32W T8EE/ELEE HIGH PWR	109
3F32EEE	3L4’ 32W T8EE/ELEE	82
3F32EEL	3L4’ 32W T8EE/ELEE LOW PWR	72
4F32EEH	4L4’ 32W T8EE/ELEE HIGH PWR	141
4F32EEE	4L4’ 32W T8EE/ELEE	107
4F32EEL	4L4’ 32W T8EE/ELEE LOW PWR	95
6F32EEH	6L4’ 32W T8EE/ELEE HIGH PWR	218
6F32EEE	6L4’ 32W T8EE/ELEE	168
6F32EEL	6L4’ 32W T8EE/ELEE LOW PWR	146
Eight Foot T8 Systems		
1F59SSE	1L8’ T8/ELIG	60
1F80SSE	1L8’ T8 HO/ELIG	85
2F59SSE	2L8’ T8/ELIG	109
2F59SSL	2L8’ T8/ELIG LOW PWR	100
2F80SSE	2L8’ T8 HO/ELIG	160
LED Lighting Fixtures		
1L002	2 WATT LED	2
1L003	3 WATT LED	3
1L004	4 WATT LED	04
1L005	5 WATT LED	05
1L006	6 WATT LED	06
1L007	7 WATT LED	07
1L008	8 WATT LED	08
1L009	9 WATT LED	09
1L010	10 WATT LED	10
1L011	11 WATT LED	11
1L012	12 WATT LED	12

Device Code	Device Description	Rated Watts
LED Lighting Fixtures (cont.)		
1L013	13 WATT LED	13
1L014	14 WATT LED	14
1L015	15 WATT LED	15
1L016	16 WATT LED	16
1L017	17 WATT LED	17
1L018	18 WATT LED	18
1L019	19 WATT LED	19
1L020	20 WATT LED	20
1L021	21 WATT LED	21
1L022	22 WATT LED	22
1L023	23 WATT LED	23
1L024	24 WATT LED	24
1L025	25 WATT LED	25
1L026	26 WATT LED	26
1L027	27 WATT LED	27
1L028	28 WATT LED	28
1L029	29 WATT LED	29
1L030	30 WATT LED	30
1L031	31 WATT LED	31
1L032	32 WATT LED	32
1L033	33 WATT LED	33
1L034	34 WATT LED	34
1L035	35 WATT LED	35
1L036	36 WATT LED	36
1L037	37 WATT LED	37
1L038	38 WATT LED	38
1L039	39 WATT LED	39
1L040	40 WATT LED	40
1L041	41 WATT LED	41
1L042	42 WATT LED	42
1L043	43 WATT LED	43
1L044	44 WATT LED	44
1L045	45 WATT LED	45
1L046	46 WATT LED	46
1L047	47 WATT LED	47
1L048	48 WATT LED	48
1L049	49 WATT LED	49
1L050	50 WATT LED	50
1L053	53 WATT LED	53
1L055	55 WATT LED	55
1L060	60 WATT LED	60
1L063	63 WATT LED	63
1L071	71 WATT LED	71
1L070	70 WATT LED	70
1L073	73 WATT LED	73

Device Code	Device Description	Rated Watts
LED Lighting Fixtures (cont.)		
1L075	75 WATT LED	75
1L080	80 WATT LED	90
1L085	85 WATT LED	85
1L090	90 WATT LED	90
1L095	95 WATT LED	95
1L100	100 WATT LED	100
1L101	101 WATT LED	101
1L106	106 WATT LED	106
1L107	107 WATT LED	107
1L116	116 WATT LED	116
1L120	120 WATT LED	120
1L125	125 WATT LED	125
1L130	130 WATT LED	130
1L131	131 WATT LED	131
1L135	135 WATT LED	135
1L139	139 WATT LED	139
1L140	140 WATT LED	140
1L145	145 WATT LED	145
1L150	150 WATT LED	150
1L155	155 WATT LED	155
1L160	160 WATT LED	160
1L164	164 WATT LED	164
1L165	165 WATT LED	165
1L170	170 WATT LED	170
1L175	175 WATT LED	175
1L180	180 WATT LED	180
1L185	185 WATT LED	185
1L186	186 WATT LED	186
1L190	190 WATT LED	190
1L200	200 WATT LED	200
1L204	204 WATT LED	204
1L205	205 WATT LED	205
1L210	210 WATT LED	210
1L211	211 WATT LED	211
1L220	220 WATT LED	220
1L233	233 WATT LED	233
1L235	235 WATT LED	235
1L237	237 WATT LED	237
1L240	240 WATT LED	240
1L256	256 WATT LED	256
1L279	279 WATT LED	279
1LED015	15 Watt LED	15
MH Track Lighting		
1M0100E	100W MH SPOT	111
1M0150E	150W MH SPOT	162

Device Code	Device Description	Rated Watts
Six Foot Systems		
1F72HSE	1L6' T8HO/ELIG	80
Incandescent Lamps		
1I0015	15W INC	15
1I0020	20W INC	20
1I0025	25W INC	25
1I0034	34W INC	34
1I0036	36W INC	36
1I0040	40W INC	40
1I0042	42W INC	42
1I0045	45W INC	45
1I0050	50W INC	50
1I0052	52W INC	52
1I0054	54W INC	54
1I0055	55W INC	55
1I0060	60W INC	60
1I0065	65W INC	65
1I0067	67W INC	67
1I0069	69W INC	69
1I0072	72W INC	72
1I0075	75W INC	75
1I0080	80W INC	80
1I0085	85W INC	85
1I0090	90W INC	90
1I0093	93W INC	93
1I0100	100W INC	100
1I0120	120W INC	120
1I0125	125W INC	125
1I0135	135W INC	135
1I0150	150W INC	150
1I0200	200W INC	200
1I0300	300W INC	300
1I0448	448W INC	448
1I0500	500W INC	500
1I0750	750W INC	750
1I1000	1000W INC	1000
1I1500	1500W INC	1500
Compact Fluorescents (CFL's)		
1C0005S	5W COMPACT HW	7
1C0007S	7W COMPACT HW	9
1C0009S	9W COMPACT HW	11
1C0011S	11W COMPACT HW	13
1C0013S	13W COMPACT HW	15
1C0018E	18W COMPACT HW ELIG	20
1C0018S	18W COMPACT HW	20
1C0022S	22W COMPACT HW	24
1C0023E	1/23W COMPACT HW ELIG	25
1C0026E	26W COMPACT HW ELIG	28
1C0026S	26W COMPACT HW	28
1C0028S	28W COMPACT HW	30
1C0032E	32W COMPACT HW ELIG	34
1C0032S	32W CIRCLINE HW	34
1C0042E	1/42W COMPACT HW ELIG	48

Device Code	Device Description	Rated Watts
Compact Fluorescents (cont.)		
1C0044S	44W CIRCLINE HW	46
1C0057E	1/57W COMPACT HW ELIG	65
1C2232S	22/32W CIRCLINE HW	58
1C2D10E	10W 2D COMPACT HW ELIG	12
1C2D16E	16W 2D COMPACT HW ELIG	18
1C2D21E	21W 2D COMPACT HW ELIG	22
1C2D28E	28W 2D COMPACT HW ELIG	28
1C2D38E	38W 2D COMP.HW ELIG	36
1C3240S	32/40W CIRCLINE HW	80
2C0005S	2/5W COMPACT HW	14
2C0007S	2/7W COMPACT HW	18
2C0009S	2/9W COMPACT HW	22
2C0011S	2/11W COMPACT HW	26
2C0013E	2/13W COMPACT HW ELIG	28
2C0013S	2/13W COMPACT HW	30
2C0018E	2/18W COMP. HW ELIG	40
2C0026E	2/26W COMP. HW ELIG	54
2C0032E	2/32W COMPACT HW ELIG	68
2C0042E	2/42W COMPACT HW ELIG	100
2C0057E	2/57W COMPACT HW ELIG	130
3C0009S	3/9W COMPACT HW	33
3C0013S	3/13W COMPACT HW	45
3C0018E	3/18W COMPACT HW ELIG	60
3C0026E	3/26W COMPACT HW ELIG	82
3C0032E	3/32W COMPACT HW ELIG	114
3C0042E	3/42W COMPACT HW ELIG	141
4C0026E	4/26W COMPACT HW ELIG	108
4C0032E	4/32W COMPACT HW ELIG	152
4C0042E	4/42W COMPACT HW ELIG	188
6C0026E	6/26W COMPACT HW ELIG	162
6C0032E	6/32W COMPACT HW ELIG	228
6C0042E	6/42W COMPACT HW ELIG	282
8C0026E	8/26W COMPACT HW ELIG	216
8C0032E	8/32W COMPACT HW ELIG	304
8C0042E	8/42W COMPACT HW ELIG	376
4C0018E	4/18W COMPACT HW ELIG	80
Low Voltage Halogen Fixture (includes Transformer)		
1R0020	20W LV HALOGEN FIXT	30
1R0025	25W LV HALOGEN FIXT	35
1R0035	35W LV HALOGEN FIXT	45
1R0042	42W LV HALOGEN FIXT	52
1R0050	50W LV HALOGEN FIXT	60
1R0065	65W LV HALOGEN FIXT	75
1R0075	75W LV HALOGEN FIXT	85

Device Code	Device Description	Rated Watts
Halogen/Quartz Lamps		
1T0035	35W HALOGEN LAMP	35
1T0040	40W HALOGEN LAMP	40
1T0042	42W HALOGEN LAMP	42
1T0045	45W HALOGEN LAMP	45
1T0047	47W HALOGEN LAMP	47
1T0050	50W HALOGEN LAMP	50
1T0052	52W HALOGEN LAMP	52
1T0055	55W HALOGEN LAMP	55
1T0060	60W HALOGEN LAMP	60
1T0072	72W HALOGEN LAMP	72
1T0075	75W HALOGEN LAMP	75
1T0090	90W HALOGEN LAMP	90
1T0100	100W HALOGEN LAMP	100
1T0150	150W HALOGEN LAMP	150
1T0200	200W HALOGEN LAMP	200
1T0250	250W HALOGEN LAMP	250
1T0300	300W HALOGEN LAMP	300
1T0350	350W HALOGEN LAMP	350
1T0400	400W HALOGEN LAMP	400
1T0425	425W HALOGEN LAMP	425
1T0500	500W HALOGEN LAMP	500
1T0750	750W HALOGEN LAMP	750
1T0900	900W HALOGEN LAMP	900
1T1000	1000W HALOGEN LAMP	1000
1T1200	1200W HALOGEN LAMP	1200
1T1500	1500W HALOGEN LAMP	1500
Mercury Vapor (MV)		
1V0040S	40W MERCURY	50
1V0050S	50W MERCURY	75
1V0075S	75W MERCURY	95
1V0100S	100W MERCURY	120
1V0175S	175W MERCURY	205
1V0250S	250W MERCURY	290
1V0400S	400W MERCURY	455
1V0700S	700W MERCURY	775
1V1000S	1000W MERCURY	1075
2V0400S	2/400W MERCURY	880
Low Pressure Sodium (LPS)		
1L0035S	35W LPS	60
1L0055S	55W LPS	85
1L0090S	90W LPS	130
1L0135S	135W LPS	180
1L0180S	180W LPS	230
High Pressure Sodium (HPS)		
1H0035S	35W HPS	45
1H0050S	50W HPS	65
1H0070S	70W HPS	90
1H0100S	100W HPS	130
1H0150S	150W HPS	190
1H0200S	200W HPS	240
1H0225S	225W HPS	275
1H0250S	250W HPS	295
1H0310S	310W HPS	350
1H0360S	360W HPS	435
1H0400S	400W HPS	460

Device Code	Device Description	Rated Watts
High Pressure Sodium (cont.)		
1H0600S	600W HPS	675
1H0750S	750W HPS	835
1H1000S	1000W HPS	1085
Electronic Metal Halide Lamps		
1M0150E	150W METAL HALIDE EB	160
1M0200E	200W METAL HALIDE EB	215
1M0250E	250W METAL HALIDE EB	270
1M0320E	320W METAL HALIDE EB	345
1M0350E	350W METAL HALIDE EB	375
1M0400E	400W METAL HALIDE EB	430
1M0450E	400W METAL HALIDE EB	480
1M0875P	875W MH CWA	950
1M0875R	875W MH LINEAR	927
MH Track Lighting		
1M0020E	20W MH SPOT	25
1M0025E	25W MH SPOT	25
1M0035E	35W MH SPOT	44
1M0039E	39W MH SPOT	47
1M0050E	50W MH SPOT	60
1M0070E	70W MH SPOT	80
Metal Halide (MH)		
1M0032S	32W METAL HALIDE	40
1M0050S	50W METAL HALIDE	65
1M0070S	70W METAL HALIDE	95
1M0100S	100W METAL HALIDE	120
1M0150S	150W METAL HALIDE	190
1M0175S	175W METAL HALIDE	205
1M0250S	250W METAL HALIDE	295
1M0360S	360W METAL HALIDE	430
1M0400S	400W METAL HALIDE	455
1M0750S	750W METAL HALIDE	825
1M0875P	875W MH CWA	950
1M0875R	875W MH LINEAR	927
1M1000S	1000W METAL HALIDE	1075
1M1500S	1500W METAL HALIDE	1615
1M1800S	1800W METAL HALIDE	1875
Pulse Start Metal Halide Lamp/Ballast		
1M0100P	100W MH CWA	128
1M0100R	100W MH LINEAR	118
1M0150P	150W MH CWA	190
1M0150R	150W MH LINEAR	172
1M0175P	175W MH CWA	208
1M0175R	175W MH LINEAR	190
1M0200P	200W MH CWA	232
1M0200R	200W MH LINEAR	218
1M0250P	250W MH CWA	288

Device Code	Device Description	Rated Watts
Pulse Start Metal Halide Lamp/Ballast		
1M0250R	250W MH LINEAR	265
1M0300P	300W MH CWA	342
1M0300R	300W MH LINEAR	324
1M0320P	320W MH CWA	365
1M0320R	320W MH LINEAR	345
1M0350P	350W MH CWA	400
1M0350R	350W MH LINEAR	375
1M0400P	400W MH CWA	455
1M0400R	400W MH LINEAR	430
1M0450P	450W MH CWA	508
1M0450R	450W MH LINEAR	480
1M0750P	750W MH CWA	815
1M0750R	750W MH LINEAR	805
1M1000P	1000W MH CWA	1080
Two Foot T8 / T12 Systems		
1F17SSE	1L2’ 17WT8/ELIG	17
1F20SSS	1L2’ 20W T12/HPF(1)	32
1F28BXE	1L2’ F28BX/ELIG	32
1F40BXE	1L2’ F40BX/ELIG	46
1F50BXE	1L2’ F50BX/ELIG	54
1F55BXE	1L2’ F55BX/ELIG	56
1F80BXE	1L2’F80BXE/ELIG	90
2F14EEE	2L2’ T5/EEELIG	32
2F17EEE	2L2’ 17W T8EE/ELEE	29
2F17SSE	2L2’ 17W T8/ELIG	37
2F17SSL	2L2’ 17W T8/ELIG LOW POWER	27
2F17SSM	2L2’ 17W T8/EEMAG	45
2F20SSS	2L2’ 20WT12/HPF(2)	56
2F24HSS	2L2’ 24 T12HO/STD/STD	85
2F28BXE	2L2’ F28BX/ELIG	63
Two Foot T8 / T12 Systems		
2F40BXE	2L2’ F40BX/ELIG	72
2F50BXE	2L2’ F50BX/ELIG	108
2F55BXE	2L2’55BXE/ELIG	112
3F17SSE	3L2’ 17W T8/ELIG	53
3F17SSL	3L2’ 17W T8/ELIG LOW POWER	39
3F20SSS	3L2’ 20WT12/HPF(3)	78
3F28BXE	3L2’ F28BX/ELIG	94
3F40BXE	3L2’ F40BX/ELIG	102
3F50BXE	3L2’ F50BX/ELIG	162
3F55BXE	3L2’ F55BX/ELIG	168
4F17SSE	4L2’ 17W T8/ELIG	62
4F20SSS	4L2’ 20WT12/HPF(2)	112
4F36BXE	4L2’ F36BX/ELIG	148

Device Code	Device Description	Rated Watts
Two Foot T8 / T12 Systems (cont.)		
4F40BXE	4L2’ F40BX/ELIG	144
4F40BXH	4L 40W T5 (Std.) HIGH LMN	170
4F50BXE	4L2’ F50BX/ELIG	216
4F55BXE	4L2’ F55BX/ELIG	224
5F40BXE	5L2’ F40BX/ELIG	190
5F50BXE	5L2’ F50BX/ELIG	270
5F55BXE	5L2’ F55BX/ELIG	280
6F36BXE	6L2’ F36BX/ELIG	212
6F40BXE	6L2’ F40BX/ELIG	204
6F50BXE	6L2’ F50BX/ELIG	324
6F55BXE	6L2’ F55BX/ELIG	336
8F36BXE	8L2’ F36BX/ELIG	296
8F40BXE	8L2’ F40BX/ELIG	288
8F50BXE	8L2’ F50BX/ELIG	432
8F55BXE	8L2’ F55BX/ELIG	448
9F36BXE	9L2’ F36BX/ELIG	318
9F40BXE	9L2’ F40BX/ELIG	306
9F50BXE	9L2’ F50BX/ELIG	486
9F55BXE	9L2’ F55BX/ELIG	504
12F40BE	12L2’ F40BX/ELIG	408
12F50BE	12L2’ F50BX/ELIG	648
12F55BE	12L2’ F55BX/ELIG	672
Three Foot T8 / T12 Systems		
1F25SSE	1L3’ 25W T8/ELIG	24
2F25SSE	2L3’ 25W T8/ELIG	47
2F25SSM	2L3’ 25W T8/EEMAG	65
1F30SEM	1L3’ 30W T12 EE/EEMAG	38
1F30SES	1L3’ 30W T12 EE/STD	42
1F30SSS	1L3’ 30W T12 STD/STD	46
2F30SEE	2L3’ 30W T12 EE/ELIG	49
2F30SEM	2L3’ 30W T12 EE/EEMAG	66
2F30SES	2L3’ 30W T12 EE/STD	73
2F30SSS	2L3’ 30W T12 STD/STD	80
2F25SSE	2L3’ 25W T8/ELIG	47
2F25SSM	2L3’ 25W T8/EEMAG	65
3F30SSS	3L3’ 30W T12 STD/STD	140
3F30SES	3L3’ 30W T12 EE/STD	127
4F25ESH	4L3’ 25W T8EE/ELEE HIGH PWR’	120
4F25ESL	4L3’ 25W T8EE/ELEE LOW PWR’	74
4F25ESN	4L3’ 25W T8EE/ELEE’	90
4F25SSE	4L3’ 25W T8/ELIG	88
4F25SSL	4L3’ 25WT8/ELIG LOW PWR	74
4F30SES	4L3’ 30W T12EE/STD	146

Device Code	Device Description	Rated Watts
Four Foot F48 T12 Systems		
1F48SES	1L4' F48T12EE/STD	50
1F48SSS	1L4' F48T12/STD	60
2F48SES	2L4' F48T12EE/STD	82
2F48SSS	2L4' F48T12/STD	102
3F48SES	3L4' F48T12EE/STD	132
3F48SSS	3L4' F48T12/STD	162
4F48SES	4L4' F48T12EE/STD	164
4F48SSS	4L4' F48T12/STD	204
1F48HES	1L4' F48HO/EE/STD	80
1F48HSS	1L4' F48H0/STD/STD	85
2F48HES	2L4' F48HO/EE/STD	135
2F48HSS	2L4' F48H0/STD/STD	145
3F48HES	3L4' F48HO/EE/STD	215
3F48HSS	3L4' F48H0/STD/STD	230
4F48HES	4L4' F48HO/EE/STD	270
4F48HSS	4L4' F48H0/STD/STD	290
Four Foot F48VHO T12 Systems		
1F48VES	1L4' F48VHO/EE/STD	123
1F48VSS	1L4' F48VHO/STD/STD	138
2F48VES	2L4' F48VHO/EE/STD	210
2F48VSS	2L4' F48VHO/STD/STD	240
3F48VES	3L4' F48VHO/EE/STD	333
3F48VSS	3L4' F48VHO/STD/STD	378
4F48VES	4L4' F48VHO/EE/STD	420
4F48VSS	4L4' F48VHO/STD/STD	480
Four Foot T12 Systems		
1F40SEE	1L4' EE/ELIG	38
1F40SEM	1L4' EE/EEMAG	40
1F40SES	1L4' EE/STD	50
1F40SSE	1L4' STD/ELIG	46
1F40SSM	1L4' STD/EEMAG	50
1F40SSS	1L4' STD/STD	57
2F40SEE	2L4' EE/ELIG	60
2F40SEM	2L4' EE/EEMAG	70
2F40SES	2L4' EE/STD	80
2F40SSE	2L4' STD/ELIG	72
2F40SSM	2L4' STD/EEMAG	86
2F40SSS	2L4' STD/STD	94
3F40SEE	3L4' EE/ELIG	90
3F40SEM	3L4' EE/EEMAG	110
3F40SES	3L4' EE/STD	130
3F40SSE	3L4' STD/ELIG	110
3F40SSM	3L4' STD/EEMAG	136
3F40SSS	3L4' STD/STD	151
4F40SEE	4L4' EE/ELIG	120

Device Code	Device Description	Rated Watts
Four Foot T12 Systems		
4F40SEM	4L4' EE/EEMAG	140
4F40SES	4L4' EE/STD	160
4F40SSE	4L4' STD/ELIG	144
4F40SSM	4L4' STD/EEMAG	172
4F40SSS	4L4' STD/STD	188
6F40SSS	6L4' STD/STD	282
Four Foot T8 Systems		
1F32SSE	1L4' T8/ELIG	30
1F32SSL	1L4 T8/ELIG LOW POWER	26
1F32SSM	1L4' T8/EEMAG	37
2F32SSE	2L4' T8/ELIG	60
2F32SSH	2L4' T8/ELIG HIGH LMN	78
2F32SSL	2L4 T8/ELIG LOW PWR	52
2F32SSM	2L4' T8/EEMAG	70
3F32SSE	3L4' T8/ELIG	88
3F32SSH	3L4' T8/ELIG HIGH LMN	112
3F32SSL	3L4 T8/ELIG LOW POWER	76
3F32SSM	3L4' T8/EEMAG	107
4F32SSE	4L4' T8/ELIG	112
4F32SSH	4L4' T8/ELIG HIGH LMN	156
4F32SSL	4L4 T8/ELIG LOW PWR	98
4F32SSM	4L4' T8/EEMAG	140
5F32SSE	5L4' T8/ELIG	148
5F32SSH	5L4' T8/ELIG HIGH LMN	190
6F32SSE	6L4' T8/ELIG	174
6F32SSH	6L4' 32W T8/ELIG HIGH LMN	224
8F32SSH	8L4' T8/ELIG HIGH LMN	312
Five Foot T8 / T12 Systems		
1F40HSE	1L5' HO/STD/ELIG	59
1F60HSM	1L5' HO/STD/EEMAG	90
1F60SSM	1L5'/STD/EEMAG	73
1F60TSM	1L5' T10HO/STD/EEMAG	135
2F40HSE	2L5' HO/STD/ELIG	123
2F40TSE	2L5'T8/ELIG	68
2F60HSM	2L5' HO/STD/EEMAG	178
2F60SSM	2L5'/STD/EEMAG	122
3F40TSE	3L5'T8/ELIG	106
Six Foot T12 & T12HO Systems		
1F72HSE	1L6' T8HO/ELIG	80
1F72HSS	1L6' F72HO/STD/STD	113
1F72SSM	1L6' STD/EEMAG	80
1F72SSS	1L6' STD/STD	95
2F72HSE	2L6'T8 HO/ELIG	160
2F72HSM	2L6' F72HO/STD/EEMAG	193

2F72HSS	2L6’ F72HO/STD	195
Device Code	**Device Description**	**Rated Watts**
Six Foot T12 & T12HO Systems		
2F72SSM	2L6’ STD/EEMAG	135
2F72SSS	2L6’ STD/STD	173
Eight Foot T12HO Systems		
1F96HES	1L8’ HO/EE/STD	125
1F96HSS	1L8’ HO/STD/STD	135
2F96HEE	2L8’ HO/EE/ELIG	170
2F96HEM	2L8’ HO/EE/EEMAG	207
2F96HES	2L8’ HO/EE/STD	227
2F96HSE	2L8’ HO/STD/ELIG	195
2F96HSM	2L8’ HO/STD/EEMAG	237
2F96HSS	2L8’ HO/STD/STD	257
3F96HES	3L8’ HO/EE/STD	352
3F96HSS	3L8’ HO/STD/STD	392
4F96HEE	4L8’ HO/EE/ELIG	340
4F96HEM	4L8’ HO/EE/EEMAG	414
4F96HES	4L8’ HO/EE/STD	454
4F96HSE	4L8’ HO/STD/ELIG	390
4F96HSM	4L8’ HO/STD/EEMAG	474
4F96HSS	4L8’ HO/STD/STD	514
Eight Foot T12VHO Systems		
1F96VES	1L8’ VHO/EE/STD	200
1F96VSS	1L8’ VHO/STD/STD	230
2F96VES	2L8’ VHO/EE/STD	390
2F96VSS	2L8’ VHO/STD/STD	450
3F96VES	3L8’ VHO/EE/STD	590
3F96VSS	3L8’ VHO/STD/STD	680

Table 4: MassSAVE Retrofit Proposed Lighting Wattage Tables

2016 MassSAVE C&I Lighting Rated Wattage Tables developed by Lighting Worksheet Team

Device Code	Device Description	Rated Watts
LED Exit Signs		
1E0002	2.0 WATT LED	2
1E0003	3.0 WATT LED	3
1E0005	5.0 WLED	5
1E0005C	0.5 WATT LEC	0.5
1E0008	8.0 WLED	8
1E0015	1.5 WATT LED	1.5
1E0105	10.5 WATT LED	10.5
T5 Systems		
1F14SSE	1L2’ 14W T5/ELIG	16
1F21SSE	1L3’ 21W T5/ELIG	24
1F24HSE	1L2’ 24W T5HO/ELIG	29
1F28SSE	1L4’ 28W T5/ELIG	32
1F39HSE	1L3’ 39W T5HO/ELIG	42
1F47HSE	1L4’ 47W T5HO/ELIG	53
1F50HSE	1L4’ 50W T5HO/ELIG	58
1F54HSE	1L4’ 54W T5HO/ELIG	59
2F14SSE	2L2’ 14W T5/ELIG	32
2F21SSE	2L3’ 21W T5/ELIG	47
2F24HSE	2L2’ 24W T5HO/ELIG	52
2F28SSE	2L4’ 28W T5/ELIG	63
2F39HSE	2L3’ 39W T5HO/ELIG	85
2F47HSE	2L4’ 47W T5HO/ELIG	103
2F50HSE	2L4’ 50W T5HO/ELIG	110
2F54HSE	2L4’ 54W T5HO/ELIG	117
3F14SSE	3L2’ 14W T5/ELIG	50
3F24HSE	3L4’ T5HO/ELIG	80
3F28SSE	3L4’ 28W T5/ELIG	95
3F47HSE	3L4’ 47W T5HO/ELIG	157
3F50HSE	3L4’ 50W T5HO/ELIG	168
3F54HSE	3L4’ 54W T5HO/ELIG	177
4F14SSE	4L2’ 14W T5/ELIG	68
4F28SSE	4L4’ 28W T5/ELIG	126
4F47HSE	4L4’ 47W T5HO/ELIG	200
4F50HSE	4L4’ 50W T5HO/ELIG	215
4F54ESH	4L4’ 54W T5HO/ELEE	218
Device Code	**Device Description**	**Rated Watts**
T5 Systems (cont.)		
4F54HSE	4L4’ 54W T5HO/ELIG	234
5F47HSE	5L4’ 47W T5HO/ELIG	260
5F50HSE	5L4’ 50W T5HO/ELIG	278
5F54HSE	5L4’ 54W T5HO/ELIG	294
6F28SSE	6L4’ 28W T5/ELIG	189
6F47HSE	6L4’ 47W T5HO/ELIG	303
6F50HSE	6L4’ 50W T5HO/ELIG	325
6F54HSE	6L4’ 54W T5HO/ELIG	351
8F54HSE	8L4’ 54W T5HO/ELIG	468
10F54HSE	10L4’ 54W T5HO/ELIG	585
Two Foot High Efficient T8 Systems		
1F17ESL	1L2’ 17W T8EE/ELEE LOW PWR	14
1F17ESN	1L2’ 17W T8EE/ELEE	17
1F17ESH	1L2’ 17W T8EE/ELEE HIGH PWR	20
1F28BXE	1L2’ F28BX/ELIG	32
2F17ESL	2L2’ 17W T8EE/ELEE LOW PWR	27
2F17ESN	2L2’ 17W T8EE/ELEE	32
2F17ESH	2L2’ 17W T8EE/ELEE HIGH PWR	40
2F28BXE	2L2’ F28BX/ELIG	63
3F17ESL	3L2’ 17W T8EE/ELEE LOW PWR	39
3F17ESN	3L2’ 17W T8EE/ELEE	46
3F17ESH	3L2’ 17W T8EE/ELEE HIGH PWR	61
3F28BXE	3L2’ F28BX/ELIG	94
Three Foot High Efficient T8 Systems		
1F25ESL	1L3’ 25W T8EE/ELEE LOW PWR	21
1F25ESN	1L3’ 25W T8EE/ELEE	24
1F25ESH	1L3’ 25W T8EE/ELEE HIGH PWR	30
2F25ESL	2L3’ 25W T8EE/ELEE LOW PWR	40
Device Code	**Device Description**	**Rated Watts**
Three Foot High Efficient T8 Systems (cont.)		
2F25ESN	2L3’ 25W T8EE/ELEE	45

2F25ESH	2L3’ 25W T8EE/ELEE HIGH PWR	60
3F25ESL	3L3’ 25W T8EE/ELEE LOW PWR	58
3F25ESN	3L3’ 25W T8EE/ELEE	67
3F25ESH	3L3’ 25W T8EE/ELEE HIGH PWR	90
Four Foot T8 High Efficient / Reduce Wattage Systems		
1F25EEH	1L4’ 25W T8EE/ELEE HIGH PWR	30
1F25EEE	1L4’ 25W T8EE/ELEE	22
1F25EEL	1L4’ 25W T8EE/ELEE LOW PWR	19
2F25EEH	2L4’ 25W T8EE/ELEE HIGH PWR	57
2F25EEE	2L4’ 25W T8EE/ELEE	43
2F25EEL	2L4’ 25W T8EE/ELEE LOW PWR	37
3F25EEH	3L4’ 25W T8EE/ELEE HIGH PWR	86
3F25EEE	3L4’ 25W T8EE/ELEE	64
3F25EEL	3L4’ 25W T8EE/ELEE LOW PWR	57
4F25EEH	4L4’ 25W T8EE/ELEE HIGH PWR	111
4F25EEE	4L4’ 25W T8EE/ELEE	86
4F25EEL	4L4’ 25W T8EE/ELEE LOW PWR	75
1F28EEH	1L4’ 28W T8EE/ELEE HIGH PWR	33
1F28EEE	1L4’ 28W T8EE/ELEE	24
1F28EEL	1L4’ 28W T8EE/ELEE LOW PWR	22
2F28EEH	2L4’ 28WT8EE/ELEE HIGH PWR	64
2F28EEE	2L4’ 28W T8EE/ELEE	48
2F28EEL	2L4’ 28W T8EE/ELEE LOW PWR	42
3F28EEH	3L4’ 28W T8EE/ELEE HIGH PWR	96
3F28EEE	3L4’ 28W T8EE/ELEE	72
3F28EEL	3L4’ 28W T8EE/ELEE LOW PWR	63
4F28EEH	4L4’ 28W T8EE/ELEE HIGH PWR	126
Device Code	**Device Description**	**Rated Watts**
Four Foot T8 High Efficient / Reduce Wattage Systems (cont.)		
4F28EEE	4L4’ 28W T8EE/ELEE	94
4F28EEL	4L4’ 28W T8EE/ELEE LOW PWR	83
1F30EEH	1L4’ 30W T8EE/ELEE HIGH PWR	36
1F30EEE	1L4’ 30W T8EE/ELEE	26
1F30EEL	1L4’ 30W T8EE/ELEE LOW PWR	24
2F30EEH	2L4’ 30WT8EE/ELEE HIGH PWR	69
2F30EEE	2L4’ 30W T8EE/ELEE	52
2F30EEL	2L4’ 30W T8EE/ELEE LOW PWR	45
3F30EEH	3L4’ 30W T8EE/ELEE HIGH PWR	103
3F30EEE	3L4’ 30W T8EE/ELEE	77
3F30EEL	3L4’ 30W T8EE/ELEE LOW PWR	68
4F30EEH	4L4’ 30W T8EE/ELEE HIGH PWR	133
4F30EEE	4L4’ 30W T8EE/ELEE	101
4F30EEL	4L4’ 30W T8EE/ELEE LOW PWR	89
1F32EEH	1L4’ 32W T8EE/ELEE HIGH PWR	38
1F32EEE	1L4’ 32W T8EE/ELEE	28
1F32EEL	1L4’ 32W T8EE/ELEE LOW PWR	25
2F32EEH	2L4’ 32W T8EE/ELEE HIGH PWR	73
2F32EEE	2L4’ 32W T8EE/ELEE	53
2F32EEL	2L4’ 32W T8EE/ELEE LOW PWR	47
3F32EEH	3L4’ 32W T8EE/ELEE HIGH PWR	109
3F32EEE	3L4’ 32W T8EE/ELEE	82
3F32EEL	3L4’ 32W T8EE/ELEE LOW PWR	72
4F32EEH	4L4’ 32W T8EE/ELEE HIGH PWR	141
4F32EEE	4L4’ 32W T8EE/ELEE	107
4F32EEL	4L4’ 32W T8EE/ELEE LOW PWR	95
5F32EEH	5L4’ 32W T8EE/ELEE HIGH PWR	182
6F28EEE	6L4’ 28W T8EE/ELEE	144
6F28EEH	6L4’ 28W T8EE/ELEE HIGH PWR	192
6F28EEL	6L4’ 28W T8EE/ELEE LOW PWR	126
6F30EEE	6L4’ 30W T8EE/ELEE	154
Device Code	**Device Description**	**Rated Watts**
Four Foot T8 High Efficient / Reduce Wattage Systems (cont.)		
6F30EEL	6L4’ 30W T8EE/ELEE LOW PWR	136

6F32EEH	6L4’ 32W T8EE/ELEE HIGH PWR	218
6F32EEE	6L4’ 32W T8EE/ELEE	168
6F32EEL	6L4’ 32W T8EE/ELEE LOW PWR	146
7F32EEH	7L4’ 32W T8EE/ELEE HIGH PWR	250
Eight Foot T8 Systems		
1F59SSE	1L8’ T8/ELIG	60
1F80SSE	1L8’ T8 HO/ELIG	85
2F59SSE	2L8’ T8/ELIG	109
2F59SSL	2L8’ T8/ELIG LOW PWR	100
2F80SSE	2L8’ T8 HO/ELIG	160
Tandem Wired T8 High Efficient		
2W32EEE	2L4’ TW T8EE/ELIG	27
2W32EEL	2L4’ TW T8EE/ELEE LOW PWR	24
3W32EEE	3L4’ TW T8EE/ELIG	39
3W32EEL	3L4’ TW T8EE/ELEE LOW PWR	34
4W32EEE	4L4’ TW T8EE/ELIG	51
4W32EEL	4L4’ TW T8EE/ELEE LOW PWR	45
Tandem-Wired Fluorescent Systems		
2W32SSE	2L4’ TW T8/ELIG	30
2W32SSH	2L4’ TW T8/HI-LUM	39
2W40SEE	2L4’ TW EE/ELIG	30
2W40SSE	2L4’ TW STD/ELIG	36
2W59HSE	2L8’ TW T8 HO/ELIG	80
2W59SSE	2L8’ TW T8/ELIG	55
2W96HEE	2L8’ TW HO-EE/ELIG	85
2W96HSE	2L8’ TW HO-STD/ELIG	98
2W96SEE	2L8’ TW EE/ELIG	55
2W96SSE	2L8’ TW STD/ELIG	67
3W32SSE	3L4’ TW T8/ELIG	29
4D17SSE	4L2’ TW T8/ELIG	31
4D32EEE	4L4’ DTW T8EE/ELIG	51
4D32EEL	4L4’ DTW T8EE/ELEE LOW PWR	45
4D32SSE	4L4’ DTW T8/ELIG	53
4D32SSL	4L4 DTWT8/ELIG LOW POWER	49
4W32SSE	4L4’ TW T8/ELIG	27
4W32SSL	4L4 TWT8/ELIG LOW POWER	25
Device Code	**Device Description**	**Rated Watts**
LED Lighting Fixtures		
1L002	2 WATT LED	2
1L003	3 WATT LED	3

1L004	4 WATT LED	4
1L005	5 WATT LED	5
1L006	6 WATT LED	6
1L007	7 WATT LED	7
1L008	8 WATT LED	8
1L009	9 WATT LED	9
1L010	10 WATT LED	10
1L011	11 WATT LED	11
1L012	12 WATT LED	12
1L013	13 WATT LED	13
1L014	14 WATT LED	14
1L015	15 WATT LED	15
1L016	16 WATT LED	16
1L017	17 WATT LED	17
1L018	18 WATT LED	18
1L019	19 WATT LED	19
1L020	20 WATT LED	20
1L021	21 WATT LED	21
1L022	22 WATT LED	22
1L023	23 WATT LED	23
1L024	24 WATT LED	24
1L025	25 WATT LED	25
1L026	26 WATT LED	26
1L027	27 WATT LED	27
1L028	28 WATT LED	28
1L029	29 WATT LED	29
1L030	30 WATT LED	30
1L031	31 WATT LED	31
1L032	32 WATT LED	32
1L033	33 WATT LED	33
1L034	34 WATT LED	34
1L035	35 WATT LED	35
1L036	36 WATT LED	36
1L037	37 WATT LED	37
1L038	38 WATT LED	38
1L039	39 WATT LED	39
1L040	40 WATT LED	40
1L041	41 WATT LED	41
1L042	42 WATT LED	42
Device Code	**Device Description**	**Rated Watts**
LED Lighting Fixtures		
1L043	43 WATT LED	43

1L044	44 WATT LED	44
1L045	45 WATT LED	45
1L046	46 WATT LED	46
1L047	47 WATT LED	47
1L048	48 WATT LED	48
1L049	49 WATT LED	49
1L050	50 WATT LED	50
1L053	53 WATT LED	53
1L055	55 WATT LED	55
1L060	60 WATT LED	60
1L063	63 WATT LED	63
1L070	70 WATT LED	70
1L071	71 WATT LED	71
1L073	73 WATT LED	73
1L075	75 WATT LED	75
1L080	90 WATT LED	90
1L085	85 WATT LED	85
1L090	90 WATT LED	90
1L095	95 WATT LED	95
1L100	100 WATT LED	100
1L101	101 WATT LED	101
1L106	106 WATT LED	106
1L107	107 WATT LED	107
1L116	116 WATT LED	116
1L120	120 WATT LED	120
1L125	125 WATT LED	125
1L130	130 WATT LED	130
1L131	131 WATT LED	131

Device Code	Device Description	Rated Watts
LED Lighting Fixtures (cont.)		
1L135	135 WATT LED	135
1L139	139 WATT LED	139
1L140	140 WATT LED	140
1L145	145 WATT LED	145
1L150	150 WATT LED	150
1L155	155 WATT LED	155
1L160	160 WATT LED	160
1L164	164 WATT LED	164
1L165	165 WATT LED	165
1L170	170 WATT LED	170
1L175	175 WATT LED	175
1L180	180 WATT LED	180
1L185	185 WATT LED	185
1L186	186 WATT LED	186
1L190	190 WATT LED	190
1L200	200 WATT LED	200
1L204	204 WATT LED	204
1L205	205 WATT LED	205
1L210	210 WATT LED	210
1L211	211 WATT LED	211
1L220	220 WATT LED	220
1L233	233 WATT LED	233
1L235	235 WATT LED	235
1L237	237 WATT LED	237
1L240	240 WATT LED	240
1L256	256 WATT LED	256
1L279	279 WATT LED	279
1LED015	15 Watt LED	15

Table 5: Default Effective Lighting Hours by Building Type[754]

Building Type	Annual Operating Hours
Assembly	2857 (one shift)
Automobile	4056 (retail)
Big Box	4057 (retail)
Community College	3255
Dormitory	3,056
Fast Food	5110
Full Service Restaurant	5110
Grocery	6074
Heavy Industrial	4,057
Hospital	8036
Hotel	8583
Large Refrigerated Space	2602 (warehouse)
Large Office	3610
Light Industrial	4,730 (two shift)
Motel	8583
Multi Story Retail	4089
Multifamily high-rise	7665 (Common Area)
Multifamily low-rise	7665 (Common Area)
Other	3951
Religious	1955
K-12 Schools	2596
Small Office	3610
Small Retail	4089
University	3255
Warehouse	3759

Table 6: Cooling and Heating Equivalent Full Load Hours

Building (or Space) Type	Annual Cooling Hours ($Hours_{cool}$)	Cooling Full Load Hours ($EFLH_{cool}$)	Heating Full Load Hours ($EFLH_{heat}$)
Average – CLC	3,027	1,172	530
Average – NSTAR	3,027	1,172	N/A
Average – National Grid	2,539	935	984
Average – Unitil	1,896	755	1,329
Average – WMECO	1,896	755	1,329
Site Specific - NSTAR	800, 1000-6000 at 1000 hour increments	800, 1000-6000 at 1000 hour increments	N/A

- Average Cooling EFLHs from the 2010 NEEP HVAC Loadshape study.[755] Regional EFLHs from the NEEP study are determined for each PA by applying weights based on ISO-NE load zones.
- Average Cooling Hours derived from the 2010 NEEP HVAC Loadshape study data.[756]

[754] Lighting hours developed from Massachusetts Common Assumptions and New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (2010). Values are provided for use when site-specific hours are not available.
[755] KEMA (2011). C&I Unitary AC LoadShape Project – Final Report. Prepared for the Regional Evaluation, Measurement & Verification Forum.

- Average Heating EFLHs derived from 2010 NEEP HVAC Loadshape study[757] and the Connecticut Program Savings Document for 2011 Program Year. [758]

[756] DNV GL (2014). *Memo – Develop Modified Runtime from NEEP HVAC Loadshape Study*. Prepared for National Grid and Northeast Utilities. August 20, 2014.
[757] Ibid.
[758] United Illuminating Company, Connecticut Light & Power Company (2010). *UI and CL&P Program Savings Documentation for 2011 Program Year*.

Appendix B: Net to Gross Impact Factors

Residential Efficiency Measures					
Measure	**PA**	**FR**	**SO_P**	**SO_{NP}**	**NTG**
Residential New Construction					
Cooling	All	30%	0%	50%	120%
Heating	All	30%	0%	50%	120%
Water Heating	All	30%	0%	50%	120%
CFL Bulb	All	See Residential Lighting – CFL Bulb			
LED Bulb	All	See Residential Lighting – LED Bulb			
Heating (High Rise)	All	0%	0%	0%	100%
Cooling (High Rise)	All	0%	0%	0%	100%
Water Heating (High Rise)	All	0%	0%	0%	100%
Lighting (High Rise)	All	See Residential Lighting – LED Bulb			
Codes and Standards	All	0%	0%	0%	100%
Residential Multi-Family Retrofit					
Air Sealing	All	19%	0%	0%	81%
Insulation	All	19%	0%	0%	81%
Duct Sealing	All	19%	0%	0%	81%
Duct Insulation	All	19%	0%	0%	81%
Pipe Wrap (Water Heating)	All	0%	0%	0%	100%
Pipe Wrap (Heating)	All	0%	0%	0%	100%
Faucet Aerator	All	15%	0%	0%	85%
Low-Flow Showerhead	All	15%	0%	0%	85%
Low-Flow Showerhead with TSV	All	15%	0%	0%	85%
Thermostatic Shut-off Valve	All	15%	0%	0%	85%
Demand Circulator	All	0%	0%	0%	100%
Boiler Reset Control	All	0%	0%	0%	100%
Programmable Thermostat	All	24%	0%	0%	76%
Wi-Fi Thermostat	All	0%	0%	0%	100%
Refrigerator	All	0%	0%	0%	100%
CFL Bulb	All	18%	0%	0%	82%
LED Bulb	All	18%	0%	0%	82%
Indoor Fixture	All	18%	0%	0%	82%
Outdoor Fixture	All	18%	0%	0%	82%
LED Indoor Fixture	All	18%	0%	0%	82%
LED Outdoor Fixture	All	18%	0%	0%	82%
Common Area Int Fixture	All	18%	0%	0%	82%
Common Area Int Fixture, LED	All	18%	0%	0%	82%
Common Area Ext Fixture	All	18%	0%	0%	82%
Common Area Ext Fixture, LED	All	18%	0%	0%	82%
Common Area Occupancy Sensor	All	18%	0%	0%	82%
Smart Strips	All	0%	0%	0%	100%
Heating System Tune-Up	All	0%	0%	0%	100%

Electric - Residential Heating & Cooling Equipment					
Central Air SEER 16.0 EER 13	All	42%	28%	0%	86%
Heat Pump SEER 16.0 EER 12 HSPF 8.5	All	42%	28%	0%	86%
Heat Pump SEER 18.0 HSPF 9.6	All	42%	28%	0%	86%
Mini Split HP SEER 18.0 HSPF 9	All	45%	7%	0%	62%
Mini Split HP SEER 20.0 HSPF 11	All	45%	7%	0%	62%
Furnace ECM	All	41%	22%	0%	81%
Circulator Pump	All	0%	0%	0%	100%
Early Retirement Central Air (EE)	All	0%	0%	0%	100%
Early Retirement Central Air (Retire)	All	0%	0%	0%	100%
Early Retirement Heat Pump (EE) SEER 16	All	0%	0%	0%	100%
Early Retirement Heat Pump (Retire) SEER 16	All	0%	0%	0%	100%
Early Retirement Heat Pump (EE) SEER 18	All	0%	0%	0%	100%
Early Retirement Heat Pump (Retire) SEER 18	All	0%	0%	0%	100%
Heat Pump Water Heater <55 gallon, Electric	All	0%	0%	0%	100%
Duct Sealing	All	0%	0%	0%	100%
Down Size 1/2 Ton	All	0%	0%	0%	100%
Heat Pump Digital Check-up/Tune-Up	All	0%	0%	0%	100%
Central Air QIV	All	0%	0%	0%	100%
Heat Pump QIV	All	0%	0%	0%	100%
Mini Split Heat Pump QIV	All	0%	0%	0%	100%
QI w/ Duct modifications	All	0%	0%	0%	100%
Gas - Residential Heating & Cooling Equipment					
Boiler 90%	All	32%	8%	0%	76%
Boiler 95%	All	31%	8%	0%	77%
Furnace w/ECM 95%	All	41%	22%	0%	81%
Furnace w/ECM 97%	All	41%	22%	0%	81%
Combo Condensing Boiler/Water Heater 90%	All	34%	8%	0%	74%
Combo Condensing Boiler/Water Heater 95%	All	34%	8%	0%	74%
Boiler Reset Control	All	0%	0%	0%	100%
Heat Recovery Ventilator	All	0%	0%	0%	100%
Condensing Water Heater 0.95	All	0%	0%	0%	100%
Stand Alone Water Heater 0.67	All	13%	13%	0%	100%
Tankless Water Heater 0.82	All	37%	25%	0%	88%
Tankless Water Heater 0.94	All	28%	25%	0%	97%
Indirect Water Heater	All	66%	0%	0%	34%
Programmable Thermostat	All	58%	0%	0%	42%
Wi-Fi Thermostat (controls gas heat only)	All	0%	0%	0%	100%
Wi-Fi Thermostat (controls elec cooling & gas heat)	All	0%	0%	0%	100%

Measure	PA	FR	SO_P	SO_{NP}	NTG
Residential Home Energy Services					
Air Sealing	All	8%	8%	28%	128%
Insulation	All	25%	20%	28%	123%
Duct Insulation	All	0%	0%	0%	100%
Duct Seal	All	0%	0%	0%	100%
Pipe Wrap (Water Heating)	All	0%	0%	0%	100%
Pipe Wrap (Heating)	All	0%	0%	0%	100%
Boiler Reset Control	All	0%	0%	0%	100%
Heating System Replacement (Boiler)	All	28%	0%	0%	72%
Heating System Replacement (Furnace)	All	28%	0%	0%	72%
Indirect Water Heater	All	29%	0%	0%	71%
On-Demand Water Heater	All	29%	0%	0%	71%
Faucet Aerator	All	0%	0%	0%	100%
Low-Flow Showerhead	All	0%	0%	0%	100%
Programmable Thermostat	All	11%	0%	0%	89%
Wi-Fi Thermostat	All	0%	0%	0%	100%
CFL Bulb	All	24%	0%	0%	76%
LED Bulb (2016)	All	0%	0%	0%	100%
LED Bulb (2017)	All	5%	0%	0%	95%
LED Bulb (2018)	All	10%	0%	0%	90%
Refrigerator (Savings Over Remaining Life)	All	14%	0%	0%	86%
Refrigerator (Savings Compared to Baseline)	All	14%	0%	0%	86%
Early Retirement CW (Retire)	All	0%	0%	0%	100%
Early Retirement CW (EE)	All	0%	0%	0%	100%
Smart Strip	All	0%	0%	0%	100%
Early Retirement Boiler, Forced Hot Water (EE)	All	0%	0%	0%	100%
Early Retirement Boiler, Forced Hot Water (Retire)	All	0%	0%	0%	100%
Early Retirement Boiler, Steam (EE)	All	0%	0%	0%	100%
Early Retirement Boiler, Steam (Retire)	All	0%	0%	0%	100%
Early Retirement Furnace (EE)	All	0%	0%	0%	100%
Early Retirement Furnace (Retire)	All	0%	0%	0%	100%

Measure	PA	FR	SO_P	SO_{NP}	NTG
Residential Lighting 2016					
CFL Bulb	All	46%	0%	0%	54%
CFL Bulb (EISA Exempt)	All	46%	0%	0%	54%
CFL Bulb (Hard to Reach)	All	7%	0%	0%	93%
CFL Bulb (School Fundraiser)	All	46%	0%	0%	54%
LED Bulb	All	10%	0%	0%	90%
LED Bulb (EISA Exempt)	All	10%	0%	0%	90%
LED Bulb (Hard to Reach)	All	0%	0%	0%	100%
LED Bulb (School Fundraiser)	All	10%	0%	0%	90%
LED Bulb (Reflectors)	All	10%	0%	0%	90%
Fixture	All	4%	0%	0%	96%
LED Fixture	All	2%	0%	0%	98%
Residential Lighting 2017					
CFL Bulb	All	47%	0%	0%	53%
CFL Bulb (EISA Exempt)	All	47%	0%	0%	53%
CFL Bulb (Hard to Reach)	All	8%	0%	0%	92%
CFL Bulb (School Fundraiser)	All	47%	0%	0%	53%
LED Bulb	All	20%	0%	0%	80%
LED Bulb (EISA Exempt)	All	20%	0%	0%	80%
LED Bulb (Hard to Reach)	All	1%	0%	0%	99%
LED Bulb (School Fundraiser)	All	20%	0%	0%	80%
LED Bulb (Reflectors)	All	20%	0%	0%	80%
Fixture	All	4%	0%	0%	96%
LED Fixture	All	7%	0%	0%	93%
Residential Lighting 2018					
CFL Bulb	All	47%	0%	0%	53%
CFL Bulb (EISA Exempt)	All	47%	0%	0%	53%
CFL Bulb (Hard to Reach)	All	9%	0%	0%	91%
CFL Bulb (School Fundraiser)	All	47%	0%	0%	53%
LED Bulb	All	30%	0%	0%	70%
LED Bulb (EISA Exempt)	All	30%	0%	0%	70%
LED Bulb (Hard to Reach)	All	2%	0%	0%	98%
LED Bulb (School Fundraiser)	All	30%	0%	0%	70%
LED Bulb (Reflectors)	All	30%	0%	0%	70%
Fixture	All	4%	0%	0%	96%
LED Fixture	All	11%	0%	0%	89%

Measure	PA	FR	SO_P	SO_{NP}	NTG
Residential Consumer Products					
Freezer Recycling	All	41%	0%	0%	59%
Freezer (Energy Star)	All	35%	0%	0%	65%
Refrigerator Recycling (Combined)	All	31%	0%	0%	69%
Refrigerator Recycling (Primary)	All	31%	0%	0%	69%
Refrigerator Recycling (Secondary Not Replaced)	All	31%	0%	0%	69%
Refrigerator Recycling (Secondary Replaced)	All	31%	0%	0%	69%
Refrigerator (Most Efficient)	All	25%	0%	0%	75%
Pool Pump (Two Speed)	All	0%	0%	0%	100%
Pool Pump (Variable Speed)	All	0%	0%	0%	100%
Room Air Cleaner	All	25%	0%	0%	75%
Smart Strip	All	0%	0%	0%	100%
Smart Strip (Tier 2)	All	0%	0%	0%	100%
Dehumidifier	All	0%	0%	0%	100%
Dehumidifier Recycling	All	0%	0%	0%	100%
Dryer (Energy Star)	All	10%	0%	0%	90%
Low-Flow Showerhead with TSV	All	0%	0%	0%	100%
Thermostatic Shutoff Valve	All	0%	0%	0%	100%
Residential Behavior/Feedback Program					
Home Energy Reports	All	0%	0%	0%	100%
Energy Education	All	0%	0%	0%	100%
Low-Income Single Family Retrofit					
All Measures	All	0%	0%	0%	100%
Low-Income Multi-Family Retrofit					
All Measures	All	0%	0%	0%	100%

Sources

Unless otherwise stated below, all PA's use Massachusetts common assumptions for all residential measure free-ridership and spillover values.

- The Net-to-Gross factors used in Residential New Construction for Heating, Cooling, and Water Heating are based on evaluation results[759] adjusted downward from an agreement with the EEAC consultants to account for the age of the study and the new Codes and Standards measure.
- The Net-to-Gross factors used in Residential Lighting and Residential New Construction for CFL Bulb and LED Bulb are from the Multistage Lighting Net-to-Gross Assessment: Overall Report[760]. The values change each year.
- The Net-to-Gross factors used in Residential Consumer Products for the Refrigerator and Freezer Recycling measures are from the Massachusetts Appliance Turn-in Program Evaluation Integrated Report Findings Report.[761]
- The Net-to-Gross factors used in Residential Heating & Cooling Equipment are from the 2012 Cool Smart and HEHE Program Evaluation report[762]
- The Net-to-Gross factors used in Residential Home Energy Services for CFL Bulb, Refrigerator, Air Sealing, and Insulation are from the Massachusetts 2011 Residential Retrofit and Low Income Net to Gross Evaluation[763]. The free-ridership for CFL Bulbs was based on this study but modified by agreement with the EEAC consultants on 7-2-12, to account for the potential for participants who would have bought CFLs outside of the HES program but through the Upstream Lighting program.
- The Net-to-Gross factors used in Residential Home Energy Services for Thermostats, Heating System Replacement and Water Heater measures are from the 2010 Net-to-Gross Findings: Home Energy Assessment study.[764]
- The Net-to-Gross factors used in Multifamily Retrofit are based on the 2011 NTG Study[765].

[759] NMR Group, Inc (2012). *Massachusetts Residential New Construction Net Impacts Report.* Prepared for the Electric Program Administrators of Massachusetts.
760 The Cadmus Group (2015). *Multistage Lighting Net-to-Gross Assessment: Overall Report.* Prepared for the Electric Program Administrators of Massachusetts.
[761] NMR Group, Inc (2011). *Massachusetts Appliance Turn-in Program Evaluation Integrated Report Findings.* Prepared for the Electric Program Administrators of Massachusetts.
[762] The Cadmus Group (2012). *2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[763] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit and Low Income Net-to-Gross Evaluation*. Prepared for the Electric and Gas Program Administrators of Massachusetts
[764] The Cadmus Group (2011). *2010 Net-to-Gross Findings: Home Energy Assessment*. Prepared for the Electric and Gas Program Administrators of Massachusetts
[765] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis.* Prepared for Massachusetts Program Administrators and the Energy Efficiency Advisory Council; June 2012

Commercial Electric Efficiency Measures					
Measure	**PA**	**FR**	**SO_P**	**SO_{NP}**	**NTG**
C&I New Buildings & Major Renovations and C&I Initial Purchase & End of Useful Life					
Advanced Lighting Design (Performance Lighting)	National Grid	22.9%	34.6%	0%	111.7%
Advanced Lighting Design (Performance Lighting)	Eversource (NSTAR)	41.6%	12.5%	0%	70.9%
Advanced Lighting Design (Performance Lighting)	Unitil	35.0%	14.8%	0%	79.9%
Advanced Lighting Design (Performance Lighting)	Eversource (WMECO)	32%	0%	2%	70%
Advanced Lighting Design (Performance Lighting)	CLC	35.5%	4.2%	0%	68.7%
Lighting Controls	National Grid	19.1%	34.2%	0%	115.1%
Lighting Controls	Eversource (NSTAR)	41.6%	12.5%	0%	70.9%
Lighting Controls	Unitil	35.0%	14.8%	0%	79.9%
Lighting Controls	Eversource (WMECO)	32%	0%	2%	70%
Lighting Controls	CLC	35.5%	4.2%	0%	68.7%
Lighting Systems	National Grid	19.1%	34.2%	0%	115.1%
Lighting Systems	Eversource (NSTAR)	41.6%	12.5%	0%	70.9%
Lighting Systems	Unitil	35.0%	14.8%	0%	79.9%
Lighting Systems	Eversource (WMECO)	32%	0%	2%	70%
Lighting Systems	CLC	35.5%	4.2%	0%	68.7%
Demand Control Ventilation (DCV)	National Grid	1.5%	0%	0%	98.5%
Demand Control Ventilation (DCV)	Eversource (NSTAR)	37.6%	0%	0.8%	63.2%
Demand Control Ventilation (DCV)	Unitil	41.5%	0%	0.7%	59.3%
Demand Control Ventilation (DCV)	Eversource (WMECO)	58.8%	0.4%	0.4%	42%
Demand Control Ventilation (DCV)	CLC	41.5%	0.0%	0.7%	59.3%
Dual Enthalpy Economizer Controls (DEEC)	National Grid	1.5%	0%	0%	98.5%
Dual Enthalpy Economizer Controls (DEEC)	Eversource (NSTAR)	37.6%	0%	0.8%	63.2%
Dual Enthalpy Economizer Controls (DEEC)	Unitil	41.5%	0%	0.7%	59.3%
Dual Enthalpy Economizer Controls (DEEC)	Eversource (WMECO)	58.8%	0.4%	0.4%	42%
Dual Enthalpy Economizer Controls (DEEC)	CLC	41.5%	0.0%	0.7%	59.3%
ECM Fan Motors	National Grid	1.5%	0%	0%	98.5%
ECM Fan Motors	Eversource (NSTAR)	37.6%	0%	0.8%	63.2%
ECM Fan Motors	Unitil	41.5%	0%	0.7%	59.3%
ECM Fan Motors	Eversource (WMECO)	58.8%	0.4%	0.4%	42%
ECM Fan Motors	CLC	9.8%%	0.0%	27.2%	117.4%
Energy Management System (EMS)	CLC	41.5%	0.0%	0.7%	59.3%
High Efficiency Chiller	National Grid	1.5%	0%	0%	98.5%
High Efficiency Chiller	Eversource (NSTAR)	37.6%	0%	0.8%	63.2%
High Efficiency Chiller	Unitil	41.5%	0%	0.7%	59.3%
High Efficiency Chiller	Eversource (WMECO)	58.8%	0.4%	0.4%	42%
High Efficiency Chiller	CLC	6.3%	0.0%	0%	93.8%
Heat Pump Systems	National Grid	36.2%	0.6%	0%	64.4%
Heat Pump Systems	Eversource (NSTAR)	0%	0%	0%	100
Heat Pump Systems	Unitil	41.5%	0%	0.7%	59.3%
Heat Pump Systems	Eversource (WMECO)	58.8%	0.4%	0.4%	42%
Heat Pump Systems	CLC	41.5%	0.0%	0.7%	59.3%
Unitary Air Conditioners	National Grid	36.2%	0.6%	0%	64.4%
Unitary Air Conditioners	Eversource (NSTAR)	0%	0%	0%	100
Unitary Air Conditioners	Unitil	41.5%	0%	0.7%	59.3%
Unitary Air Conditioners	Eversource (WMECO)	58.8%	0.4%	0.4%	42%

Measure	PA	FR	SO_P	SO_{NP}	NTG
C&I New Buildings & Major Renovations and C&I Initial Purchase & End of Useful Life					
Unitary Air Conditioners	CLC	41.5%	0%	0.7%	59.30%
High Efficiency Air Compressor	National Grid	46.4%	0%	4.6%	58.2%
High Efficiency Air Compressor	Eversource (NSTAR)	46.3%	9.6%	0%	63.3%
High Efficiency Air Compressor	Unitil	37.2%	3.3%	1.3%	67.4%
High Efficiency Air Compressor	Eversource (WMECO)	13.3%	5.8%	0%	92.5%
High Efficiency Air Compressor	CLC	37.2%	3.3%	1.3%	67.4%
Refrigerated Air Dryers	National Grid	46.4%	0%	4.6%	58.2%
Refrigerated Air Dryers	Eversource (NSTAR)	46.3%	9.6%	0%	63.3%
Refrigerated Air Dryers	Unitil	37.2%	3.3%	1.3%	67.4%
Refrigerated Air Dryers	Eversource (WMECO)	13.3%	5.8%	0%	92.5%
Refrigerated Air Dryers	CLC	37.2%	3.3%	1.3%	67.4%
Variable Frequency Drives	National Grid	41.5%	0%	0%	58.5%
Variable Frequency Drives	Eversource (NSTAR)	13.7%	0%	27.2%	113.5%
Variable Frequency Drives	Unitil	41.5%	0.0%	0.0%	58.5%
Variable Frequency Drives	Eversource (WMECO)	9.8%	0%	27.2%	117.4%
Variable Frequency Drives	CLC	41.5%	0.0%	0.0%	58.5%
Commercial Electric Ovens	All	0%	0%	0%	100%
Commercial Electric Steam Cooker	All	0%	0%	0%	100%
Commercial Electric Griddle	All	0%	0%	0%	100%
Commercial Dishwashers	All	0%	0%	0%	100%
Commercial Ice Machines	All	0%	0%	0%	100%
Commercial Fryers	All	0%	0%	0%	100%
Food Holding Cabinets	All	0%	0%	0%	100%
Custom	National Grid	22.9%	34.6%	0%	111.7%
Custom	Unitil	22.9%	34.6%	0%	111.7%
Custom	CLC	22.9%	34.6%	0%	111.7%
Custom - Compressed Air	Eversource (NSTAR)	46.3%	9.6%	0%	63.3%
Custom - Compressed Air	Eversource (WMECO)	13.3%	5.8%	0%	92.5%
Custom - HVAC	Eversource (NSTAR)	37.6%	0%	0.8%	63.2%
Custom - HVAC	Eversource (WMECO)	58.8%	0.4%	0.4%	42%
Custom - HVAC	CLC	41.5%	0%	0.7%	59.3%
Custom - Lighting	Eversource (NSTAR)	41.6%	12.5%	0%	70.9%
Custom - Lighting	Eversource (WMECO)	32%	0%	2.0%	70%
Custom - Lighting	CLC	35%	14.8%	0%	79.9%
Custom - Motors	Eversource (NSTAR)	13.7%	0%	27.2%	113.5%
Custom - Motors	Eversource (WMECO)	9.8%	0%	27.2%	117.4%
Custom - Process	Eversource (WMECO)	17.4%	0%	0%	82.6%
Custom - Process Equipment	Eversource (NSTAR)	17.4%	0%	0%	82.6%
Custom - Refrigeration	Eversource (NSTAR)	6.3%	0%	0%	93.7%
Custom - Refrigeration	Eversource (WMECO)	6.3%	0%	0%	93.7%
Custom – Refrigeration	CLC	6.3%	0%	0%	93.8%
Custom - Food Services (Ovens, Cookers, etc)	Eversource (NSTAR)	0%	0%	0%	100%
Custom - Food Services (Ovens, Cookers, etc)	Eversource (WMECO)	0%	0%	0%	100%

Measure	PA	FR	SO_P	SO_{NP}	NTG
C&I Existing Building Retrofit					
Lighting Controls	National Grid	14.8%	11.1%	0%	96.3%
Lighting Controls	Eversource (NSTAR)	9.9%	11.8%	0%	101.9%
Lighting Controls	Unitil	14.1%	11.3%	0%	97.2%
Lighting Controls	Eversource (WMECO)	43.2%	4.9%	0%	61.7%
Lighting Controls	CLC	14.1%	11.3%	0%	97.2%
Lighting Systems	National Grid	14.8%	11.1%	0%	96.3%
Lighting Systems	Eversource (NSTAR)	9.9%	11.8%	0%	101.9%
Lighting Systems	Unitil	14.1%	11.3%	0%	97.2%
Lighting Systems	Eversource (WMECO)	43.2%	4.9%	0%	61.7%
Lighting Systems	CLC	14.1%	11.3%	0%	97.2%
Vending Machine and Cooler Controls (Lighting)	Eversource (NSTAR)	10.5%	0%	0%	89.5%
Energy Management System	National Grid	37.7%	23.9%	0%	86.2%
Energy Management System	Eversource (NSTAR)	13.3%	8.7%	0%	95.4%
Energy Management System	Unitil	14.7%	8.8%	0%	94%
Energy Management System	Eversource (WMECO)	14.7%	8.8%	0%	94.1%
Energy Management System	CLC	14.7%	8.8%	0%	94.0%
LEDs in Freezers/Coolers	CLC	13%	0%	0%	87%
Vending Misers	National Grid	37.7%	23.9%	0%	86.2%
Vending Misers	Unitil	13%	0%	0%	87%
Vending Misers	Eversource (WMECO)	13%	0%	0%	87%
Vending Misers	Eversource (NSTAR)	10.5%	0%	0%	89.5%
Vending Misers	CLC	13%	0%	0%	87%
Variable Frequency Drives	National Grid	6.8%	0%	0%	93.2%
Variable Frequency Drives	Eversource (NSTAR)	12.5%	3.6%	23.6%	114.7%
Variable Frequency Drives	Unitil	6.8%	0%	0%	93.2%
Variable Frequency Drives	Eversource (WMECO)	45%	7.1%	20.1%	82.2%
Variable Frequency Drives	CLC	6.8%	0%	0%	93.2%
Custom	National Grid	3.9%	0.7%	0%	96.8%
Custom	Unitil	3.9%	0.7%	0%	96.8%
Custom	CLC	3.9%	0.7%	0%	96.8%
Custom - Compressed Air	Eversource (NSTAR)	16.1%	0%	4.6%	88.5%
Custom – Compressed Air	Eversource (WMECO)	16.1%	0%	4.6%	88.5%
Custom - HVAC	Eversource (NSTAR)	13.3%	8.7%	0%	95.4%
Custom – HVAC	Eversource (WMECO)	14.7%	8.8%	0%	94.1%
Custom - HVAC	CLC	14.7%	8.8%	0%	94.1%
Custom - Lighting	Eversource (NSTAR)	9.9%	11.8%	0%	101.9%
Custom - Lighting	Eversource (WMECO)	43.2%	4.9%	0%	61.7%
Custom - Lighting	CLC	14.1%	11.3%	0%	97.2%
Custom – Motors	Eversource (NSTAR)	12.5%	3.6%	23.6%	114.7%
Custom – Motors	Eversource (WMECO)	45%	7.1%	20.1%	82.2%
Custom - Process	Eversource (NSTAR)	1.7%	3.6%	0%	101.9%
Custom – Process	Eversource (WMECO)	2.2%	3.1%	0%	100.9%
Custom – Refrigeration	Eversource (NSTAR)	10.5%	0%	0%	89.5%
Custom – Refrigeration	Eversource (WMECO)	13%	0%	0%	87%
Custom – Refrigeration	CLC	13%	0%	0%	127%
Custom – CHP	Eversource (NSTAR)	0.7%	0%	0%	99.3%

Measure	PA	FR	SO_P	SO_{NP}	NTG
Custom – CHP	Eversource (WMECO)	0.7%	0%	0%	99.3%
Custom – CHP	CLC	0.7%	0%	0%	99.3%
C&I Small Business					
Lighting Controls	National Grid	7.4%	1.8%	0.2%	94.6%
Lighting Controls	Eversource (NSTAR)	4.4%	6.1%	0%	101.7%
Lighting Controls	Unitil	8.7%	1.6%	0.4%	93.3%
Lighting Controls	Eversource (WMECO)	5.1%	14.6%	0%	109.5%
Lighting Controls	CLC	7.3%	12.0%	0%	104.8%
Lighting Systems	National Grid	7.4%	1.8%	0.2%	94.6%
Lighting Systems	Eversource (NSTAR)	4.4%	6.1%	0%	101.7%
Lighting Systems	Unitil	8.7%	1.6%	0.4%	93.3%
Lighting Systems	Eversource (WMECO)	5.1%	14.6%	0%	109.5%
Lighting Systems	CLC	7.3%	12.0%	0%	104.8%
Energy Management Systems (EMS)	CLC	3.3%	4.3%	0%	101%
Hotel Occupancy Sensors	CLC	7.3%	12.0%	0%	104.8%
Programmable Thermostats	National Grid	2.5%	7.2%	0%	104.7%
Programmable Thermostats	Eversource (NSTAR)	1.5%	5.8%	0%	104.3%
Programmable Thermostats	Unitil	3.3%	4.3%	0%	101%
Programmable Thermostats	CLC	3.3%	4.3%	0%	101%
Case Motor Replacement	National Grid	2.5%	7.2%	0%	104.7%
Case Motor Replacement	Eversource (NSTAR)	12.1%	0%	0%	87.9%
Case Motor Replacement	Unitil	12.2%	2.7%	0%	90.5%
Case Motor Replacement	Eversource (WMECO)	9.9%	15.1%	0%	105.2%
Case Motor Replacement	CLC	9.0%	0.7%	26.5%	118.3%
Cooler Night Covers	National Grid	2.5%	7.2%	0%	104.7%
Cooler Night Covers	Eversource (NSTAR)	12.1%	0%	0%	87.9%
Cooler Night Covers	Unitil	12.2%	2.7%	0%	90.5%
Cooler Night Covers	Eversource (WMECO)	9.9%	15.1%	0%	105.2%
Cooler Night Covers	CLC	20.3%	5.1%	0%	84.9%
Cooler/Freezer Door Heater Control	National Grid	2.5%	7.2%	0%	104.7%
Cooler/Freezer Door Heater Control	Eversource (NSTAR)	12.1%	0%	0%	87.9%
Cooler/Freezer Door Heater Control	Unitil	12.2%	2.7%	0%	90.5%
Cooler/Freezer Door Heater Control	Eversource (WMECO)	9.9%	15.1%	0%	105.2%
Cooler/Freezer Door Heater Control	CLC	20.3%	5.1%	0%	84.9%
Cooler/Freezer Evaporator Fan Controls	National Grid	2.5%	7.2%	0%	104.7%
Cooler/Freezer Evaporator Fan Controls	Eversource (NSTAR)	12.1%	0%	0%	87.9%
Cooler/Freezer Evaporator Fan Controls	Unitil	12.2%	2.7%	0%	90.5%
Cooler/Freezer Evaporator Fan Controls	Eversource (WMECO)	9.9%	15.1%	0%	105.2%
Cooler/Freezer Evaporator Fan Controls	CLC	20.3%	5.1%	0%	84.9%
ECM for Evaporator Fans in Walk-in Coolers and Freezers	National Grid	2.5%	7.2%	0%	104.7%
ECM for Evaporator Fans in Walk-in Coolers and Freezers	Eversource (NSTAR)	12.1%	0%	0%	87.9%
ECM for Evaporator Fans in Walk-in Coolers and Freezers	Unitil	12.2%	2.7%	0%	90.5%
ECM for Evaporator Fans in Walk-in Coolers and Freezers	Eversource (WMECO)	9.9%	15.1%	0%	105.2%

Measure	PA	FR	SO_P	SO_{NP}	NTG
ECM for Evaporator Fans in Walk-in Coolers and Freezers	CLC	20.3%	5.1%	0%	84.9%
Electronic Defrost Control	National Grid	2.5%	7.2%	0%	104.7%
Electronic Defrost Control	Eversource (NSTAR)	12.1%	0%	0%	87.9%
Electronic Defrost Control	Unitil	12.2%	2.7%	0%	90.5%
Electronic Defrost Control	Eversource (WMECO)	9.9%	15.1%	0%	105.2%
Electronic Defrost Control	CLC	20.3%	5.1%	0%	84.9%
LEDs in Freezers/Coolers	National Grid	7.4%	1.8%	0.2%	94.6%
LEDs in Freezers/Coolers	Eversource (NSTAR)	12.1%	0%	0%	87.9%
LEDs in Freezers/Coolers	Unitil	8.7%	1.6%	0.4%	93.3%
LEDs in Freezers/Coolers	Eversource (WMECO)	9.9%	15.1%	0%	105.2%
LEDs in Freezers/Coolers	CLC	7.3%	12.0%	0%	104.8%
Novelty Cooler Shutoff	National Grid	2.5%	7.2%	0%	104.7%
Novelty Cooler Shutoff	Eversource (NSTAR)	12.1%	0%	0%	87.9%
Novelty Cooler Shutoff	Unitil	12.2%	2.7%	0%	90.5%
Novelty Cooler Shutoff	Eversource (WMECO)	9.9%	15.1%	0%	105.2%
Novelty Cooler Shutoff	CLC	20.3%	5.1%	0%	84.9%
Vending Misers	CLC	20.3%	5.1%	0%	84.9%
Variable Frequency Drives	CLC	5.8%	2.70%	24.6%	121.4%
Variable Frequency Drives	Eversource (NSTAR)	10.1%	0%	27.2%	117.1%
Variable Frequency Drives	Eversource (WMECO)	9%	0.7%	26.5%	118.2%
Hot Water	Eversource (NSTAR)	11.3%	0%	0%	88.7%
Hot Water	Eversource (WMECO)	11.3%	0%	0%	88.7%
Process	Eversource (NSTAR)	21.8%	0%	0%	78.2%
Process	Eversource (WMECO)	21.8%	0%	0%	78.2%
Custom - HVAC	CLC	3.3%	4.3%	0%	101%
Custom – Building Envelope	CLC	25.0%	0%	0%	75%
Custom - Lighting	CLC	7.3%	12.0%	0%	104.8%
Custom – Motors	CLC	5.8%	2.70%	24.6%	121.4%
Custom – Refrigeration	CLC	20.3%	5.1%	0%	84.9%
Custom – Hot Water	CLC	11.3%	0%	0%	88.7%
C&I Multifamily Retrofit					
HVAC - Multifamily	National Grid	3%	7%	0%	105%
Hot Water - Multifamily	National Grid	3%	7%	0%	105%
Lighting - Multifamily	National Grid	18%	0%	0%	82%
HVAC Custom- Multifamily	National Grid	3.9%	0.7%	0%	96.8%
Hot Water Custom- Multifamily	National Grid	3.9%	0.7%	0%	96.8%
Lighting Custom- Multifamily	National Grid	3.9%	0.7%	0%	96.8%
HVAC - Multifamily	Eversource (NSTAR)	13.3%	8.7%	0%	95.4%
Hot Water - Multifamily	Eversource (NSTAR)	11.3%	0%	0%	88.7%
Lighting - Multifamily	Eversource (NSTAR)	18%	0%	0%	82%
HVAC Custom- Multifamily	Eversource (NSTAR)	13.3%	8.7%	0%	95.4%
Hot Water Custom- Multifamily	Eversource (NSTAR)	11.3%	0%	0%	88.7%
Lighting Custom- Multifamily	Eversource (NSTAR)	9.9%	11.8%	0%	102%
HVAC Custom- Multifamily	Eversource (WMECO)				
Hot Water Custom- Multifamily	Eversource (WMECO)				
Lighting Custom- Multifamily	Eversource (WMECO)				

Measure	PA	FR	SO_P	SO_{NP}	NTG
HVAC - Multifamily	Unitil	3.9%	0.7%	0%	96.8%
Hot Water - Multifamily	Unitil	3.9%	0.7%	0%	96.8%
Lighting - Multifamily	Unitil	18%	0%	0%	82%
HVAC Custom- Multifamily	Unitil	3.9%	0.7%	0%	96.8%
Hot Water Custom- Multifamily	Unitil	3.9%	0.7%	0%	96.8%
Lighting Custom- Multifamily	Unitil	3.9%	0.7%	0%	96.8%
HVAC Custom- Multifamily	CLC	14.7%	8.8%	0%	94.1%
Hot Water Custom- Multifamily	CLC	11.3%	0%	0%	88.7%
Lighting Custom- Multifamily	CLC	14.1%	11.3%	0%	97.2%
C&I Upstream Lighting 2016					
Upstream LED Linear	All	10.0%	10.0%	0.0%	100.0%
Upstream LED Screw In	All	21.0%	63.0%	1.0%	143.0%
Upstream Fluorescent	All	26.0%	0.0%	0.0%	74.0%
C&I Upstream Lighting 2017					
Upstream LED Linear	All	15.0%	10.0%	0.0%	95.0%
Upstream LED Screw In	All	26.0%	58.0%	1.0%	133.0%
Upstream Fluorescent	All	36.0%	0.0%	0.0%	64.0%
C&I Upstream Lighting 2018					
Upstream LED Linear	All	20%	10.0%	0.0%	90.0%
Upstream LED Screw In	All	31.0%	53.0%	1.0%	123.0%

EVALUATIONS

All factors except for Upstream Lighting are from the National Grid, NSTAR, Western Massachusetts Electric Company, Unitil, and Cape Light Compact 2013 Commercial and Industrial Electric Programs Free-ridership and Spillover Study.[766] Upstream LED Linear are MA Common Assumptions. Upstream LED Fluorescent comes from the Upstream Lighting Process evaluation completed in 2013[767] Upstream LED Screw in comes from the C&I LED Spillover study[768].

[766] TetraTech (2015). National Grid, Eversource (NSTAR), Western Massachusetts Electric Company, Unitil, and Cape Light Compact 2013 Commercial and Industrial Electric Programs Free-ridership and Spillover Study. February 17, 2015
[767] KEMA (2013). *Process Evaluation of the 2012 Bright Opportunities Program.* MA LCIEC Project 17.
[768] DNV-GL (2015). *Final report of Massachusetts LED Spillover Analysis.*

Commercial Natural Gas Measures					
Measure	**PA**	**FR**	**SO_P**	**SO_{NP}**	**NTG**
C&I New Buildings & Major Renovations and C&I Initial Purchase & End of Useful Life					
Furnace w/ECM	National Grid	30.1%	14.7%	0.0%	84.6%
Furnace w/ECM	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Furnace w/ECM	Columbia	29.3%	0.1%	0.4%	71.2%
Furnace w/ECM	Berkshire	43.7%	5.0%	0.0%	61.3%
Furnace w/ECM	Liberty	57.6%	11.6%	0.0%	54.0%
Furnace w/ECM	Unitil	32.4%	7.6%	0.6%	75.8%
Condensing Boiler	National Grid	30.1%	14.7%	0.0%	84.6%
Condensing Boiler	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Condensing Boiler	Columbia	29.3%	0.1%	0.4%	71.2%
Condensing Boiler	Berkshire	43.7%	5.0%	0.0%	61.3%
Condensing Boiler	Liberty	57.6%	11.6%	0.0%	54.0%
Condensing Boiler	Unitil	32.4%	7.6%	0.6%	75.8%
Condensing Unit Heater <= 300 mbh	National Grid	30.1%	14.7%	0.0%	84.6%
Condensing Unit Heater <= 300 mbh	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Condensing Unit Heater <= 300 mbh	Columbia	29.3%	0.1%	0.4%	71.2%
Condensing Unit Heater <= 300 mbh	Berkshire	43.7%	5.0%	0.0%	61.3%
Condensing Unit Heater <= 300 mbh	Liberty	57.6%	11.6%	0.0%	54.0%
Condensing Unit Heater <= 300 mbh	Unitil	32.4%	7.6%	0.6%	75.8%
Infrared Heaters	National Grid	30.1%	14.7%	0.0%	84.6%
Infrared Heaters	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Infrared Heaters	Columbia	29.3%	0.1%	0.4%	71.2%
Infrared Heaters	Berkshire	43.7%	5.0%	0.0%	61.3%
Infrared Heaters	Liberty	57.6%	11.6%	0.0%	54.0%
Infrared Heaters	Unitil	32.4%	7.6%	0.6%	75.8%
Combo Condensing Boiler/Water Heater	National Grid	30.1%	14.7%	0.0%	84.6%
Combo Condensing Boiler/Water Heater	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Combo Condensing Boiler/Water Heater	Columbia	29.3%	0.1%	0.4%	71.2%
Combo Condensing Boiler/Water Heater	Berkshire	43.7%	5.0%	0.0%	61.3%
Combo Condensing Boiler/Water Heater	Liberty	57.6%	11.6%	0.0%	54.0%
Combo Condensing Boiler/Water Heater	Unitil	32.4%	7.6%	0.6%	75.8%
Combination Oven	National Grid	30.1%	14.7%	0.0%	84.6%
Combination Oven	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Combination Oven	Columbia	29.3%	0.1%	0.4%	71.2%
Combination Oven	Berkshire	43.7%	5.0%	0.0%	61.3%
Combination Oven	Liberty	57.6%	11.6%	0.0%	54.0%
Combination Oven	Unitil	32.4%	7.6%	0.6%	75.8%
Convection Oven	National Grid	30.1%	14.7%	0.0%	84.6%
Convection Oven	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Convection Oven	Columbia	29.3%	0.1%	0.4%	71.2%
Convection Oven	Berkshire	43.7%	5.0%	0.0%	61.3%

Measure	PA	FR	SO_P	SO_{NP}	NTG
Convection Oven	Liberty	57.6%	11.6%	0.0%	54.0%
Convection Oven	Unitil	32.4%	7.6%	0.6%	75.8%
Conveyer Oven	National Grid	30.1%	14.7%	0.0%	84.6%
Conveyer Oven	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Conveyer Oven	Columbia	29.3%	0.1%	0.4%	71.2%
Conveyer Oven	Berkshire	43.7%	5.0%	0.0%	61.3%
Conveyer Oven	Liberty	57.6%	11.6%	0.0%	54.0%
Conveyer Oven	Unitil	32.4%	7.6%	0.6%	75.8%
Rack Oven	National Grid	30.1%	14.7%	0.0%	84.6%
Rack Oven	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Rack Oven	Columbia	29.3%	0.1%	0.4%	71.2%
Rack Oven	Berkshire	43.7%	5.0%	0.0%	61.3%
Rack Oven	Liberty	57.6%	11.6%	0.0%	54.0%
Rack Oven	Unitil	32.4%	7.6%	0.6%	75.8%
Griddle	National Grid	30.1%	14.7%	0.0%	84.6%
Griddle	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Griddle	Columbia	29.3%	0.1%	0.4%	71.2%
Griddle	Berkshire	43.7%	5.0%	0.0%	61.3%
Griddle	Liberty	57.6%	11.6%	0.0%	54.0%
Griddle	Unitil	32.4%	7.6%	0.6%	75.8%
Fryer	National Grid	30.1%	14.7%	0.0%	84.6%
Fryer	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Fryer	Columbia	29.3%	0.1%	0.4%	71.2%
Fryer	Berkshire	43.7%	5.0%	0.0%	61.3%
Fryer	Liberty	57.6%	11.6%	0.0%	54.0%
Fryer	Unitil	32.4%	7.6%	0.6%	75.8%
Steamer	National Grid	30.1%	14.7%	0.0%	84.6%
Steamer	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Steamer	Columbia	29.3%	0.1%	0.4%	71.2%
Steamer	Berkshire	43.7%	5.0%	0.0%	61.3%
Steamer	Liberty	57.6%	11.6%	0.0%	54.0%
Steamer	Unitil	32.4%	7.6%	0.6%	75.8%
Custom	National Grid	11.0%	2.6%	0.3%	91.9%
Custom	Eversource (NSTAR)	20.6%	2.4%	1.0%	82.8%
Custom	Columbia	19.0%	5.2%	0.0%	86.2%
Custom	Berkshire	5.3%	3.4%	0.5%	98.6%
Custom	Liberty	15.7%	29.1%	0.0%	113.4%
Custom	Unitil	15.7%	3.4%	0.5%	88.2%

Measure	PA	FR	SO_P	SO_{NP}	NTG
C&I Existing Building Retrofit and C&I Small Business					
Boiler Reset Control	National Grid	30.1%	14.7%	0.0%	84.6%
Boiler Reset Control	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Boiler Reset Control	Columbia	29.3%	0.1%	0.4%	71.2%
Boiler Reset Control	Berkshire	43.7%	5.0%	0.0%	61.3%
Boiler Reset Control	Liberty	57.6%	11.6%	0.0%	54.0%
Boiler Reset Control	Unitil	32.4%	7.6%	0.6%	75.8%
Programmable Thermostat	National Grid	30.1%	14.7%	0.0%	84.6%
Programmable Thermostat	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Programmable Thermostat	Columbia	29.3%	0.1%	0.4%	71.2%
Programmable Thermostat	Berkshire	43.7%	5.0%	0.0%	61.3%
Programmable Thermostat	Liberty	57.6%	11.6%	0.0%	54.0%
Programmable Thermostat	Unitil	32.4%	7.6%	0.6%	75.8%
Wi-Fi Thermostat	National Grid	30.1%	14.7%	0.0%	84.6%
Wi-Fi Thermostat	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Wi-Fi Thermostat	Columbia	29.3%	0.1%	0.4%	71.2%
Wi-Fi Thermostat	Berkshire	43.7%	5.0%	0.0%	61.3%
Wi-Fi Thermostat	Liberty	57.6%	11.6%	0.0%	54.0%
Wi-Fi Thermostat	Unitil	32.4%	7.6%	0.6%	75.8%
Duct Insulation	National Grid	30.1%	14.7%	0.0%	84.6%
Duct Insulation	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Duct Insulation	Columbia	29.3%	0.1%	0.4%	71.2%
Duct Insulation	Berkshire	43.7%	5.0%	0.0%	61.3%
Duct Insulation	Liberty	57.6%	11.6%	0.0%	54.0%
Duct Insulation	Unitil	32.4%	7.6%	0.6%	75.8%
Duct Sealing	National Grid	30.1%	14.7%	0.0%	84.6%
Duct Sealing	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Duct Sealing	Columbia	29.3%	0.1%	0.4%	71.2%
Duct Sealing	Berkshire	43.7%	5.0%	0.0%	61.3%
Duct Sealing	Liberty	57.6%	11.6%	0.0%	54.0%
Duct Sealing	Unitil	32.4%	7.6%	0.6%	75.8%
Faucet Aerator	National Grid	30.1%	14.7%	0.0%	84.6%
Faucet Aerator	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Faucet Aerator	Columbia	29.3%	0.1%	0.4%	71.2%
Faucet Aerator	Berkshire	43.7%	5.0%	0.0%	61.3%
Faucet Aerator	Liberty	57.6%	11.6%	0.0%	54.0%
Faucet Aerator	Unitil	32.4%	7.6%	0.6%	75.8%
Low-Flow Showerhead	National Grid	30.1%	14.7%	0.0%	84.6%
Low-Flow Showerhead	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Low-Flow Showerhead	Columbia	29.3%	0.1%	0.4%	71.2%
Low-Flow Showerhead	Berkshire	43.7%	5.0%	0.0%	61.3%
Low-Flow Showerhead	Liberty	57.6%	11.6%	0.0%	54.0%
Low-Flow Showerhead	Unitil	32.4%	7.6%	0.6%	75.8%
Pre-Rinse Spray Valve	National Grid	30.1%	14.7%	0.0%	84.6%
Pre-Rinse Spray Valve	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%

Measure	PA	FR	SO_P	SO_{NP}	NTG
Pre-Rinse Spray Valve	Columbia	29.3%	0.1%	0.4%	71.2%
Pre-Rinse Spray Valve	Berkshire	43.7%	5.0%	0.0%	61.3%
Pre-Rinse Spray Valve	Liberty	57.6%	11.6%	0.0%	54.0%
Pre-Rinse Spray Valve	Unitil	32.4%	7.6%	0.6%	75.8%
Steam Traps	National Grid	30.1%	14.7%	0.0%	84.6%
Steam Traps	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Steam Traps	Columbia	29.3%	0.1%	0.4%	71.2%
Steam Traps	Berkshire	43.7%	5.0%	0.0%	61.3%
Steam Traps	Liberty	57.6%	11.6%	0.0%	54.0%
Steam Traps	Unitil	32.4%	7.6%	0.6%	75.8%
Hot Water Pipe Insulation	National Grid	30.1%	14.7%	0.0%	84.6%
Hot Water Pipe Insulation	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Hot Water Pipe Insulation	Columbia	29.3%	0.1%	0.4%	71.2%
Hot Water Pipe Insulation	Berkshire	43.7%	5.0%	0.0%	61.3%
Hot Water Pipe Insulation	Liberty	57.6%	11.6%	0.0%	54.0%
Hot Water Pipe Insulation	Unitil	32.4%	7.6%	0.6%	75.8%
Steam Pipe Insulation	National Grid	30.1%	14.7%	0.0%	84.6%
Steam Pipe Insulation	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Steam Pipe Insulation	Columbia	29.3%	0.1%	0.4%	71.2%
Steam Pipe Insulation	Berkshire	43.7%	5.0%	0.0%	61.3%
Steam Pipe Insulation	Liberty	57.6%	11.6%	0.0%	54.0%
Steam Pipe Insulation	Unitil	32.4%	7.6%	0.6%	75.8%
Custom Measures	National Grid	11.0%	2.6%	0.3%	91.9%
Custom Measures	Eversource (NSTAR)	20.6%	2.4%	1.0%	82.8%
Custom Measures	Columbia	19.0%	5.2%	0.0%	86.2%
Custom Measures	Berkshire	5.3%	3.4%	0.5%	98.6%
Custom Measures	Liberty	15.7%	29.1%	0.0%	113.4%
Custom Measures	Unitil	15.7%	3.4%	0.5%	88.2%
C&I Multifamily Retrofit					
Building Shell - Custom	National Grid	11%	2.6%	0.3%	91.9%
Building Shell - Custom	Eversource (NSTAR)	20.6%	2.4%	1.0%	82.8%
Building Shell - Custom	Columbia	19.0%	5.2%	0.0%	86.2%
Building Shell - Custom	Berkshire	5.3%	3.4%	0.5%	98.6%
Building Shell - Custom	Liberty	15.7%	3.4%	0.5%	88.3%
Building Shell - Custom	Unitil	15.7%	3.4%	0.5%	88.3%
HVAC - Custom	National Grid	11%	2.6%	0.3%	91.9%
HVAC - Custom	Eversource (NSTAR)	20.6%	2.4%	1.0%	82.8%
HVAC - Custom	Columbia	19.0%	5.2%	0.0%	86.2%
HVAC - Custom	Berkshire	5.3%	3.4%	0.5%	98.6%
HVAC - Custom	Liberty	15.7%	3.4%	0.5%	88.3%
HVAC - Custom	Unitil	15.7%	3.4%	0.5%	88.3%
Heating - Custom	National Grid	11%	2.6%	0.3%	91.9%
Heating - Custom	Eversource (NSTAR)	20.6%	2.4%	1.0%	82.8%
Heating - Custom	Columbia	19.0%	5.2%	0.0%	86.2%
Heating - Custom	Berkshire	5.3%	3.4%	0.5%	98.6%

Measure	PA	FR	SO_P	SO_{NP}	NTG
Heating - Custom	Liberty	15.7%	29.1%	0.0%	113.4%
Heating - Custom	Unitil	15.7%	3.4%	0.5%	88.3%
Hot Water - Custom	National Grid	11%	2.6%	0.3%	91.9%
Hot Water - Custom	Eversource (NSTAR)	20.6%	2.4%	1.0%	82.8%
Hot Water - Custom	Columbia	19.0%	5.2%	0.0%	86.2%
Hot Water - Custom	Berkshire	5.3%	3.4%	0.5%	98.6%
Hot Water - Custom	Liberty	15.7%	3.4%	0.5%	88.3%
Hot Water - Custom	Unitil	15.7%	3.4%	0.5%	88.3%
Duct Sealing	National Grid	11%	2.6%	0.3%	91.9%
Duct Sealing	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Duct Sealing	Columbia	19.0%	5.2%	0.0%	86.2%
Duct Sealing	Berkshire	43.7%	5.0%	0.0%	61.3%
Duct Sealing	Liberty	57.6%	11.6%	0%	54.0%
Duct Sealing	Unitil	32.4%	7.6%	0.6%	75.8%
Duct Insulation	National Grid	11%	2.6%	0.3%	91.9%
Duct Insulation	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Duct Insulation	Columbia	19.0%	5.2%	0.0%	86.2%
Duct Insulation	Berkshire	43.7%	5.0%	0.0%	61.3%
Duct Insulation	Liberty	57.6%	11.6%	0%	54.0%
Duct Insulation	Unitil	32.4%	7.6%	0.6%	75.8%
Pipe Wrap (Water Heating)	National Grid	30.1%	14.7%	0.0%	84.6%
Pipe Wrap (Water Heating)	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Pipe Wrap (Water Heating)	Columbia	19.0%	5.2%	0.0%	86.2%
Pipe Wrap (Water Heating)	Berkshire	43.7%	5.0%	0.0%	61.3%
Pipe Wrap (Water Heating)	Liberty	57.6%	11.6%	0%	54.0%
Pipe Wrap (Water Heating)	Unitil	32.4%	7.6%	0.6%	75.8%
Pipe Wrap (Heating)	National Grid	30.1%	14.7%	0.0%	84.6%
Pipe Wrap (Heating)	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Pipe Wrap (Heating)	Columbia	19.0%	5.2%	0.0%	86.2%
Pipe Wrap (Heating)	Berkshire	43.7%	5.0%	0.0%	61.3%
Pipe Wrap (Heating)	Liberty	57.6%	11.6%	0%	54.0%
Pipe Wrap (Heating)	Unitil	32.4%	7.6%	0.6%	75.8%
Faucet Aerator	National Grid	30.1%	14.7%	0.0%	84.6%
Faucet Aerator	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Faucet Aerator	Columbia	19.0%	5.2%	0.0%	86.2%
Faucet Aerator	Berkshire	43.7%	5.0%	0.0%	61.3%
Faucet Aerator	Liberty	57.6%	11.6%	0%	54.0%
Faucet Aerator	Unitil	32.4%	7.6%	0.6%	75.8%
Low-Flow Showerhead	National Grid	30.1%	14.7%	0.0%	84.6%
Low-Flow Showerhead	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Low-Flow Showerhead	Columbia	19.0%	5.2%	0.0%	86.2%
Low-Flow Showerhead	Berkshire	43.7%	5.0%	0.0%	61.3%
Low-Flow Showerhead	Liberty	57.6%	11.6%	0%	54.0%
Low-Flow Showerhead	Unitil	32.4%	7.6%	0.6%	75.8%
Programmable Thermostat	National Grid	30.1%	14.7%	0.0%	84.6%

Measure	PA	FR	SO_P	SO_{NP}	NTG
Programmable Thermostat	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Programmable Thermostat	Columbia	19.0%	5.2%	0.0%	86.2%
Programmable Thermostat	Berkshire	43.7%	5.0%	0.0%	61.3%
Programmable Thermostat	Liberty	57.6%	11.6%	0%	54.0%
Programmable Thermostat	Unitil	32.4%	7.6%	0.6%	75.8%
Wi-Fi Thermostat	National Grid	30.1%	14.7%	0.0%	84.6%
Wi-Fi Thermostat	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Wi-Fi Thermostat	Columbia	19.0%	5.2%	0.0%	86.2%
Wi-Fi Thermostat	Berkshire	43.7%	5.0%	0.0%	61.3%
Wi-Fi Thermostat	Liberty	57.6%	11.6%	0%	54.0%
Wi-Fi Thermostat	Unitil	32.4%	7.6%	0.6%	75.8%
Demand Circulator	National Grid	30.1%	14.7%	0.0%	84.6%
Demand Circulator	Eversource (NSTAR)	35.2%	2.8%	0.5%	68.1%
Demand Circulator	Columbia	19.0%	5.2%	0.0%	86.2%

Sources

For C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life, C&I Existing Building Retrofit, C&I Small Business and C&I Multifamily Retrofit all Net-to-Gross factors are based on the results of the 2014-2015 Commercial and Industrial Natural Gas Programs Free-ridership and Spillover Study conducted by TetraTech for the MA Gas PAs.[769] This study developed free-ridership and participant spillover rates for each PA for prescriptive and custom measures. PAs that had fewer than 10 customers surveyed for a program type used the statewide rates.

For C&I Multifamily Retrofit, National Grid, Eversource, Berkshire and Liberty use the Custom NTG values for Custom measures and the Prescriptive NTG values for all other measures. Columbia uses Custom NTG values for all C&I MF Retrofit measures.

[769] TetraTech (2015). National Grid, Eversource, Unitil, Berkshire Gas, Columbia Gas of MA, and Liberty Utilities 2014-2015 Commercial and Industrial Natural Gas Programs Free-ridership and Spillover Study. August 2015.

Appendix C: Non-Resource Impacts

	NEI Category	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per KWh	Annual $ per Therm	One-time $ per Therm
Residential New Construction							
CFL Bulb	Lighting Quality and Lifetime		3.00				
LED Bulb	Lighting Quality and Lifetime		3.00				
Heating	Property Value Increase	72.00					
Heating	Thermal Comfort	77.00					
Heating	Noise Reduction	40.00					
Heating (High Rise) - Gas PA only	Property Value Increase	72.00					
Heating (High Rise) - Gas PA only	Thermal Comfort	77.00					
Heating (High Rise) - Gas PA only	Noise Reduction	40.00					
Residential Multi-Family Retrofit							
Air Sealing	Thermal Comfort	10.13					
Air Sealing	Noise Reduction	4.88					
Air Sealing	Home Durability	3.95					
Air Sealing	Health Benefits	0.32					
Air Sealing	Property Value Increase		135.83				
Insulation	Thermal Comfort	25.15					
Insulation	Noise Reduction	11.54					
Insulation	Home Durability	9.82					
Insulation	Health Benefits	0.80					
Insulation	Property Value Increase		378.05				
Duct Seal	Thermal Comfort	0.16					
Duct Seal	Home Durability	0.06					
Duct Seal	Health Benefits	0.01					
Duct Seal	Property Value Increase		2.51				
Low-Flow Showerhead	Property Value Increase		0.03				
Low-Flow Showerhead with TSV	Property Value Increase		0.03				
Wi-Fi Thermostat	Thermal Comfort	3.99					
Wi-Fi Thermostat	Home Durability	1.33					
Wi-Fi Thermostat	Health Benefits	0.13					
Wi-Fi Thermostat	Property Value Increase		51.49				
Programmable Thermostat	Thermal Comfort	3.99					
Programmable Thermostat	Home Durability	1.33					
Programmable Thermostat	Health Benefits	0.13					
Programmable Thermostat	Property Value Increase		51.49				

	NEI Category	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per KWh	Annual $ per Therm	One-time $ per Therm
Refrigerator	Property Value Increase		1.44				
CFL Bulb	Lighting Quality and Lifetime		3.00				
LED Bulb	Lighting Quality and Lifetime		3.00				
Fixtures	Lighting Quality and Lifetime		3.50				
Residential Home Energy Services							
Air Sealing	Thermal Comfort	10.13					
Air Sealing	Noise Reduction	4.88					
Air Sealing	Home Durability	3.95					
Air Sealing	Health Benefits	0.32					
Air Sealing	Property Value Increase		135.83				
Insulation	Thermal Comfort	25.15					
Insulation	Noise Reduction	11.54					
Insulation	Home Durability	9.82					
Insulation	Health Benefits	0.80					
Insulation	Property Value Increase		378.05				
Duct Seal	Thermal Comfort	0.16					
Duct Seal	Home Durability	0.06					
Duct Seal	Health Benefits	0.01					
Duct Seal	Property Value Increase		2.51				
Programmable Thermostat	Thermal Comfort	3.99					
Programmable Thermostat	Home Durability	1.33					
Programmable Thermostat	Health Benefits	0.13					
Programmable Thermostat	Property Value Increase		51.49				
Early Retirement Boiler (EE)	Thermal Comfort	24.32					
Early Retirement Boiler (EE)	Home Durability	5.75					
Early Retirement Boiler (EE)	Health Benefits	0.78					
Early Retirement Boiler (EE)	Property Value Increase		339.26				
Early Retirement Boiler (Retire)	Thermal Comfort	24.32					
Early Retirement Boiler (Retire)	Home Durability	11.67					
Early Retirement Boiler (Retire)	Health Benefits	0.78					
Early Retirement Boiler (Retire)	Equipment Maintenance	102.40					
Early Retirement Boiler (Retire)	Property Value Increase		339.26				
Heating System Replacement	Thermal Comfort	24.32					

	NEI Category	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per KWh	Annual $ per Therm	One-time $ per Therm
Heating System Replacement	Home Durability	5.75					
Heating System Replacement	Health Benefits	0.78					
Heating System Replacement	Property Value Increase		339.26				
Indirect Water Heater	Home Durability	0.70					
Indirect Water Heater	Property Value Increase		41.28				
On Demand Water Heater	Home Durability	0.70					
On Demand Water Heater	Property Value Increase		41.28				
Low-Flow Showerhead	Property Value Increase		0.03				
Refrigerator	Property Value Increase		1.44				
CFL Bulb	Lighting Quality and Lifetime		3.00				
LED Bulb	Lighting Quality and Lifetime		3.00				
Residential Heating & Cooling Equipment							
Central Air SEER 16	Thermal Comfort	2.24					
Central Air SEER 16	Noise Reduction	2.03					
Central Air SEER 16	Home Durability	0.65					
Central Air SEER 16	Equipment Maintenance	1.07					
Central Air SEER 16	Health Benefits	0.07					
Central Air SEER 16	Property Value Increase		35.77				
Heat Pump SEER 16	Thermal Comfort	2.88					
Heat Pump SEER 16	Home Durability	0.84					
Heat Pump SEER 16	Equipment Maintenance	1.34					
Heat Pump SEER 16	Health Benefits	0.09					
Heat Pump SEER 16	Property Value Increase		46.07				
Heat Pump SEER 18	Thermal Comfort	2.88					
Heat Pump SEER 18	Home Durability	0.84					
Heat Pump SEER 18	Equipment Maintenance	1.34					
Heat Pump SEER 18	Health Benefits	0.09					
Heat Pump SEER 18	Property Value Increase		46.07				
Mini Split HP (SEER 18)	Thermal Comfort	2.53					
Mini Split HP (SEER 18)	Home Durability	0.65					
Mini Split HP (SEER 18)	Equipment Maintenance	-					
Mini Split HP (SEER 18)	Health Benefits	0.08					
Mini Split HP (SEER 18)	Property Value Increase		40.35				
Mini Split HP (SEER 20)	Thermal Comfort	2.53					
Mini Split HP (SEER 20)	Home Durability	0.65					
Mini Split HP (SEER 20)	Equipment Maintenance	-					
Mini Split HP (SEER 20)	Health Benefits	0.08					

	NEI Category	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per KWh	Annual $ per Therm	One-time $ per Therm
Mini Split HP (SEER 20)	Property Value Increase		40.35				
Down size 1/2 ton	Thermal Comfort	0.19					
Down size 1/2 ton	Home Durability	0.07					
Down size 1/2 ton	Equipment Maintenance	0.37					
Down size 1/2 ton	Health Benefits	0.01					
Down size 1/2 ton	Property Value Increase		3.01				
Digital Check up/tune up	Thermal Comfort	0.47					
Digital Check up/tune up	Home Durability	0.18					
Digital Check up/tune up	Equipment Maintenance	0.87					
Digital Check up/tune up	Health Benefits	0.01					
Digital Check up/tune up	Property Value Increase		7.44				
QIV	Thermal Comfort	0.47					
QIV	Home Durability	0.18					
QIV	Equipment Maintenance	0.87					
QIV	Health Benefits	0.01					
QIV	Property Value Increase		7.44				
DHW - Condensing 0.95	Home Durability	0.70					
DHW - Condensing 0.95	Property Value Increase		41.28				
DHW - Tankless 0.82	Home Durability	1.23					
DHW - Tankless 0.82	Property Value Increase		56.39				
DHW - Tankless 0.94	Home Durability	1.23					
DHW - Tankless 0.94	Property Value Increase		56.39				
DHW - Indirect	Home Durability	0.70					
DHW - Indirect	Property Value Increase		41.28				
DHW - Stand Alone 0.67	Home Durability	1.30					
DHW - Stand Alone 0.67	Property Value Increase		24.09				
Combo Condensing Boiler/Water Heater 90%	Thermal Comfort	1.21					
Combo Condensing Boiler/Water Heater 90%	Home Durability	0.39					
Combo Condensing Boiler/Water Heater 90%	Equipment Maintenance	1.10					
Combo Condensing Boiler/Water Heater 90%	Health Benefits	0.04					
Combo Condensing Boiler/Water Heater 90%	Property Value Increase		19.27				
Combo Condensing Boiler/Water Heater 90%	Thermal Comfort	1.21					
Combo Condensing Boiler/Water Heater 90%	Home Durability	0.39					
Combo Condensing Boiler/Water Heater 90%	Equipment Maintenance	1.10					

	NEI Category	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per KWh	Annual $ per Therm	One-time $ per Therm
Combo Condensing Boiler/Water Heater 90%	Health Benefits	0.04					
Combo Condensing Boiler/Water Heater 90%	Property Value Increase		19.27				
Furnace w/ECM 95%	Thermal Comfort	27.18					
Furnace w/ECM 95%	Home Durability	7.12					
Furnace w/ECM 95%	Equipment Maintenance	11.98					
Furnace w/ECM 95%	Health Benefits	0.87					
Furnace w/ECM 95%	Property Value Increase		379.29				
Furnace w/ECM 97%	Thermal Comfort	27.18					
Furnace w/ECM 97%	Home Durability	7.12					
Furnace w/ECM 97%	Equipment Maintenance	11.98					
Furnace w/ECM 97%	Health Benefits	0.87					
Furnace w/ECM 97%	Property Value Increase		379.29				
Boiler 90%	Thermal Comfort	27.61					
Boiler 90%	Home Durability	7.33					
Boiler 90%	Equipment Maintenance	13.88					
Boiler 90%	Health Benefits	0.89					
Boiler 90%	Property Value Increase		385.23				
Boiler 95%	Thermal Comfort	27.49					
Boiler 95%	Home Durability	7.28					
Boiler 95%	Equipment Maintenance	13.47					
Boiler 95%	Health Benefits	0.88					
Boiler 95%	Property Value Increase		383.53				
Programmable Thermostat	Thermal Comfort	3.99					
Programmable Thermostat	Home Durability	1.33					
Programmable Thermostat	Health Benefits	0.13					
Programmable Thermostat	Property Value Increase		51.49				
Wi-Fi Thermostat	Thermal Comfort	3.99					
Wi-Fi Thermostat	Home Durability	1.33					
Wi-Fi Thermostat	Health Benefits	0.13					
Wi-Fi Thermostat	Property Value Increase		51.49				
Residential Lighting							
CFL Bulb	Lighting Quality and Lifetime		3.00				
LED Bulb	Lighting Quality and Lifetime		3.00				
Fixture	Lighting Quality and Lifetime		3.50				
Low-Income Single Family Retrofit							
Participants/TLC Kit	Arrearages	2.61					
Participants/TLC Kit	Bad Debt Write-offs	3.74					

	NEI Category	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per KWh	Annual $ per Therm	One-time $ per Therm
Participants/TLC Kit	Terminations and Reconnections	0.43					
Participants/TLC Kit	Customer Calls and Collections	0.58					
Participants/TLC Kit	Notices	0.34					
Participants/TLC Kit	Lighting Quality and Lifetime		56.00				
Participants/TLC Kit	Lighting Property Value Increase		226.31				
Participants/TLC Kit	Rate Discounts			Varies		Varies	
Participants/TLC Kit	Price Hedging				0.01		0.076
Weatherization	Thermal Comfort	55.61					
Weatherization	Noise Reduction	29.95					
Weatherization	Home Durability	19.37					
Weatherization	Health Benefits	10.46					
Weatherization	Property Value Increase		368.56				
Weatherization	Rate Discounts			Varies		Varies	
Weatherization	Price Hedging				0.01		0.076
Air Sealing	Thermal Comfort	30.23					
Air Sealing	Noise Reduction	16.39					
Air Sealing	Home Durability	10.61					
Air Sealing	Health Benefits	5.69					
Air Sealing	Property Value Increase		144.93				
Air Sealing	Rate Discounts			Varies		Varies	
Air Sealing	Price Hedging				0.01		0.076
Insulation	Thermal Comfort	25.38					
Insulation	Noise Reduction	13.56					
Insulation	Home Durability	8.76					
Insulation	Health Benefits	4.77					
Insulation	Property Value Increase		223.63				
Insulation	Rate Discounts			Varies		Varies	
Insulation	Price Hedging				0.01		0.076
Heating System Retrofit	Safety Related Emergency Calls	8.43					
Heating System Retrofit	Thermal Comfort	28.01					
Heating System Retrofit	Equipment Maintenance	9.72					
Heating System Retrofit	Home Durability	27.43					
Heating System Retrofit	Health Benefits	5.27					
Heating System Retrofit	Improved Safety	45.05					
Heating System Retrofit	Property Value Increase	-	249.20				
Heating System Retrofit	Rate Discounts			Varies		Varies	
Heating System Retrofit	Price Hedging	-			0.01		0.076

	NEI Category	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per KWh	Annual $ per Therm	One-time $ per Therm
Heat Pump Water Heater <55 gallon	Home Durability	0.20					
Heat Pump Water Heater <55 gallon	Property Value Increase		1.65				
Heat Pump Water Heater <55 gallon	Rate Discounts			Varies		Varies	
Heat Pump Water Heater <55 gallon	Price Hedging				0.01		0.076
Duct Seal	Thermal Comfort	0.68					
Duct Seal	Home Durability	0.23					
Duct Seal	Health Benefits	0.13					
Duct Seal	Property Value Increase		5.11				
Duct Seal	Rate Discounts			Varies		Varies	
Duct Seal	Price Hedging				0.01		0.076
Pipe Wrap (Water Heating)	Thermal Comfort	5.56					
Pipe Wrap (Water Heating)	Health Benefits	1.05					
Pipe Wrap (Water Heating)	Property Value Increase		5.00				
Duct Seal	Rate Discounts			Varies		Varies	
Duct Seal	Price Hedging				0.01		0.076
Low-Flow Showerhead	Property Value Increase		1.72				
Low-Flow Showerhead	Rate Discounts			Varies		Varies	
Low-Flow Showerhead	Price Hedging				0.01		0.076
Faucet Aerator - Gas PA only	Property Value Increase		26.61				
Faucet Aerator	Rate Discounts			Varies		Varies	
Faucet Aerator	Price Hedging				0.01		0.076
CFL Bulb	Rate Discounts			Varies		Varies	
CFL Bulb	Price Hedging				0.01		0.076
LED Bulb	Rate Discounts			Varies		Varies	
LED Bulb	Price Hedging				0.01		0.076
Fixture	Rate Discounts			Varies		Varies	
Fixture	Price Hedging				0.01		0.076
Freezer Replacement	Rate Discounts			Varies		Varies	
Freezer Replacement	Property Value Increase		26.61				
Freezer Replacement	Price Hedging				0.01		0.076
Refrigerator Replacement	Rate Discounts			Varies		Varies	
Refrigerator Replacement	Property Value Increase		26.61				
Refrigerator Replacement	Price Hedging				0.01		0.076
Appliance Removal	Rate Discounts			Varies		Varies	
Appliance Removal	Price Hedging				0.01		0.076
Smart Strips	Rate Discounts			Varies		Varies	

	NEI Category	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per KWh	Annual $ per Therm	One-time $ per Therm
Smart Strips	Price Hedging				0.01		0.076
Programmable Thermostat	Thermal Comfort	4.87					
Programmable Thermostat	Home Durability	1.68					
Programmable Thermostat	Health Benefits	0.92					
Programmable Thermostat	Property Value Increase		34.47				
Window AC Replacement	Window Air Conditioner Replacement	49.50					
Window AC Replacement	Rate Discounts			Varies		Varies	
Window AC Replacement	Price Hedging				0.01		0.076
Waterbed	Rate Discounts			Varies		Varies	
Waterbed	Price Hedging				0.01		0.076
Dehumidifier	Rate Discounts			Varies		Varies	
Dehumidifier	Price Hedging				0.01		0.076
Low-Income Multi-Family Retrofit							
Participant	Arrearages	2.61					
Participant	Bad Debt Write-offs	3.74					
Participant	Terminations and Reconnections	0.43					
Participant	Customer Calls and Collections	0.58					
Participant	Notices	0.34					
Participant – Electric PA only	Lighting Quality and Lifetime		56.00				
Participant	Rate Discounts			Varies		Varies	
Participant	Price Hedging				0.01		0.076
Air Sealing	Thermal Comfort	30.23					
Air Sealing	Noise Reduction	16.39					
Air Sealing	Home Durability	10.61					
Air Sealing	Health Benefits	5.69					
Air Sealing	Property Durability	2.58					
Air Sealing	Rental Unit Increased Property Value		1.19				
Air Sealing	Rental Units Marketability	0.07					
Air Sealing	Reduced Tenant Complaints	1.37					
Air Sealing	Property Value Increase		144.93				
Air Sealing	Rate Discounts			Varies		Varies	
Air Sealing	Price Hedging				0.01		0.076
Insulation	Thermal Comfort	25.38					
Insulation	Noise Reduction	13.56					
Insulation	Home Durability	8.76					
Insulation	Health Benefits	4.77					

	NEI Category	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per KWh	Annual $ per Therm	One-time $ per Therm
Insulation	Property Value Increase		223.63				
Insulation	Rate Discounts			Varies		Varies	
Insulation	Price Hedging				0.01		0.076
Heating System Retrofit	Safety Related Emergency Calls	8.43					
Heating System Retrofit	Thermal Comfort	28.01					
Heating System Retrofit	Equipment Maintenance	9.72					
Heating System Retrofit	Home Durability	27.43					
Heating System Retrofit	Health Benefits	5.27					
Heating System Retrofit	Improved Safety	45.05					
Heating System Retrofit	Property Value Increase	-	249.20				
Heating System Retrofit	Rate Discounts			Varies		Varies	
Heating System Retrofit	Price Hedging	-			0.01		0.076
Duct Seal	Thermal Comfort	0.68					
Duct Seal	Home Durability	0.23					
Duct Seal	Health Benefits	0.13					
Duct Seal	Property Value Increase		5.11				
Duct Seal	Rate Discounts			Varies		Varies	
Duct Seal	Price Hedging				0.01		0.076
Pipe Wrap (Water Heating)	Thermal Comfort	5.56					
Pipe Wrap (Water Heating)	Health Benefits	1.05					
Pipe Wrap (Water Heating)	Property Value Increase		5.00				
Pipe Wrap (Water Heating)	Rate Discounts			Varies		Varies	
Pipe Wrap (Water Heating)	Price Hedging				0.01		0.076
Pipe Wrap (Heating)	Thermal Comfort	5.56					
Pipe Wrap (Heating)	Health Benefits	1.05					
Pipe Wrap (Heating)	Property Value Increase		5.00				
Pipe Wrap (Heating)	Rate Discounts			Varies		Varies	
Pipe Wrap (Heating)	Price Hedging				0.01		0.076
Water Heater	Home Durability	0.20					
Water Heater	Rental Units Marketability	0.01					
Water Heater	Reduced Tenant Complaints	0.20					
Water Heater	Property Durability	0.37					
Water Heater	Rental Unit Increased Property Value		0.17				
Water Heater	Property Value Increase		1.65				
Water Heater	Rate Discounts			Varies		Varies	
Water Heater	Price Hedging				0.01		0.076
Low-Flow Showerhead	Property Value Increase		1.72				

	NEI Category	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per KWh	Annual $ per Therm	One-time $ per Therm
Low-Flow Showerhead	Rate Discounts			Varies		Varies	
Low-Flow Showerhead	Price Hedging				0.01		0.076
Low-Flow Showerhead	Rental Units Marketability	0.01					
Low-Flow Showerhead	Home Durability	0.37					
Low-Flow Showerhead	Reduced Tenant Complaints	0.20					
Low-Flow Showerhead	Rental Unit Increased Property Value		0.17		0.01		0.076
Faucet Aerator - Gas PA only	Property Value Increase		26.61				
Faucet Aerator	Rate Discounts			Varies		Varies	
Faucet Aerator	Price Hedging				0.01		0.076
Faucet Aerator	Rental Units Marketability	0.01					
Faucet Aerator	Home Durability	0.37					
Faucet Aerator	Reduced Tenant Complaints	0.20					
Faucet Aerator	Rental Unit Increased Property Value		0.17		0.01		0.076
Programmable Thermostat	Thermal Comfort	4.87					
Programmable Thermostat	Property Value Increase		34.47				
Programmable Thermostat	Home Durability	1.68					
Programmable Thermostat	Health Benefits	0.92					
Programmable Thermostat	Rental Unit Marketability	0.11					
Programmable Thermostat	Equipment Maintenance Reliability Due to Thermostats	3.91					
Programmable Thermostat	Property Durability	4.05					
Programmable Thermostat	Rental Unit Increased Property Value		1.87				
Programmable Thermostat	Reduced Tenant Complaints	2.16					
Programmable Thermostat	Rate Discounts			Varies		Varies	
Programmable Thermostat	Price Hedging				0.01		0.076
CFL Bulb	Rate Discounts			Varies		Varies	
CFL Bulb	Price Hedging				0.01		0.076
LED Bulb	Rate Discounts			Varies		Varies	
LED Bulb	Price Hedging				0.01		0.076
Fixture	Rate Discounts			Varies		Varies	
Fixture	Price Hedging				0.01		0.076
Freezer Replacement	Property Value Increase		26.61				
Freezer Replacement	Rental Units Marketability	0.34					
Freezer Replacement	Property Durability	12.90					
Freezer Replacement	Rental Unit Increased Property Value		5.96				
Freezer Replacement	Reduced Tenant Complaints	6.86					

	NEI Category	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per KWh	Annual $ per Therm	One-time $ per Therm
Freezer Replacement	Rate Discounts			Varies		Varies	
Freezer Replacement	Price Hedging				0.01		0.076
Refrigerator Replacement	Property Value Increase		26.61				
Refrigerator Replacement	Rental Units Marketability	0.34					
Refrigerator Replacement	Property Durability	12.90					
Refrigerator Replacement	Rental Unit Increased Property Value		5.96				
Refrigerator Replacement	Reduced Tenant Complaints	6.86					
Refrigerator Replacement	Rate Discounts			Varies		Varies	
Refrigerator Replacement	Price Hedging				0.01		0.076
Window AC Replacement	Window Air Conditioner Replacement	49.50					
Window AC Replacement	Rate Discounts			Varies		Varies	
Window AC Replacement	Price Hedging				0.01		0.076
Waterbed	Rate Discounts			Varies		Varies	
Waterbed	Price Hedging				0.01		0.076
C&I Existing Building Retrofit							
Compressed Air - Custom	Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal			0.056			
HVAC - Custom	Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal			0.024			
HVAC - Prescriptive	Administrative costs, other costs, other labor costs, O&M, rent revenue			0.097			
Lighting - Custom	Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal			0.059			
Lighting - Prescriptive	Administrative costs, material handling, material movement, other labor costs, O&M, sales revenue, waste disposal			0.027			

	NEI Category	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per KWh	Annual $ per Therm	One-time $ per Therm
Process - Custom	Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal			0.056			
Refrigeration - Custom	Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal			0.047			
Refrigeration - Prescriptive	Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal			0.047			
CHP Systems	Administrative costs, O&M			(0.015)			
Boiler Reset Controls	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					1.35	
Steam Traps	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					1.35	
Thermostat	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					1.35	
Custom	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					0.25	
C&I Small Business							
HVAC	Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal			0.097			
Lighting	Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal			0.027			

	NEI Category	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per KWh	Annual $ per Therm	One-time $ per Therm
Process	Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal			0.056			
Refrigeration	Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal			0.047			
Duct Insulation	Admin costs, fees, material movement, O&M, product spoilage, rent revenue					1.35	
Pipe Wrap	Admin costs, fees, material movement, O&M, product spoilage, rent revenue					1.35	
Thermostat	Admin costs, fees, material movement, O&M, product spoilage, rent revenue					1.35	
Boiler Reset Controls	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					1.35	
Heating - Prescriptive	Admin costs, fees, material movement, O&M, product spoilage, rent revenue					1.35	
Custom	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					0.25	
C&I Multifamily Retrofit							
Lighting	Administrative costs, material handling, material movement, other labor costs, O&M, sales revenue, waste disposal			0.027			
Duct Insulation	Admin costs, fees, material movement, O&M, product spoilage, rent revenue					1.35	
Pipe Wrap	Admin costs, fees, material movement, O&M, product spoilage, rent revenue					1.35	
Thermostat	Admin costs, fees, material movement, O&M, product spoilage, rent revenue					1.35	
Custom	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					0.25	

	NEI Category	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per KWh	Annual $ per Therm	One-time $ per Therm
C&I Upstream Lighting							
Upstream LED Screw In	Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal			0.027			

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Appendix E: Acronyms

ACRONYM	DESCRIPTION
AC	Air Conditioning
AFUE	Annual Fuel Utilization Efficiency (see the Glossary)
AHU	Air Handling Unit
Btu	British Thermal Unit (see the Glossary)
CF	Coincidence Factor (see the Glossary)
CFL	Compact Fluorescent Lamp
CHP	Combined Heat and Power
COP	Coefficient of Performance (see the Glossary)
DCV	Demand Controlled Ventillation
DHW	Domestic Hot Water
DOER	Department of Energy Resources
DSM	Demand Side Management (see the Glossary)
ECM	Electrically Commutated Motor
EER	Energy Efficiency Ratio (see the Glossary)
EF	Efficiency Factor
EFLH	Equivalent Full Load Hours (see the Glossary)
ES	ENERGY STAR® (see the Glossary)
FCM	Forward Capacity Market
FR	Free-Ridership (see the Glossary)
HE	High-Efficiency
HID	High-Intensity Discharge (a lighting technology)
HP	Horse Power (see the Glossary)
HSPF	Heating Seasonal Performance Factor (see the Glossary)
HVAC	Heating, Ventilating, and Air Conditioning
ISO	Independent System Operator
ISR	In-Service Rate (see the Glossary)
kW	Kilo-Watt, a unit of electric demand equal to 1,000 watts
kWh	Kilowatt-Hour, a unit of energy (1 kilowatt of power supplied for one hour)
LED	Light-Emitting Diode (one type of solid-state lighting)
LCD	Liquid Crystal Display (a technology used for computer monitors and similar displays)
MMBtu	One million British Thermal Units (see “Btu” in the Glossary)
MW	Megawatt – a measure of electric demand equal to 1,000 kilowatts
MWh	Megawatt-hour – a measure of energy equal to 1,000 kilowatt-hours
NEB	Non-Electric Benefit (see the Glossary)
NEI	Non-Energy Impact
NE-ISO	New England Independent System Operator
NTG	Net-to-Gross (see the Glossary)
O&M	Operations and Maintenance
PA	Program Administrator (see the Glossary)
PARIS	Planning And Reporting Information System (a DOER database - see the Glossary)
PC	Personal Computer
RR	Realization Rate (see the Glossary)
SEER	Seasonal Energy Efficiency Ratio (see the Glossary)
SO	Spillover (see the Glossary)
SPF	Savings Persistence Factor (see the Glossary)
SSL	Solid-State Lighting (e.g., LED lighting)
VSD	Variable-Speed Drive

Appendix F: Glossary

This glossary provides definitions as they are applied in this TRM for Massachusetts' energy efficiency programs. Alternate definitions may be used for some terms in other contexts.

TERM	DESCRIPTION
Adjusted Gross Savings	Gross savings (as calculated by the measure savings algorithms) that have been subsequently adjusted by the application of all impact factors except the net-to-gross factors (free-ridership and spillover). For more detail, see the section on Impact Factors for Calculating Adjusted Gross and Net Savings.
AFUE	Annual Fuel Utilization Efficiency. The measure of seasonal or annual efficiency of a furnace or boiler. AFUE takes into account the cyclic on/off operation and associated energy losses of the heating unit as it responds to changes in the load, which in turn is affected by changes in weather and occupant controls.
Baseline Efficiency	The level of efficiency of the equipment that would have been installed without any influence from the program or, for retrofit cases where site-specific information is available, the actual efficiency of the existing equipment.
Btu	British thermal unit. A Btu is approximately the amount of energy needed to heat one pound of water by one degree Fahrenheit.
Coefficient of Performance (COP)	Coefficient of Performance is a measure of the efficiency of a heat pump, air conditioner, or refrigeration system. A COP value is given as the Btu output of a device divided by the Btu input of the device. The input and output are determined at AHRI testing standards conditions designed to reflect peak load operation.
Coincidence Factor (CF)	Coincidence Factors represent the fraction of connected load expected to occur concurrent to a particular system peak period; separate CF are found for summer and winter peaks. The CF given in the TRM includes both coincidence and diversity factors multiplied into one number. Coincidence factors are provided for peak periods defined by the NE-ISO for FCM purposes and calculated consistent with the FCM methodology.
Connected Load kW Savings	The connected load kW savings is the power saved by the equipment while in use. In some cases the savings reflect the maximum power draw of equipment at full load. In other cases the connected load may be variable, which must be accounted for in the savings algorithm.
Deemed Savings	Savings values (electric, fossil fuel and/or non-energy benefits) determined from savings algorithms with assumed values for all algorithm parameters. Alternatively, deemed savings values may be determined from evaluation studies. A measure with deemed savings will have the same savings per unit since all measure assumptions are the same. Deemed savings are used by program administrators to report savings for measures with well-defined performance characteristics relative to baseline efficiency cases. Deemed savings can simplify program planning and design, but may lead to over- or under-estimation of savings depending on product performance.
Deemed Calculated Savings	Savings values (electric, fossil fuel and/or non-energy benefits) that depend on a standard savings algorithm and for which at least one of the algorithm parameters (e.g., hours of operation) is project specific.
Demand Savings	The reduction in demand due to installation of an energy efficiency measure, usually expressed as kW and measured at the customer's meter (see Connected Load kW Savings).
Demand Side Management (DSM)	Strategies used to manage energy demand including energy efficiency, load management, fuel substitution, and load building.
Diversity	A characteristic of a variety of electric loads whereby individual maximum demands occur at different times. For example, 50 efficient light fixtures may be installed, but they are not necessarily all on at the same time. See Coincidence Factor.

TERM	DESCRIPTION
Diversity Factor	This TRM uses coincidence factors that incorporate diversity (See Coincidence Factor), thus this TRM has no separate diversity factors. A diversity factor is typically calculated as: 1) the percent of maximum demand savings from energy efficiency measures available at the time of the company's peak demand, or 2) the ratio of the sum of the demands of a group of users to their coincident maximum demand.
End Use	Refers to the category of end use or service provided by a measure or technology (e.g., lighting, cooling, etc.). For the purpose of this manual, end uses with their PARIS codes include: ALght Lighting; HEUBe Behavior HVAC HVAC; Ienvl Insulation & Air Sealing CMoDr Motors & Drives; JGchp Combined Heat & Power DRefr Refrigeration; KSdhw Solar Hot Water EHoWa Hot Water; LDmdR Demand Response FComA Compressed Air; MPvEl Photovoltaic Panels GProc Process* *For residential measures, "process" is used for products that have low savings, such as consumer electronics, or do not conform to existing end use categories. For commercial and industrial measures, "process" is used for systematic improvements to manufacturing or pump systems, or efficient models of specialty equipment not covered in other end uses.
Energy Efficiency Ratio (EER)	The Energy Efficiency Ratio is a measure of the efficiency of a cooling system at a specified peak, design temperature, or outdoor temperature. In technical terms, EER is the steady-state rate of heat energy removal (i.e. cooling capacity) of a product measured in Btuh output divided by watts input.
ENERGY STAR® (ES)	Brand name for the voluntary energy efficiency labeling initiative sponsored by the U.S. Environmental Protection Agency.
Energy Costing Period	A period of relatively high or low system energy cost, by season. The energy periods defined by ISO-NE are: • **Summer Peak**: 6am–10pm, Monday–Friday (except ISO holidays), June–September • **Summer Off-Peak:** Summer hours not included in the summer peak hours: 10pm–6am, Monday–Friday, all day on Saturday and Sunday, and ISO holidays, June–September • **Winter Peak:** 6am–10pm, Monday–Friday (except ISO holidays), January–May and October–December • **Winter Off-Peak:** Winter hours not included in the sinter peak hours: 10pm–6am, Monday–Friday, all day on Saturday and Sunday, and ISO holidays, January–May and October–December.
Equivalent Full Load Hours (EFLH)	The equivalent hours that equipment would need to operate at its peak capacity in order to consume its estimated annual kWh consumption (annual kWh/connected kW).
Free Rider	A customer who participates in an energy efficiency program, but would have installed some or all of the same measure(s) on their own, with no change in timing of the installation, if the program had not been available.
Free-Ridership Rate	The percentage of savings attributable to participants who would have installed the measures in the absence of program intervention.
Gross kW	Expected demand reduction based on a comparison of standard or replaced equipment and equipment installed through an energy efficiency program.
Gross kWh	Expected kWh reduction based on a comparison of standard or replaced equipment and equipment installed through an energy efficiency program.

TERM	DESCRIPTION
Gross Savings	A saving estimate calculated from objective technical factors. In this TRM, "gross savings" are calculated with the measure algorithms and do not include any application of impact factors. Once impact factors are applied, the savings are called "Adjusted Gross Savings". For more detail, see the section on Impact Factors for Calculating Adjusted Gross and Net Savings.
High Efficiency (HE)	Refers to the efficiency measures that are installed and promoted by the energy efficiency programs.
Horsepower (HP)	A unit for measuring the rate of doing work. One horsepower equals about three-fourths of a kilowatt (745.7 watts).
Heating Seasonal Performance Factor (HSPF)	A measure of the seasonal heating mode efficiencies of heat pumps expressed as the ratio of the total heating output to the total seasonal input energy.
Impact Factor	Generic term for a value used to adjust the gross savings estimated by the savings algorithms in order to reflect the actual savings attributable to the efficiency program. In this TRM, impact factors include realization rates, in-service rates, savings persistence, peak demand coincidence factors, free-ridership, spillover and net-to-gross factors. See the section on Impact Factors for more detail.
In-Service Rate	The percentage of units that are actually installed. For example, efficient lamps may have an in-service rate less than 100% since some lamps are purchased as replacement units and are not immediately installed. The in-service rate for most measures is 100%.
Measure Life	The number of years that an efficiency measure is expected to garner savings. These are generally based on engineering lives, but sometimes adjusted based on observations of market conditions.
Lost Opportunity	Refers to a measure being installed at the time of planned investment in new equipment or systems. Often this reflects either new construction, renovation, remodeling, planned expansion or replacement, or replacement of failure.
Measure	A product (a piece of equipment), combination of products, or process designed to provide energy and/or demand savings. Measure can also refer to a service or a practice that provides savings. Measure can also refer to a specific combination of technology and market/customer/practice/strategy (e.g., direct install low income CFL).
Net Savings	The final value of savings that is attributable to a program or measure. Net savings differs from gross savings (or adjusted gross savings) because it includes adjustments due to free-ridership and/or spillover. Net savings is sometimes referred to as "verified" or "final" savings. For more detail see the section on Impact Factors for Calculating Adjusted Gross and Net Savings.
Net-to-Gross Ratio	The ratio of net savings to the adjusted gross savings (for a measure or program). The adjusted gross savings include any adjustment by the impact factors other than free-ridership or spillover. Net-to-gross is usually expressed as a percent.
Non-Electric Benefits (NEBs)	Quantifiable benefits (beyond electric savings) that are the result of the installation of a measure. Fossil fuel, water, and maintenance are examples of non-electric benefits. Non-electric benefits can be negative (i.e. increased maintenance or increased fossil fuel usage which results from a measure) and therefore are sometimes referred to as "non-electric impacts".
Non-Participant	A customer who is eligible to participate in a program, but does not. A non-participant may install a measure because of a program, but the installation of the measure is not through regular program channels; as a result, their actions are normally only detected through evaluations.
On-Peak kW	See Summer/Winter On-peak kW
Operating Hours	Hours that a piece of equipment is expected to be in operation, not necessarily at full load (typically expressed per year).

TERM	DESCRIPTION
PARIS	Planning And Reporting Information System, a statewide database maintained by the Department of Energy Resources (DOER) that emulates the program administrators' screening model. As a repository for quantitative data from plans, preliminary reports, and reports, PARIS generates information that includes funding sources, customer profiles, program participation, costs, savings, cost-effectiveness and program impact factors from evaluation studies. DOER developed PARIS in 2003 as a collaborative effort with the Department of Public Utilities and the electric program administrators. Beginning with the 2010 plans, PARIS holds data from gas program administrators.
Participant	A customer who installs a measure through regular program channels and receives any benefit (i.e. incentive) that is available through the program because of their participation. Free-riders are a subset of this group.
Prescriptive Measure	A prescriptive measure is generally offered by use of a prescriptive form with a prescribed incentive based on the parameters of the efficient equipment or practice.
Program Administrator (PA)	Those entities that oversee public benefit funds in the implementation of energy efficiency programs. This generally includes regulated utilities, other organizations chosen to implement such programs, and state energy offices. The Massachusetts electric PAs include Cape Light Compact, National Grid, NSTAR, Western Massachusetts Electric Company (WMECo), and Unitil. The Massachusetts natural gas PAs include Bay State Gas, Berkshire Gas, and New England Gas.
Realization Rate (RR)	The ratio of measure savings developed from impact evaluations to the estimated measure savings derived from the TRM savings algorithms. This factor is used to adjust the estimated savings when significant justification for such adjustment exists. The components of the realization rate are described in detail in the section on Impact Factors.
Retrofit	The replacement of a piece of equipment or device before the end of its useful or planned life for the purpose of achieving energy savings. "Retrofit" measures are sometimes referred to as "early retirement" when the removal of the old equipment is aggressively pursued.
Savings Persistence Factor (SPF)	Percentage of first-year energy or demand savings expected to persist over the life of the installed energy efficiency equipment. The SPF is developed by conducting surveys of installed equipment several years after installation to determine the operational capability of the equipment. In contrast, *measure persistence* takes into account business turnover, early retirement of installed equipment, and other reasons the installed equipment might be removed or discontinued. Measure persistence is generally incorporated as part of the measure life, and therefore is not included as a separate impact factor.
Seasonal Energy Efficiency Ratio (SEER)	A measurement of the efficiency of a central air conditioner over an entire season. In technical terms, SEER is a measure of equipment the total cooling of a central air conditioner or heat pump (in Btu) during the normal cooling season as compared to the total electric energy input (in watt-hours) consumed during the same period.
Seasonal Peak kW	See Summer/Winter Seasonal Peak kW, and Summer/Winter On-Peak Peak kW.
Sector	A system for grouping customers with similar characteristics. For the purpose of this manual, the sectors are Commercial and Industrial (C&I), Small Business, Residential, and Low Income.
Spillover Rate	The percentage of savings attributable to the program, but additional to the gross (tracked) savings of a program. Spillover includes the effects of (a) participants in the program who install additional energy efficient measures outside of the program as a result of hearing about the program and (b) non-participants who install or influence the installation of energy efficient measures as a result of being aware of the program.
Summer/Winter On-Peak kW	The average demand reduction during the summer/winter on-peak period. The summer on-peak period is 1pm-5pm on non-holiday weekdays in June, July and August; the winter on-peak period is 5pm-7pm on non-holiday weekdays in December and January.

TERM	DESCRIPTION
Summer/Winter Seasonal Peak kW	The demand reduction occurring when the actual, real-time hourly load for Monday through Friday on non-holidays, during the months of June, July, August, December, and January, as determined by the ISO, is equal to or greater than 90% of the most recent 50/50 system peak load forecast, as determined by the ISO, for the applicable summer or winter season.
Ton	Unit of measure for determining cooling capacity. One ton equals 12,000 Btu.
Watt	A unit of electrical power. Equal to 1/1000 of a kilowatt.

W. **Database Background Materials**

Chart of Database Events

Date	Database Event/Participation
January 31, 2013	DPU Order Approving Budget for Development of Database
April 8, 2013	EEAC Database Subcommittee Meeting
April 22, 2013	EEAC Database Subcommittee Meeting
April 29, 2013	EEAC Database Subcommittee Meeting
June 19, 2013	EEAC Database Subcommittee Meeting
August 5, 2013	EEAC Database Subcommittee Meeting
October 2013	Individual PA interviews by Energy Platforms
October 29, 2013	EEAC Database Working Group and Subcommittee Meetings
November 12, 2013	Group PA interview by Energy Platforms
November 26, 2013	EEAC Database Working Group and Subcommittee Meetings; Energy Platforms hands out database specifications
December 23, 2013	PA Comments on Energy Platform's Conceptual Proposal
January 9, 2014	Energy Platforms provides revised database specifications
January 13, 2014	EEAC Database Working Group and Subcommittee Meetings
January 22, 2014	Energy Platform provides vision statement for database specifications
January 23, 2014	EEAC Database Subcommittee Meeting
April 1, 2014	Energy Platforms provides revised database specifications
April 2, 2014	Comments of the Program Administrators on Customer Confidentiality Issues Associated with Energy Platform's Conceptual Proposal
April 2, 2014	DOER provides revised vision statement
April 4, 2014	EEAC Database Working Group and Subcommittee Meetings
April 15, 2014	Comments of the Program Administrators on April 2014 Statewide Database Vision Statement and Energy Platform's Database Specifications
April 28, 2014	EEAC Database Subcommittee Meeting
May 13, 2014	EEAC Request to Department for Data Input Guidance
May 15, 2014	DOER Response: Resolution of the EEAC Concerning the State Database Request to the Department dated 5/13/14
July 14, 2014	Department Technical Session attended by PAs and Stakeholders, discussing (1) stakeholder views on data to be included in database and level of aggregation of such data; (2) areas of commonality and differences among stakeholders re: data to be included; (3) reasons stakeholders find current PA data reporting requirements insufficient; (4) issues related to data privacy.
July 18, 2014	PAs provided straw data reporting as requested on July 14, 2014 by DPU
July 24, 2014	Department approved slightly modified dataset inventory and directed PAs to populate spreadsheet
August 7, 2014	Pas populated spreadsheet as requested by Department
August 21, 2014	Stakeholders populated spreadsheet as requested by Department
September 5, 2014	LEAN provided comments to Department re: privacy of customer data
December 1, 2014	Department Order in Response to May 13, 2014 Resolution of the Energy Efficiency Advisory Council
December 22, 2014	Joint Motion of the Program Administrators for Reconsideration and to Stay Compliance Filing
January 2015	Stakeholders opposed motion for reconsideration
March 5, 2015	PAs provided informal database status report to Department

COMMENTS OF THE PROGRAM ADMINISTRATORS ON CUSTOMER CONFIDENTIALITY ISSUES ASSOCIATED WITH ENERGY PLATFORM'S CONCEPTUAL PROPOSAL

INTRODUCTION

On January 9, 2014, Energy Platforms, the database facilitator hired by the Energy Efficiency Advisory Council (the "EEAC"), circulated to stakeholders a revised conceptual proposal for a statewide energy efficiency database ("EP Proposal"). If adopted, this proposal would require the Program Administrators (or "PAs")[1] to export from their internal systems sensitive customer-specific account information that will be housed in the database and be accessible to non-PAs. As part of their evaluation of the EP Proposal, the Program Administrators analyzed the legal issues associated with disclosing such sensitive customer information. The PAs also reviewed their corporate policies regarding the dissemination of sensitive customer-specific account information. As the EEAC database process is to reconvene on April 4, 2014, with a focus on privacy, the PAs provide these comments for consideration in advance of those meetings.

As discussed below, the EP Proposal seeks disclosure of sensitive customer data that is strictly controlled by the PAs. Such sensitive data is accessible to the PAs' employees and contracted vendors only in the conduct of regulated PA business. Customer consent is required to disclose such sensitive data outside the conduct of regulated PA business.

DATA ELEMENTS IN EP PROPOSAL

Although the purpose for and the contents of the database have not been determined and discussions are ongoing, according to the EP Proposal, the database would contain customer-specific account information including, customer names, account numbers, rate class, location, usage and demand data, and project/measure level information, among other data (collectively "Customer Account Data").[2] EP Proposal at §§ 1.3.1, 2.2.2, 3.3, 4.3, 6. Energy Platforms states that Customer Account Data will be stored in a "secured access data 'Vault." EP Proposal at

[1] The Program Administrators include the following gas and electric distribution companies and a municipal aggregator: Bay State Gas Company d/b/a Columbia Gas of Massachusetts ("CMA"), The Berkshire Gas Company ("Berkshire"), Blackstone Gas Company, Boston Gas Company and Colonial Gas Company each d/b/a National Grid, Cape Light Compact ("Compact"), Fitchburg Gas & Electric Light Company d/b/a Unitil, Massachusetts Electric Company and Nantucket Electric Company each d/b/a National Grid, Liberty Utilities f/k/a New England Gas Company, NSTAR Electric Company and NSTAR Gas Company ("NSTAR"), and Western Massachusetts Electric Company ("WMECo").

[2] The Customer Account Data constitutes sensitive data that is strictly controlled by the PAs and requires customer consent prior to disclosure. In contrast, limited data such as customer name and address information or aggregate data that is combined in a manner that leaves individual customers unidentifiable is generally not considered sensitive, is not required to be under the same strict controls, and is not subject to the same customer consent requirements.

§§ 1.3.2, 2.2.3. The EP Proposal would allow "Data Consumers"[3] access to Customer Account Data "[t]o derive their own views of the source data as required subject to appropriate privacy protections." EP Proposal at § 1.2. Energy Platforms states that Customer Account Data will be protected and identifies privacy protection tools that could be used such as non-disclosure agreements, controlled access to the "Vault," access privileges to the database, and data aggregation. EP Proposal at §§ 1.3.6, 2.2.3, 3.3.

ANALYSIS OF PRIVACY AND SECURITY ISSUES

Giving third parties access to Customer Account Data raises serious concerns related to both privacy and security.[4] In those states that have squarely addressed the issue, disclosure of data sets such as Customer Account Data for a purpose unrelated to the conduct of regulated utility business requires customer consent.[5] Such consent is consistent with relevant federal privacy practices governing customer data access and privacy concerns and is central to healthcare industry privacy rules.[6] Absent consent, such disclosure could violate state privacy laws, leading to civil and criminal suits and potential penalties.[7] It could also violate privacy policies adopted by public utilities commissions and their regulated entities, resulting in civil liability and possible federal enforcement action.[8]

In Massachusetts, customer consent is necessary to permit third-party access to Customer Account Data outside the conduct of regulated PA business. Such sensitive data is accessible to the PAs' employees and contracted vendors only to the extent needed to carry out regulated PA business. As disclosure of Customer Account Data to a statewide database would serve no regulated PA business purpose, customer consent is required by Department of Public Utilities (the "Department") precedent as well as PA corporate policies and practices, which is consistent with how such information is treated in other states.[9] More importantly, absent consent,

3 The EP Proposal defines "Data Consumers" as including "regulators, consultants, stakeholders, and the public." EP Proposal at § 1.1.

4 For a general discussion of these issues, please refer to: State and Local Energy Efficiency Action Network. 2012. *A Regulator's Privacy Guide to Third-Party Data Access for Energy Efficiency*. Prepared by M. Dworkin, K. Johnson, D. Kreis, C. Rosser, J. Voegele, Vermont Law School; S. Weissman, UC Berkeley; M. Billingsley, C. Goldman, Lawrence Berkeley National Laboratory. http://www1.eere.energy.gov/seeaction/pdfs/cib_regulator_privacy_guide.pdf; Emerging Customer Privacy Issues, NARUC Summer Meeting (July 22, 2012) http://www.narucmeetings.org/Presentations/EmergingCustomerPrivacyIssues-Part1.pdf

5 See *A Regulator's Privacy Guide to Third-Party Data Access for Energy Efficiency* at § 3.

6 See id. at § 4 (discussing Fair Information Practice Principles (FIPPs), the Consumer Privacy Bill of Rights, FTC Codes of Conduct, non-binding industry standards, and a other emerging initiatives) and § 5.2 (discussing healthcare).

7 See id. at § 3.9.

8 See id. at §§ 2.2, 3, 4.1.3, 6.4.

9 See id. § 3.5 (also see Figure ES-1 and Table 2).

disclosure of such sensitive data could expose an individual PA, or the group of PAs, to liability under the Massachusetts Right to Privacy Act, M.G.L. c. 214, § 1B or Chapter 93A, and potentially other statutes.[10]

The Department has recognized the right to confidentiality of Customer Account Data, even in the context of promoting policies mandated by the Legislature. See 220 C.M.R. § 11.04; 220 C.M.R. § 14.03; Low Income Discount Rate Enrollment, D.T.E. 01-106-A at 11-12 (2003) (customer authorization in context of legislative directive to participate in low-income discount matching program); Competitive Market Initiatives, D.T.E. 01-54-A (2001) (customer authorization in context of legislative directive to develop competitive choice under Restructuring Act). In the absence of informed customer consent to public disclosure, the Department routinely grants motions for confidential treatment protecting from public disclosure Customer Account Data. See 2013-2015 Energy Efficiency Plan, D.P.U. 12-100 through D.P.U. 12-111, Hearing Officer Ruling (February 3, 2014) (granting motion dated December 20, 2012); Bay State Gas Company, D.T.E. 06-36, Hearing Officer Ruling (January 18, 2007); East Northfield Water Company, D.P.U. 11-50, Hearing Officer Ruling (March 19, 2012) (granting motion dated January 18, 2012).

Safeguarding the confidentiality of Customer Account Data is not only a legal obligation, but an important corporate responsibility for the PAs. Each of the PAs maintains physical, electronic, and procedural safeguards to protect Customer Account Data. Each PA has also adopted corporate privacy policies that require Customer Account Data to be protected and disclosed without customer consent only in the conduct of its regulated business. See, e.g., NSTAR's Privacy Policy;[11] WMECO's Privacy Policy;[12] Berkshire's Privacy Policy;[13] CMA's Privacy Statement.[14] For example, in the course of conducting their regulated business, the PAs disclose Customer Account Data without customer consent to their vendors, who must meet certain privacy, insurance, and security requirements in order to receive Customer Account Data. The contractual terms and conditions imposed on PA vendors require them to, among other things, indemnify the PAs, employ industry standard data system security measures and maintain certain types and levels of insurance. See Appendix A for sample terms and conditions.

[10] See Commonwealth v. Augustine, MA SJC-11482 (February 18, 2014) (holding individual has reasonable expectation of privacy in his historical cell site location information given its capacity to track movements of user thus search warrant required). While the U.S. Supreme Court has not yet directly ruled on application of the Fourth Amendment's protection against unreasonable searches and seizure extending to utility records or energy usage data the Court has recognized, "that an individual's privacy in the home is 'the very core' of the Fourth Amendment." *A Regulator's Privacy Guide to Third-Party Data Access for Energy Efficiency* at § 4.2, n.83 citing Silverman v. United States, 365 U.S. 505 (1961).

[11] http://www.nstar.com/about_nstar/legal_statements/privacy.asp.

[12] https://www.wmeco.com/security/help/PrivacyPolicyHelp.aspx.

[13] http://www.uinet.com.

[14] https://www.columbiagasma.com/en/about-us/privacy-statement.

The PAs' privacy policies reflect their legal obligations and are typical of utilities across the country that require customer consent for disclosure of Customer Account Data outside the conduct of their regulated business. See, e.g., California;[15] Vermont;[16] Minnesota.[17] In California, the public utility commission issued an order finding that utilities may disclose Customer Account Data, including energy usage, without customer consent only in the conduct of their regulated business.[18] All other purposes are considered secondary and require customer consent in order for Customer Account Data to be disclosed.[19] Similarly, in Vermont, the public service board issued an order finding that the statewide regulated energy efficiency utility, Vermont Energy Investment Corporation ("VEIC"), may use sensitive customer information such as energy usage data in the conduct of its regulated business.[20] Otherwise, VEIC, which operates under the name Efficiency Vermont, may not disclose customer or project-level information without customer consent.[21]

Providing Customer Account Data to a statewide database is not permissible without customer consent because it would serve no regulated PA business purpose. The purpose of the statewide database outlined in the EP Proposal is to facilitate third-party access to energy efficiency data for general analysis. As discussed above, the PAs' vendors are not allowed such open-ended access to sensitive customer data. Instead, in order to receive Customer Account Data, they agree to be bound by strict contractual terms and conditions and may use the information only for the regulated business purposes outlined in the contract. Customers have a reasonable expectation of privacy in their Customer Account Data and, particularly, their energy usage information, which provides insight into their behavior. They have the legal right to choose whether to disclose Customer Account Data for the purpose of a statewide database.

The PAs provide Customer Account Data to the Department, as requested and necessary to support Department filings. It is legally permissible to provide this information because the

15 http://www.pge.com/en/about/company/privacy/customer/index.page.

16 http://www.efficiencyvermont.com/About-Us/Privacy-Policy.

17 http://www.minnesotaenergyresources.com/privacy.aspx; http://www.alliantenergy.com/AboutAlliantEnergy/PrivacyLegalCopyright/; http://www.xcelenergy.com/staticfiles/xe/Admin/Xcel%20Online%20Privacy%20Policy.pdf.

18 Decision Adopting Rules to Protect the Privacy and Security of the Electricity Usage Data of the Customers of Pacific Gas and Electric Company, Southern California Edison Company, and San Diego Gas & Electric Company, Decision 11-07-056, California Public Utilities Commission (2011). http://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/140369.PDF.

19 Id.

20 Investigation into Dispute Regarding the Provision of Customer Information to Efficiency Vermont by the Village of Hyde Park Electric Department, Docket Number 6379, Vermont Public Service Board (2000). www.state.vt.us/psb/orders/document/6379fnl.pdf.

21 Id.; Investigation into Petition Filed by Vermont Department of Public Service Re: Energy Efficiency Utility Structure- Phase 2, Docket No. 7466, Vermont Public Service Board at 32-35 (2010). http://psb.vermont.gov/sites/psb/files/orders/2010/7466OrderRePhase2Issues.pdf.

Department has express statutory authority both over the PAs and to protect confidential information.[22] The state agencies who are members of the EEAC have no such statutory authority either over the PAs or to protect confidential information.[23] Moreover, they are bound by the Massachusetts Public Records Law, G.L. c. 66, which considers any information provided to a public agency or official a public record that must be disclosed upon request.[24] Even assuming *arguendo* that it was legal to provide Customer Account Data to state agencies other than the Department, they would bear little or no liability for a data breach if they disclosed such information, potentially leaving the PAs' liable. Compare G.L. c. 258, § 2 with Appendix A.

CONCLUSION

Absent customer consent, the PAs cannot legally provide Customer Account Data to a statewide energy efficiency database. In Massachusetts, customers, not the PAs, retain authority to decide whether to allow disclosure of their Customer Account Data to third parties for purposes outside the conduct of the PAs' regulated business. Customers may not want to disclose Customer Account Data for a variety of personal or business reasons, including concerns of privacy or potential competitive disadvantage. Obtaining customer consent for the release of Customer Account Data to third parties for a purpose outside the conduct of regulated PA business is a recognized practice and an appropriate safeguard against taking action that could

[22] See G.L. c. 164 § 76 (Department supervisory authority); G.L. c. 25, §§ 19, 21-22 (Department has final administrative review of energy efficiency determinations); M.G.L. c. 25, § 5D (expressly excludes from definition of public records, "trade secrets, confidential, competitively sensitive or other proprietary information" provided to Department during its regulatory proceedings).

[23] For example, the Department of Energy Resources ("DOER") has authority to collect and protect certain limited energy supply information under G.L. c. 25A, § 7, which does not include Customer Account Data. The Compact, however, has authority to protect customer data from disclosure pursuant to G.L. c 4, § 7(26)(s). That statute provides in relevant part: "trade secrets or confidential, competitively-sensitive or other proprietary information provided in the course of activities conducted by a governmental body as an energy supplier under a license granted by the department of public utilities pursuant to section 1F of chapter 164, in the course of activities conducted as a municipal aggregator under section 134 of said chapter 164 or in the course of activities conducted by a cooperative consisting of governmental entities organized pursuant to section 136 of said chapter 164, when such governmental body, municipal aggregator or cooperative determines that such disclosure will adversely affect its ability to conduct business in relation to other entities making, selling or distributing electric power and energy; provided, however, that this subclause shall not exempt a public entity from disclosure required of a private entity so licensed."

[24] Public records must, upon request, be made available for public inspection, unless the custodian of the records can show that it is specifically exempt from mandatory disclosure under one or more statutory exemptions. M.G.L. c. 66, § 10(c). Although M.G.L. c. 4, § 7, cl. 26(c) prohibits the disclosure of any information that may result in an unwarranted invasion of privacy, it is no guarantee against public disclosure. Determinations under the statute are made on a case-by-case basis and depend on balancing the public's right to know about the subject data against the severity of the intrusion of privacy. See Attorney Gen. v. Sch. Comm. of Northampton, 375 Mass. 127, 131-32 (1978) (requiring showing of privacy exemption for each individual application rather than group of applicants); Torres v. Attorney Gen., 391 Mass. 1, 9 (1984); Massachusetts Supervisor of Public Records Determination Letter, SPR10/150 (Aug. 16, 2010) (finding that DOER was required to disclose names and addresses of people who secured reservations for rebates under MassSave Great Appliance Exchange).

erode customer confidence, reflect poorly on energy efficiency programs, discourage participation or produce other unintended consequences.

As the statewide database discussions resume, the PAs are happy to discuss how aggregate data that is combined in a manner that leaves individual customers unidentifiable may be an alternative source of information for a statewide database. Disclosure of such aggregate data would reduce the privacy risks to customers while still enabling analysis of trends.[25] A better delineation of the specific purpose of third-party access to energy efficiency data (aside from generic data analysis) would facilitate such a discussion.

If the final specifications for a statewide database require the inclusion or disclosure of Customer Account Data, the PAs will not be able to comply without an Order from the Department permitting them to do so. The Department is in the best position to determine the legal and privacy issues associated with disclosing Customer Account Data to third parties and is currently exploring customer privacy issues in open dockets.[26] A proceeding at the Department would allow for a comprehensive discussion of customer privacy implications, including legal and practical constraints, data needs associated with specified purposes, data security standards, data breach liability, and other issues such as indemnification, insurance, and resources for making affected customers' whole in the event of a data breach, all of which are legitimate PA concerns given recent examples of data breaches.

[25] See *A Regulator's Privacy Guide to Third-Party Data Access for Energy Efficiency* at viii, §§ 2.3.3, 3.6, 6.2; see also supra nn. 15-17 (allowing disclosure of certain aggregate data); http://ecdms.energy.ca.gov/ (California consumption data is aggregated and available by county).

[26] There was a panel hearing on privacy in Grid Modernization, D.P.U. 12-76, on February 27, 2014. The Department has also opened a docket on cybersecurity and held a technical session on February 14, 2014.

APPENDIX A – SAMPLE PA TERMS AND CONDITIONS

(In the sample terms and conditions below "Owner" means the PA)

INSURANCE.

Consultant shall provide the following coverages to meet Owner's insurance requirements:

(a) Commercial General Liability in the amount of $x,000,000 per occurrence.

(b) Business Auto Coverage with a $x,000,000 each accident limit and shall include owned, non-owned, leased and hired vehicle coverage.

(c) Workers' Compensation, including the following: Statutory Coverage applicable in the State where the Services are performed and Employers Liability Coverage "B" (or stop gap coverage), in the amount of $x,000,000.

(d) Professional Liability Insurance with a combined single limit of not less than $x,000,000 per occurrence.

(e) Cyber Insurance in the amount of $x,000,000 per occurrence depending on context.

(f) Before any Services begin, Consultant must furnish properly executed certificates of insurance and endorsements naming Owner as an additional insured on Consultant's Commercial General Liability policy. An authorized representative of the insurance company shall execute the foregoing. Additional insured means, naming Owner as an insured under the liability coverages with respect to the Services under the Agreement and providing that such insurance is primary and non-contributory to any liability insurances covered by Owner.

(g) Consultant shall directly provide to Owner notices of non-renewal and/or cancellation and/or reduction in limits or material change in any of the required coverages within (7) days of receipt of such notices.

(h) Consultant shall fully comply with all state and federal requirements applying to this insurance in the states where the Services are performed with a waiver of subrogation in favor of Owner. Whenever Consultant shall have Owner's property in its possession for Consultant's fabrication or otherwise as herein required, Consultant shall be deemed the insurer thereof and shall be responsible for such property until its return to and acceptance by Owner.

CONFIDENTIAL INFORMATION.

"CONFIDENTIAL INFORMATION" means any and all data, documentation, methods, processes, materials, and all other information relating to the past, present and future business of Owner and its Affiliates. Confidential Information also includes all information owned by customers, suppliers or other third parties to whom Owner or its Affiliates owe an obligation of confidentiality. Confidential Information also includes all Work Product. Confidential Information does not include any information that is publicly available or becomes publicly available through no breach of this Agreement or other Confidentiality Agreement by Consultant, its Subcontractors or its employees or information that Consultant can show, by written records, was known to Consultant prior to the date of this Agreement.

(a) Consultant's Obligations with respect to all Confidential Information

1. During the term of this Agreement and thereafter, except as Owner may authorize in writing, Consultant shall and shall cause its employees and Subcontractors to: (i) treat and cause to be treated as confidential all Confidential Information; (ii) not disclose any Confidential Information to any third party or make available any reports, recommendations, extracts, summaries, analysis or conclusions based on the Confidential Information; (iii) reveal the Confidential Information only to those employees of Consultant who require such access in order to perform the Services hereunder; (iv) grant access to Confidential Information only to employees of Consultant or Subcontractors who have signed a confidentiality agreement if required by Owner; (v) use or grant access to Confidential Information only in connection with the performance of Services pursuant to this Agreement; (vi) make copies of any tangible embodiment of Confidential Information only as necessary for the performance of such Services; (vii) remove any tangible embodiment of Confidential Information from the premises of Owner only with the express written permission of Owner; and (viii) maintain policies and procedures and comply with all applicable laws and regulations to detect, prevent and mitigate the risk of loss, unauthorized access, use, modification, destruction or disclosure of Owner's and its Affiliates' Confidential Information.

2. Consultant may disclose only such Confidential Information as is necessary to comply with a regulatory, legal, or governmental request and only after providing immediate notification to Owner allowing sufficient time for Owner to seek a protective or limiting order or otherwise prohibiting the disclosure of the requested Confidential Information as Owner deems necessary in its sole discretion. Consultant shall act in good faith to assist Owner where appropriate with respect to Owner's efforts to seek a protective order or order limiting disclosure.

3. In performing the Services, at a minimum, Consultant and its Subcontractors shall employ industry standard data and system security measures for securing Confidential Information so as to reasonably ensure that Confidential Information is not lost or stolen, or otherwise used, modified or accessed, attempted to be accessed, or allow access to any third party without Owner's prior express written approval or by any Consultant employee or agent who is not authorized to access the Confidential Information. Consultant and its Subcontractors shall upon discovery of any breach of security or unauthorized access, immediately: (i) notify Owner of any loss or unauthorized disclosure, possession, use or modification of the Confidential Information or any suspected attempt at such activity or breach of Consultant's or its Subcontractors' security measures, by any person or entity; (ii) investigate and take corrective action in response thereto; and (iii) provide assurance to Owner's reasonable satisfaction that such activities or breach or potential breach shall not reoccur.

4. While at Owner's or its Affiliate's facilities or using Owner's or its Affiliate's equipment or accessing Owner's or its Affiliate's systems (including telephone systems, electronic mail systems, and computer systems) Consultant, its Subcontractors and their respective personnel shall observe and follow all applicable Owner or Affiliate policies and standards, including those policies relating to security of and access to Confidential Information as such policies and standards are modified and supplemented from time to time. Applicable policies will be made available upon request.

5. Upon termination of this Agreement or applicable Purchase Order, Consultant and its Subcontractors, at Owner's discretion, shall either return the Confidential Information to Owner or comply with the following minimum standards regarding the proper disposal of Confidential Information: (i) implement and monitor compliance with policies and procedures that prohibit unauthorized access to, acquisition of, or use of Confidential Information during the collection, transportation and disposal of Confidential Information; (ii) paper documents containing Confidential Information shall be either redacted, burned, pulverized or shredded so that Confidential Information cannot practicably be read or reconstructed; and (iii) electronic media and other non-paper media containing Confidential Information shall be destroyed or erased so that Confidential Information cannot practicably be read or reconstructed.

(b) Consultant's Additional Obligations with respect to Personal Information

1. Personal Information is a subset of Confidential Information and includes any information that identifies a person (e.g., name in combination with any of the following: social security number; driver license number; state identification number; credit or debit card account number; bank account number; or other financial account number) who is a former, current or prospective customer, employee or shareholder of the Owner or any of its Affiliates. With respect to the protection of and access to Personal Information, Consultant and its Subcontractors shall comply with all applicable laws regarding Personal Information.

2. If Consultant or its Subcontractors store or maintain Personal Information, Consultant and its Subcontractors, as applicable, shall employ industry standard systems and practices with respect to: (i) intrusion detection systems including actively monitoring such systems for signatures that correspond to attempts at breaking the security of Personal Information; and (ii) backup procedures relating to software, system configurations and Personal Information.

3. To the extent Consultant or its Subcontractors has access to or uses Personal Information in the performance of its Services for Owner or any of its Affiliates and such Personal Information contains personal information of residents of the Commonwealth of Massachusetts, Consultant shall comply with the requirements of 201 CMR 17.00: Standards for the Protection of Personal Information of Residents of the Commonwealth, as currently promulgated or subsequently amended. A current copy of 201 CMR 17.00 will be provided upon Consultant's request.

(c) Consultant's Additional Obligations with respect to Federal Red Flag Obligations. If Consultant or its Subcontractors provision of Services involves the processing of Personal Information so as to place Consultant or its Subcontractors in a position to observe indicators of identify theft (e.g. consumer fraud alerts, notifications or warnings; suspicious documents, personal identification information, or activity; or notice from customers, law enforcement or others regarding identity theft), Consultant and its Subcontractors shall: (i) maintain policies and procedures to identify, detect and respond to Red Flags, substantially in accordance with Owner's program regarding such Red Flags, as updated from time to time, a current copy of which will be made available upon request, (ii) report the detection of any such Red Flags to Owner; and (iii) take appropriate measures to prevent or mitigate the risk of identify theft that may arise in the performance of such Services.

(d) Irreparable Harm. Consultant acknowledges that the breach of any of the covenants contained in this Article will result in irreparable harm and continuing damages to Owner and Owner's business, and that Owner's remedy at law for any such breach or threatened breach would be inadequate. Accordingly, in addition to such remedies as may be available to Owner at law or in equity in the event of any such breach, any court of competent jurisdiction may issue an injunction (both preliminary and permanent), without bond, enjoining and restricting the breach or threatened breach of any such covenant, including an injunction restraining Consultant from disclosing, in whole or in part, any Confidential

Information. Consultant shall pay all of Owner's costs and expenses, including reasonable attorneys' fees and accountants' fees, incurred in enforcing such covenants.

(e) By executing this Agreement, Consultant acknowledges and agrees to comply with the foregoing and will provide further evidence of such compliance upon Owner's request. The obligations of this Article shall survive any termination of this Agreement.

INDEMNIFICATION.

(a) To the fullest extent permitted by law, Consultant waives any right of contribution and agrees to indemnify, defend and hold harmless Owner and its parent company, agents, affiliates and employees (collectively, "Indemnitees") from and against all claims, damages, losses, fines, penalties and expenses, including attorneys' fees, related in any way to (i) any breach of this Agreement by Consultant; or (ii) Consultant's or its Subcontractors' or agents' performance of the Work (collectively, "Claims"), provided that any such Claims in subsection (a)(ii) above are caused in whole or in part by any negligent act or omission of Consultant, any Subcontractor or any of its respective direct or indirect employees or agents for whose acts any of them may be liable. Such obligation shall not negate, abridge, or otherwise reduce any other right or obligation of indemnity or contribution in favor of the Indemnitees. Such obligation to indemnify, defend and hold harmless shall not be limited in any way by any limitation on the amount or type of damages, compensation, benefits or insurance proceeds payable by, for or to Consultant or anyone directly or indirectly employed by Consultant. The obligations of Consultant under this Agreement shall not extend to the liability of the Indemnitees arising out of the Indemnitees' sole negligence. Consultant shall impose identical indemnification, defense and hold harmless obligations upon all Subcontractors.

(b) To the fullest extent permitted by law, Consultant expressly (i) waives the benefit, for itself and all Subcontractors, insofar as the indemnification, defense and hold harmless obligations of Indemnitees are concerned, of the provisions of any applicable workers' compensation law limiting the tort or other liability of any employer on account of injuries to the employer's employees, and (ii) assumes liability in accordance with this Article.

(c) Consultant agrees to perform all required Work under this Agreement, including disposition of resulting waste products, in compliance with all applicable federal, state, and local environmental and safety laws, regulations, and ordinances**,** including the Occupational Safety and Health Act and applicable regulations. To the fullest extent permitted by law, Consultant agrees to indemnify, defend and hold harmless Indemnitees from any claims made or asserted against same arising out of or related to such Work and alleging a failure to comply with any such environmental requirements, including any and all judgments, monetary penalties or fines directed against Indemnitees as a result of Consultant's performance of the Work, including attorney's fees and expenses incurred by Indemnitees in any litigation or regulatory action arising out of such Work.

(d) Indemnitees shall have the right (but not the obligation) to defend any Claim for which they are indemnified by Consultant or Subcontractor hereunder and, in the event Indemnitees elect to exercise such right to defend themselves, shall be entitled to select counsel of its choice to conduct such defense and to be reimbursed by Consultant for the reasonable costs and expenses of such counsel; provided that the Indemnitees shall not settle such claim or cause of action prior to obtaining the written consent of Consultant. In the event Indemnitees elect not to defend any such Claim, Consultant shall have the right to defend and settle such Claim in the name and stead of Indemnitees and in its own name, and to select counsel of its choice to represent itself and Indemnitees together or alone, whichever the case may be; provided that Consultant shall not settle such Claim or cause of action prior to obtaining the written consent of the Indemnitees; and provided further that if there is an actual or potential conflict of interest between Indemnitees and Consultant with respect to any such Claim, such that counsel selected by Consultant cannot represent both the Indemnitees and Consultant without waivers of such conflict, then Consultant shall pay the reasonable costs and expenses of the Indemnitees' separate legal representation, in addition to the cost of counsel selected by Consultant. Indemnitees shall give notice to Consultant of its election whether to defend any such claim or cause of action.

(e) Consultant shall indemnify, defend and hold Indemnitees harmless from and against any claim, expense, fine, levy, penalty or liability of any kind sought to be imposed on Owner by any governmental authority or person as a result of Consultant or Subcontractor's failure to comply with regulations pertaining to anti-drug and alcohol testing programs and operator qualification programs. Consultant further agrees to indemnify, defend and hold Indemnitees harmless from and against any costs, including reasonable attorneys' fees, incurred by Indemnitees in the course of any litigation or regulatory action arising out of noncompliance with such programs and regulations.

(f) Consultant's indemnification obligations set forth in paragraphs (c), (d) and (e) above are in addition to, and in no way shall be a limitation of, Consultant's indemnification obligations set forth in paragraph (a) above.

(g) Consultant's obligations under this Article shall survive any termination of the Agreement, the Work, or any Purchase Order for a specific Project.

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF
ENERGY AND ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENERGY RESOURCES
100 CAMBRIDGE ST., SUITE 1020
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Deval L. Patrick
Governor

Richard K. Sullivan, Jr.
Secretary

Mark D. Sylvia
Commissioner

May 15, 2014

Mr. Mark Marini, Secretary
Department of Public Utilities
One South Station, Fifth Floor
Boston, Massachusetts 02110

Re: Resolution of the Energy Efficiency Advisory Council Concerning the Statewide Database Request to the Department of Public Utilities dated May 13, 2014.

Dear Secretary Marini:

Enclosed please find the Resolution of the Energy Efficiency Advisory Council ("EEAC", "Council") with respect to certain capabilities and access requirements that a Statewide Energy Efficiency Database may have upon implementation. Pursuant to the Department of Public Utilities ("Department") Order approving each of the Program Administrator's Three-Year Energy Efficiency Investment Plans for 2013 through 2015, D.P.U. 12-100 through D.P.U. 12-111, the Department ruled that the development of a statewide database is consistent with, and complementary to, the revised reporting protocols previously established in D.P.U. 11-120-A, Phase II. The Department further stated that it would participate in the development of the statewide database process. In that Order, the Department also acknowledged that the Department of Energy Resources ("DOER") would assume a leadership role in the development of the database. See Order, p.60.

In its capacity as Chair of the Council, the DOER obtained the consent of the Council to establish a Database Subcommittee. The Database Subcommittee, in turn, created a Database Working Group. Working in tandem, these two bodies have advanced the goal of developing a Statewide Energy Efficiency Database. Their good work has resulted in a clarification of certain issues upon which there is not currently a consensus.

The enclosed Resolution of the Council passed on May 13, 2014 represents a request for guidance from the Department by the Council. As Chair of the Council, the Massachusetts

Department of Energy Resources ("DOER") submits this Resolution of the EEAC to the Department of Public Utilities. The Voting Councilors of the EEAC approved the enclosed Resolution by a vote of thirteen in favor and zero against. Two Voting Councilors were not present for the vote.

On behalf of the Council, the DOER requests that the Department consider the enclosed Council Resolution and take the steps it deems appropriate to make a determination in response to the Council's request for guidance. The DOER thanks the Department for its participation in this process. We stand ready to assist the Department in our shared objective of realizing the Statewide Energy Efficiency Database.

Sincerely,

Steven I. Venezia
Deputy General Counsel

Enclosure

Massachusetts Energy Efficiency Advisory Council
Resolution on Statewide Database
Request to the Department of Public Utilities

The Energy Efficiency Advisory Council ("EEAC") has determined that designing, building, and implementing a statewide energy efficiency database ("Statewide Database") is a chief priority.

Accordingly, the EEAC created a database subcommittee to provide oversight on behalf of the EEAC for activities regarding the design, development, and implementation of a Statewide Database.

The Department of Public Utilities (**"**DPU**"**) recognized that the Department of Energy Resources (**"**DOER**"**) would assume a leadership role in developing a Statewide Database through a stakeholder process. Further, the DPU agreed to participate in the stakeholder process to ensure consistency between the development of the Statewide Database and future energy efficiency performance reports.

A *Massachusetts Statewide Energy Efficiency Database System Specification* and a *Massachusetts Statewide Energy Efficiency Database System Cost and Schedule Estimate* were completed pursuant to the EEAC Database Subcommittee process where there was not full consensus. see Appendix A).

At this time, to continue the development of the Statewide Database, the EEAC is requesting guidance from the DPU on two matters:

1. The EEAC hereby requests that the DPU with all deliberate speed identify the data inputs, required to inform the EEAC and the DPU in their respective mandates to oversee the pursuit of all cost-effective energy efficiency on a statewide basis, which include site, project, measure, and participant and non participant usage that shall be included in the Statewide Database.

If, in answering 1. above, the DPU identifies customer data to be included in the Statewide Database that the DPU deems subject to Massachusetts data privacy laws then:

2. The EEAC hereby requests that the DPU with all deliberate speed decide on the reporting schedules and recommended data privacy controls for:

    (a) Confidential, granular statewide energy efficiency and ratepayer usage data;

    (b) Publically viewable datasets, which will be derived from the data stored in the Statewide Database; and

    c) Responsibility for funding and hosting a Statewide Database containing confidential data.

X. **Responses and Roadmap to Department's Additional Filing Requirements**

2016-2018 Three-Year Energy Efficiency Plans
Additional Filing Requirements

1. Provide pre-filed testimony describing the development and determination of the proposed statewide and Program Administrator-specific savings goals. Explain how technical potential studies and other sources were used in this regard, and provide copies of all statewide and Program Administrator-specific technical potential studies and other sources that were used.

Response:

Please see Pre-Filed Testimony of each Program Administrator (available at Exhibit 2 to each PA's Petition), and Studies of Remaining Potential included in Appendix M of this Plan. Additionally, please see Section IV.A of the Plan for additional information on development of goals.

2. Incorporate the following information into the D.P.U. 08-50 tables, by core initiative, providing actual and estimated values for plan years 2013-2015,[1] and planned values for plan years 2016-2018:[2]

a. Savings Tables 1 through 4: savings per total resource cost ("TRC") (i.e., electric savings (megawatt-hour ("MWh")/$ spent), gas savings (therms/$ spent), and oil savings (million British Thermal Units ("MMBtu")/$ spent));

b. Savings Tables 1 through 4: savings per participant per TRC (i.e., electric annual savings MWh/participant/$ spent; gas annual savings therms/participant/$ spent; oil annual savings mmBTU/participant/$ spent);

c. Benefits Tables 1 though 4: resource benefits per program cost;

d. Benefits Tables 1 through 4: resource benefits per TRC;

e. Benefits Tables 1 through 4: resource benefits per participant per TRC (i.e., total resource benefits/participant/$ spent);

f. Savings Tables 1 through 4: average percent savings (i.e., annual reduction vs. previous year billed usage) applicable to direct incentive (or downstream) core initiatives where Program Administrators have information on participant energy usage; and

g. Savings Tables 1 through 4: same-year load-weighted participation by program by meter (percent of eligible customer load participating in at least one direct incentive program).

Response:

For responses to parts (a) through (e), please see the "Elec/Gas Add. Filing Reqs" tab of the Energy Efficiency Data Tables, filed individually by PAs as Exhibit 4 to each PA's Petition, and aggregated statewide in Appendix C to this Plan. PAs included the additional materials required under this question all on one tab in order to assist in review and to keep other tables consistent with past filings.

f. The PAs cannot provide average percent savings per core initiative. The definitions of participants, available in Appendix P, show that a single customer class can be a participant in multiple core initiatives within a program and sector. Core initiatives were not designed to be offered exclusively to specific customers or rate classes, so usage cannot be isolated or allocated per core initiative. Therefore, in attempting to make this calculation, the denominator (usage) for most core initiatives would overlap with other core initiatives, and would not provide data that could tie to any specific core initiative.

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[1] Where in these additional filing requirements data are sought for program years 2013-2014, file actual values; for program year 2015, file the most up-to-date actual values available.

[2] The Department recognizes the complexities involved in evaluating program participation. In providing the requested information, the Program Administrators should explain how participation is estimated and define what constitutes a "participant."

Additionally, due to numerous factors, including, but not limited to, varying weather conditions, timing of when savings occurred, and economic conditions, the PAs suggest that it is not useful or meaningful to compare savings to the previous year's billed usage without a detailed accounting for other factors through rigorous evaluation.

PAs have sought to understand how participation in the PA programs affects energy usage through EM&V. During the evaluation of PA measures and/or core initiatives, the evaluation team has employed the type of analysis raised in this question, commonly referred to as a billing analysis. This analysis seeks to isolate the impact that program-supported energy efficiency measures will have on controlled pre/post measurement of usage. The pre/post measurement must control for weather, economic conditions, facility sizing, operational changes, changes in occupancy, and manufacturing cycles, as well as many other variables that can significantly change usage from one year to the next. Changes in usage may or may not be due to the installation of program-supported energy efficiency measures; without taking steps to both annualize and weather normalize savings data, and isolate various other factors, it is not possible to determine with any confidence that changes in individual usage were related to a program or measure's savings. Conducting this analysis for every core initiative would be a multi-stage, lengthy, and expensive undertaking, and would be redundant to the evaluation billing analysis that has been completed through the evaluation studies.

The PAs recognize the importance of understanding how, over time, customers are participating across programs. Through the statewide EM&V process, the PAs research and seek to understand participation through market assessment evaluations, such as the customer profile studies. The goal of these studies is to aggregate statewide data by PA, market sector, and premise in order to better understand participation across the statewide programs.

For further information on the Customer Profile Studies, please see Appendix T (evaluation summaries) and Appendix U (evaluation studies).

g. As stated in the response to Question 2f above, because core initiatives were not designed to be offered exclusively to specific customers or rate classes, load or usage cannot be isolated or allocated per core initiative as most core initiatives overlap with other core initiatives. In order to provide information to help reach the intent of the question, the PAs have provided data at the sector-level for 2013 and 2014, the years in which PAs have data from the Customer Profile Studies.

The percent of eligible customer load participating in at least one direct incentive program can be shown through the results from the C&I and Residential Customer Profile Studies. The C&I Customer Profile study includes preliminary results from 2013 and 2014, while the Residential Customer Profile study includes preliminary results from 2013. Data for 2015 is not available through either customer profile study at this time. For 2016-2018, the Program Administrators only have planned participation and forecasted load. Therefore, there are no accounts to tie usage to.

Table 2-1 below shows Residential and Low-Income participant usage (not including the behavioral and upstream initiatives) as a percent of total usage by PA. This table was provided by the evaluation contractor who aggregated data at the premise level to support the Residential Customer Profile Study completed in October of 2015. Because it was the first time that this type of study was completed in the residential sector and took longer than expected to complete, this data is only available for 2013. The PAs anticipate doing a similar study to include additional years of data in the future; the PAs currently have an open RFP for residential evaluation work, which is expected to include the residential customer profile study going forward. Please see Table 2-1 below for residential and low-income weighted participation rates by PA and statewide.

Table 2-1: Residential & Low-Income Weighted Participation Rates

Fuel Type	Program Administrator	2013
Electric	Cape Light Compact	7.6%
	Eversource	6.2%
	National Grid	8.3%
	Unitil	4.3%
	Statewide	**7.3%**
Gas	Berkshire Gas	4.6%
	Columbia gas	4.7%
	Eversource	6.4%
	Liberty Utilities	2.0%
	National Grid	7.0%
	Unitil	2.5%
	Statewide	**6.1%**

Table 2-2 below shows C&I usage as a percent of total usage by PA. Data is provided separately for 2013 and 2014. The C&I Customer Profile Study for 2014 is currently underway, and past year information is refreshed with each updated study, so both the 2013 and 2014 data is preliminary. Please note that the majority of upstream lighting data is not included in Table 2-2, since these customers could not necessarily be linked to individual billing accounts. This causes the consumption-weighted participation rates to be underestimated for all electric PAs. Further, not all non-upstream participant accounts could be matched with billing account information. For the gas programs, the statewide merge success rate of tracking to billing account information is 85% for 2014. For the electric programs, the statewide merge success rate for 2014 is 36% when the upstream data is included, and 87% when upstream data is not included. Please see Table 2-2 below for C&I weighted participation rates by PA and statewide.

Table 2-2: C&I Weighted Participation Rates			
Fuel Type	**Program Administrator**	**2013**	**2014**
Electric	Cape Light Compact	40.1%	38.7%
	Eversource	49.5%	50.5%
	National Grid	46.6%	45.4%
	Unitil	52.9%	55.1%
	Statewide	**48.0%**	**48.0%**
Gas	Berkshire Gas	18.8%	16.1%
	Columbia gas	18.6%	15.8%
	Eversource	22.1%	19.2%
	Liberty Utilities	29.0%	33.5%
	National Grid	29.2%	25.4%
	Unitil	22.0%	19.9%
	Statewide	**25.6%**	**24.3%**

3. Provide the following information for program years 2013 through 2015. Include pre-filed testimony describing how the Program Administrators used this (and other) information to address participation barriers and achieve deeper participant savings:

a. market sector participation rates in the commercial and industrial ("C&I") energy efficiency programs (e.g., municipal, healthcare, real estate, education, non-profits, hospitality, and small and mid-sized C&I);

b. total number and percentage of new and repeat participants (i.e., participants that participated in at least one direct incentive program over the previous three-year period) by core initiative;

c. percentage of savings associated with new participants and repeat participants by core initiative;

d. total number and percentage of customers participating in multiple core initiatives over the past three years by customer class and/or sector;

e. percentage of participants receiving HEAT loans versus total participants installing HEAT-loan eligible measures;

f. Home Energy Services ("HES") close rate (i.e., percentage of residences that received a retrofit following a home energy assessment, regardless of the number of efficiency measures installed) and savings and associated budget from measures installed under the C&I direct install core initiative compared to the total measures recommended but not installed; and

g. (electric only) percentage of HES oil heating participants receiving either weatherization or heating system upgrades.

Response:

For information on how the PAs use the information requested in this question to address participation barriers and achieve deeper participant savings, please see Pre-Filed Testimony of each Program Administrator (available at Exhibit 2 to each PA's Petition) and the information set forth below.

The PAs use a variety of data sources to evaluate program participation, address participation barriers, and achieve deeper participant savings. The PAs, however, do not use the data in the form expressly as requested in Question 3 of the Department's Additional Filing Requirements to evaluate or project program participation. Valuable sources of information for participant data are the Residential and C&I Customer Profile Studies that the Program Administrators completed in advance of the 2016-2018 Plan. See Appendix U, Study 9; 2014 Energy Efficiency Plan-Year Reports, D.P.U. 15-49, Appendix 4D, Study 14-25.[3] The Residential and C&I Customer Profile Studies, expected to be completed annually going forward, analyze the PAs' billing and tracking data to provide greater insights into the population and participation trends

[3] The C&I Customer Profile Study for 2014 is currently underway.

characterizing the PAs' energy efficiency programs in the Commonwealth. The PAs have used these studies to understand participation and to respond to certain requests for information in the Department's Additional Filing Requirements memorandum.

The Residential and C&I Customer Profile Studies were designed to help streamline and gain insight into the impact that energy efficiency programs are having in Massachusetts across all PAs, electric and gas, in a holistic way. The advantage of this aggregated method is the ability to view data for the Commonwealth as a whole. This study can be used in conjunction with other, more PA-specific segmentation and customer strategies to help understand participation and design programs and "go to market" strategies to achieve greater energy savings and increase program participation. One primary drawback of these studies, however, is that (like other evaluations), there is a time lag between participation and when data analysis is available. The C&I Customer Profile Study includes preliminary results for 2013 and 2014, while the Residential Customer Profile Study includes preliminary results for 2013. The PAs expect to continue work on customer profile studies during the Plan term in order to continue gaining insight into the PAs' customers and their participation in the programs.

The profile studies provide many distinct insights that allow PAs to:

- **Examine changes over time.** While the first Residential Profile study has recently been completed, the C&I Evaluation Database, prepared to support the C&I Profile Study, is populated with four years of consistent, standardized PA billing and tracking data. This data is updated and cleaned each year to support reliable, up-to-date comparisons of program participation and savings over time (*e.g.*, savings achieved by the Healthcare segment between 2011 and 2014).
- **Ensure confidentiality.** The annual Customer Profile Studies, performed by third-party contractors, preserve PAs' customer confidentiality utilizing robust IT system controls, while allowing PAs to evaluate how their standardized data compares to the standardized data for other PAs and the state as a whole.
- **Pinpoint savings opportunities.** PAs plan to supplement billing and tracking data with GIS libraries and tax assessor data to identify and target specific areas and customers with high savings potential. For example, Figure 2 from the 2014 C&I Customer Profile study shows that the Accommodation and Food Service sector had consistently higher energy use intensities ("EUIs") on Cape Cod than in any other region of Massachusetts. See 2014 Energy Efficiency Plan-Year Reports, D.P.U. 15-49, Appendix 4D, Study 14-25. This may represent an opportunity for account-level targeting for efficiency measures, or a more blanketed marketing push.
- **Efficiently identify and analyze research questions.** The annual Customer Profile Studies identify key researchable questions for subsequent study, and the C&I Evaluation Database provides a common collection and storage point for data that can be leveraged across all non-residential evaluation activities, including impact evaluations, market assessments, and process evaluations. Using a common data source also ensures consistency and comparability across studies.

Market Sector Participation Rates

The Customer Profile Studies are used to help improve PAs' understanding of markets, including the C&I markets. Evaluation, such as the Customer Profile Studies, is used to enhance the implementation process. Through implementation, PAs address participant barriers and formulate strategies to obtain deeper and broader savings. PAs employ implementation strategies that are specific to their service territory and size. Many of these strategies in C&I are based on customer engagement; Program Administrators have developed relationships over time with customers, and engage directly with those customers to learn about barriers and provide solutions. Thus, while quantitative data such as market segment participation rates help PAs see trends and find areas on which to focus, PAs use qualitative work with customer engagement and implementation strategies to address participation barriers and achieve deeper participant savings.

New and Repeat Customers

For the majority of core initiatives, the PAs do not use the data requested by the Department on new and repeat customers to address participation barriers or achieve deeper savings. Rather, the PAs address these barriers and goals through program design strategies. In the residential sector, the programs are designed to address participation barriers and achieve deeper savings by offering assessments at no cost to the customer, installing instant savings measures, offering special incentives to help customers overcome low-cost pre-weatherization barriers, incentivizing comprehensive weatherization opportunities, providing downstream rebates on a variety of products, and offering interest-free financing. The goal of these initiatives is to realize deep savings per participant in as few visits to a customer's home as possible, as it is costly to pay for repeat assessments, with diminishing returns on savings opportunities. The data provided does show a low percentage of repeat customers during the term. Most repeat participation in the residential direct install programs shown in the data tables is caused by participation that crosses over from one year to the next, when assessments and installations do not occur in the same calendar year.

The upstream programs are designed to have a broader reach and higher participation rates, as well as greater repeat participation in a core initiative, such as Residential Lighting. Because this core initiative is upstream and not tied to accounts, however, the PAs can only estimate, through the use of evaluation studies, the number of repeat customers.

As shown in the tables in response to questions 3b and 3c, the bulk of repeat participation occurs in the C&I sector, which is based on strategic planning with customers. These customers represent large portions of overall sales, and they typically are large enough to engage in multi-year or multi-phased projects. This PAs have found that in order to maintain high level sustainable energy savings on a portfolio basis, these customers must be engaged on a consistent basis. At the same time, as the customer spends dollars installing energy efficiency, the cost rises while the opportunity diminishes over time. Therefore, holding technological innovation constant, the all cost-effective savings opportunity will decline as the potential for high-savings projects with large repeat customers declines. In addition to very large customers, more moderately sized C&I customers may repeat participation as they may address one end use at a time in a facility, e.g., HVAC in year one and lighting in year two.

Customers Participating in Multiple Core Initiatives

In the Residential and Low-Income Whole House programs, comprehensive core initiatives are designed to treat different market segments and customer classes (*e.g.*, single or multi-family, new construction or retrofit), and therefore do not lend themselves to participation across multiple core initiatives. Customers participating in Whole House may also participate in one of the Residential Products program core initiatives, but many of these rebates (such as Residential Lighting) are offered upstream and are not tied to specific accounts, making it difficult to quantify the percentage of customers participating in multiple initiatives. Due to these reasons, the PAs do not use this data to address residential participation barriers and achieve deeper savings and cannot accurately calculate it where upstream initiatives are included.

While the Program Administrators did not expressly use the data requested on customers participating in multiple core initiatives to address participation barriers, PAs are constantly using information from evaluation studies, feedback from stakeholders, customers, and vendors to improve program offerings. Examples of additional enhancements and strategic targeted approaches included in this Plan are new efforts geared toward renters and moderate income customers, described further in Section III.E.3 and III.E.5 of this Plan.

C&I customers are more likely to participate across C&I core initiatives, but the PAs do not focus on this data to address participation barriers. This is because both the customer and the PA are focused on ensuring that the customer has the opportunity to explore all cost-effective energy efficiency projects at the facility, using whichever core initiatives are appropriate for that customer. Due to the broad range of projects available to a single customer under a single C&I core initiative, participation in one core initiative is not a good indicator that the customer has exhausted options to participate further in that core initiative, or that they are necessarily a good candidate to participate in a different core initiative. Participation in one core initiative does not provide the PA or the customer insight into other opportunities at the facility; insight is gained primarily through PA-customer engagement, where PAs learn about the customer needs, including which initiatives the customer has already pursued projects in, and what opportunities are still available.

HEAT Loan Participation Rate

HEAT Loan is an important tool that the PAs offer to overcome a barrier that some residential customers may face in investing in energy efficiency improvements. The financing of nearly $300 million of HEAT Loans to residential customers has been one of the critical steps in achieving a higher adoption of deeper saving measures in the PA programs. Thus, while the PAs do not typically use the calculations requested by the Department for planning purposes (such as addressing participation barriers and achieving deeper savings), HEAT Loan is a critical piece to the residential portfolio's planning process. PAs analyze historical expenditures on HEAT Loan, along with expected changes in the number and cost of eligible measures and participants, as the primary considerations for planning purposes. The HEAT Loan expenditures exceeded expectations in 2013-2015; based on these high levels of uptake, many PAs submitted Mid-Term Modifications to continue this popular offering. For 2016-2018, the PAs have been able to forecast with greater precision given five years of historical data, providing a better sense of demand for HEAT Loan.

The PAs also rely on evaluation results to help them in planning. The Home Energy Services Initiative and HEAT Loan Delivery Assessment, completed in July 2015, demonstrated the popularity and effectiveness of the HEAT Loan financing option. This evaluation noted that 83 percent of respondents that received a HEAT Loan were "Very Satisfied" with it. For those customers that financed a measure with the HEAT Loan, the HEAT Loan was identified as the most influential factor in the decision making process. These types of evaluation results show that HEAT Loan is effective at helping PAs to address customer financing barriers and achieve energy savings.

Home Energy Services and C&I Direct Install Close Rates

Customer participation in the Home Energy Services core initiative has been very robust, and is expected to continue to be a successful offering in 2016-2018. The percent of customers installing insulation and air-sealing has also continued to increase each year. This is due to a multitude of strategies undertaken by the PAs to address participation barriers and achieve deeper participant savings.

While the PAs have long offered generous incentives, interest-free financing, and targeted customer follow up to achieve deeper participant savings, over the past three years the PAs undertook additional efforts to understand and address more niche markets. Those strategies include increasing consumer education through ongoing marketing, introducing an online energy assessment that provides customers property specific recommendations, and strategic follow up to customers with identified opportunities. Additionally, the PAs will continue to offer the pre-weatherization barrier incentives in 2016-2018. Based on the lessons learned from Efficient Neighborhoods+®, the PAs have developed a new enhanced offering for moderate income customers in 2016-2018 to address participation barriers and achieve deeper savings.

In addition to the strategies mentioned above, the PAs have also taken into account customer response to volatile electric rates in the winter and the effect of severe weather in recent years. These circumstances have contributed to increasing demand for residential energy efficiency services, which the PAs have, and will continue to, respond to in order to achieve greater participant savings.

Regarding the C&I Direct Install core initiative, the PAs have substantial experience in serving this customer group, as they have been offering the C&I Direct Install core initiative in various forms for over two decades. The PAs do not look at project measures installed versus measures proposed for planning purposes. Instead, to increase participation and per-customer savings, the PAs seek segment-specific opportunities, review city or town small business participation rates, and study technological penetration rates when planning new initiatives targeted at small businesses.

HES Oil Heating Participants

The electric PAs offer fuel-blind energy efficiency services to customers in homes with 1-4 units through the HES core initiative, including customers who heat with oil. The PAs do not use the data requested in this question regarding percentage of HES oil heating participants receiving either weatherization or heating system upgrades to address participation barriers or achieve deeper savings. Increasing participation among all customers, including those who heat with oil, is a focus of PA efforts through its fuel blind programs.

One example of PA programs that reach oil heating customers is the early heating system replacement initiative, which has been a highly successful offering for customers who heat with oil. This initiative has historically been promoted as a limited time offer and encourages customers with functioning oil boilers 30 years or older and oil furnaces 12 years or older to replace that equipment with energy efficient alternatives. Customers are offered enhanced incentives for replacing these systems prior to failure. This initiative has attracted over 4,000 oil heat participants to date, despite it being a limited time offer.

Standard oil heating and hot water system rebates and rebate forms are on the Mass Save website; customers may apply for their rebates online without a home energy assessment. The success of current fuel blind programs among participants in HES has helped the PAs to estimate fuel-blind planning values for participants in the multi-family core initiative in the 2016-2018 Plan term.

a. The following tables give the un-weighted participation rates for each PA in 2013 and 2014 by Industry Sector (Table 3-1 and Table 3-2) and by customer size range (Table 3-3 and Table 3-4). Data is provided separately for 2013 and 2014. The C&I Customer Profile Study for 2014 is currently underway, and past year information is refreshed with each updated study, so both the 2013 and 2014 data is preliminary. The majority of upstream lighting data is not included in the provided data, since these customers could not necessarily be linked to individual billing accounts. Further, not all non-upstream participant accounts could be matched with billing account information. For the gas programs, the statewide merge success rate of tracking to billing account information is 85% for 2014. For the electric programs, the statewide merge success rate for 2014 is 36% when the upstream data is included, and 87% when upstream data is not included. Since a large segment of participation data cannot be linked to billing data, the participation rates given in this response should be cautiously interpreted.

   Along with the recognizable Industry sector descriptions included in the following tables, there are three categories used to group data that could not be categorized:

   - No Data – Indicates that a record was blank and nothing is known about that account. This is most often the case when a participant account could not be matched to billing data, as with upstream.

- Unknown – Indicates the PA provided a code for the industry sector, but the provided code was mis-keyed, such as 99999.
- NA – Almost always a result of information provided by tax data for accounts with a residential code. In such cases, the tax code is kept, but the account is not a good fit for any other industrial sector category. An example could be an office run out of a residential home address.

Results by size range are shown by kW for electric programs, and therms for gas programs.

Table 3-1

Electric Yearly Participation Rate – Unweighted*		**Year**	
PA	**Industry Sector**	**2013**	**2014**
Cape Light Compact	Accommodation and Food Services	6.7%	7.1%
	Agriculture, Forestry, Fishing and Hunting	2.4%	2.5%
	Arts, Entertainment, and Recreation	7.0%	7.3%
	Educational Services	25.7%	26.0%
	Health Care and Social Assistance	5.0%	5.2%
	Information	37.5%	41.4%
	Manufacturing	5.6%	5.6%
	Mining, Quarrying, and Oil and Gas Extraction	0.0%	0.0%
	NA	3.2%	3.9%
	No Data	12.5%	1.8%
	Other Services (except Public Administration)	6.3%	6.8%
	Professional, Scientific, and Technical Services	6.7%	7.1%
	Public Administration	10.5%	10.6%
	Retail Trade	10.6%	11.3%
	Transportation and Warehousing	4.8%	5.1%
	Unknown	1.2%	1.3%
	Utilities	0.0%	0.0%
Eversource	Accommodation and Food Services	9.8%	10.8%
	Administrative and Support and Waste Management and Remediation Services	7.0%	9.1%
	Agriculture, Forestry, Fishing and Hunting	6.3%	7.0%
	Arts, Entertainment, and Recreation	11.3%	13.3%
	Construction	9.5%	11.3%
	Educational Services	16.5%	18.6%
	Finance and Insurance	7.2%	9.2%
	Health Care and Social Assistance	9.2%	11.0%
	Information	4.7%	6.8%
	Management of Companies and Enterprises	10.8%	15.1%

	Manufacturing	6.8%	7.7%
	Mining, Quarrying, and Oil and Gas Extraction	10.3%	8.8%
	NA	6.3%	7.1%
	No Data	5.5%	3.0%
	Other Services (except Public Administration)	11.1%	12.6%
	Professional, Scientific, and Technical Services	5.2%	7.1%
	Public Administration	5.1%	5.2%
	Real Estate and Rental and Leasing	5.4%	6.7%
	Retail Trade	18.1%	21.1%
	Transportation and Warehousing	4.7%	5.0%
	Unknown	8.2%	9.5%
	Utilities	4.2%	4.4%
	Wholesale Trade	13.1%	14.2%
National Grid	Accommodation and Food Services	3.0%	3.2%
	Administrative and Support and Waste Management and Remediation Services	3.5%	3.6%
	Agriculture, Forestry, Fishing and Hunting	4.4%	4.3%
	Arts, Entertainment, and Recreation	10.2%	10.6%
	Construction	3.7%	3.9%
	Educational Services	16.9%	17.5%
	Finance and Insurance	6.6%	6.9%
	Health Care and Social Assistance	6.1%	6.2%
	Information	1.8%	1.9%
	Management of Companies and Enterprises	7.1%	8.0%
	Manufacturing	15.4%	16.0%
	Mining, Quarrying, and Oil and Gas Extraction	8.7%	7.9%
	NA	0.8%	1.0%
	No Data	0.9%	0.8%
	Other Services (except Public Administration)	6.9%	7.2%
	Professional, Scientific, and Technical Services	4.5%	4.6%
	Public Administration	6.7%	6.7%
	Real Estate and Rental and Leasing	3.6%	3.6%
	Retail Trade	14.3%	15.2%
	Transportation and Warehousing	5.7%	6.0%
	Unknown	2.7%	2.8%
	Utilities	7.6%	7.5%
	Wholesale Trade	9.2%	9.5%
Unitil	Accommodation and Food Services	1.1%	1.0%
	Agriculture, Forestry, Fishing and Hunting	0.0%	0.0%
	Arts, Entertainment, and Recreation	10.3%	11.5%
	Educational Services	28.2%	13.0%

	Finance and Insurance	5.0%	5.3%
	Health Care and Social Assistance	3.9%	3.9%
	Information	0.0%	0.0%
	Manufacturing	18.2%	18.2%
	Mining, Quarrying, and Oil and Gas Extraction	0.0%	0.0%
	NA	5.6%	5.1%
	No Data	4.4%	4.2%
	Other Services (except Public Administration)	0.0%	0.0%
	Professional, Scientific, and Technical Services	5.7%	5.8%
	Public Administration	23.4%	16.7%
	Retail Trade	11.7%	11.7%
	Transportation and Warehousing	10.0%	10.1%
	Utilities	0.0%	0.0%
Statewide	Accommodation and Food Services	4.9%	4.9%
	Administrative and Support and Waste Management and Remediation Services	3.8%	4.1%
	Agriculture, Forestry, Fishing and Hunting	4.3%	4.4%
	Arts, Entertainment, and Recreation	9.9%	10.7%
	Construction	4.3%	4.5%
	Educational Services	16.9%	18.1%
	Electric Total	3.0%	1.6%
	Finance and Insurance	6.9%	7.8%
	Health Care and Social Assistance	6.9%	7.4%
	Information	3.0%	3.4%
	Management of Companies and Enterprises	10.7%	14.8%
	Manufacturing	10.1%	11.3%
	Mining, Quarrying, and Oil and Gas Extraction	9.0%	8.0%
	NA	2.9%	3.2%
	Other Services (except Public Administration)	8.3%	8.7%
	Professional, Scientific, and Technical Services	5.2%	6.6%
	Public Administration	6.5%	6.6%
	Real Estate and Rental and Leasing	4.5%	4.9%
	Retail Trade	15.4%	16.7%
	Transportation and Warehousing	5.0%	5.3%
	Unknown	5.9%	6.2%
	Utilities	3.7%	3.6%
	Wholesale Trade	9.7%	10.1%

*Industry sector data could not be matched to all accounts. For the electric programs, the statewide success rate for matching industry sector to accounts was 85% for 2014 data and 95% for 2013 data

Table 3-2

Gas Yearly Participation Rate – Unweighted**		Year	
PA	**Industry Sector**	**2013**	**2014**
Eversource	Accommodation and Food Services	19.0%	19.7%
	Administrative and Support and Waste Management and Remediation Services	11.1%	11.1%
	Agriculture, Forestry, Fishing and Hunting	0.0%	0.0%
	Arts, Entertainment, and Recreation	10.0%	11.0%
	Construction	8.9%	9.3%
	Educational Services	10.2%	10.6%
	Finance and Insurance	3.2%	3.5%
	Health Care and Social Assistance	8.0%	8.4%
	Information	7.8%	8.8%
	Management of Companies and Enterprises	5.7%	6.9%
	Manufacturing	6.9%	7.7%
	Mining, Quarrying, and Oil and Gas Extraction	0.0%	0.0%
	NA	6.3%	6.7%
	No Data	2.7%	1.1%
	Other Services (except Public Administration)	5.4%	5.6%
	Professional, Scientific, and Technical Services	5.9%	6.6%
	Public Administration	5.9%	5.9%
	Real Estate and Rental and Leasing	3.9%	4.2%
	Retail Trade	7.8%	8.3%
	Transportation and Warehousing	3.9%	4.0%
	Unknown	7.9%	8.5%
	Utilities	3.2%	3.2%
	Wholesale Trade	3.6%	4.3%
National Grid	Accommodation and Food Services	35.0%	34.9%
	Administrative and Support and Waste Management and Remediation Services	4.8%	4.8%
	Agriculture, Forestry, Fishing and Hunting	7.8%	8.2%
	Arts, Entertainment, and Recreation	8.1%	8.2%
	Construction	2.9%	3.2%
	Educational Services	10.8%	10.7%
	Finance and Insurance	4.6%	4.6%
	Health Care and Social Assistance	8.2%	8.0%
	Information	5.1%	5.2%
	Management of Companies and Enterprises	4.0%	4.3%
	Manufacturing	7.0%	7.4%
	Mining, Quarrying, and Oil and Gas Extraction	3.1%	3.0%
	NA	9.3%	10.7%

	No Data	2.5%	1.0%
	Other Services (except Public Administration)	5.9%	6.1%
	Professional, Scientific, and Technical Services	4.4%	4.6%
	Public Administration	7.4%	7.4%
	Real Estate and Rental and Leasing	5.9%	6.0%
	Retail Trade	8.2%	8.5%
	Transportation and Warehousing	2.0%	1.9%
	Unknown	8.2%	8.4%
	Utilities	2.3%	2.4%
	Wholesale Trade	4.9%	5.1%
Small Gas PAs	Accommodation and Food Services	6%	7%
	Agriculture, Forestry, Fishing and Hunting	0%	0%
	Arts, Entertainment, and Recreation	6%	6%
	Construction	0%	0%
	Educational Services	8%	8%
	Finance and Insurance	1%	1%
	Health Care and Social Assistance	8%	8%
	Information	0%	0%
	Manufacturing	6%	6%
	Mining, Quarrying, and Oil and Gas Extraction	0%	0%
	NA	10%	10%
	No Data	5%	4%
	Other Services (except Public Administration)	9%	10%
	Professional, Scientific, and Technical Services	7%	7%
	Public Administration	6%	6%
	Retail Trade	4%	4%
	Transportation and Warehousing	5%	5%
	Unknown	6%	6%
	Utilities	0%	0%
Unitil	Accommodation and Food Services	2.4%	1.9%
	Agriculture, Forestry, Fishing and Hunting	0.0%	0.0%
	Arts, Entertainment, and Recreation	0.0%	0.0%
	Educational Services	20.0%	20.0%
	Finance and Insurance	0.0%	0.0%
	Health Care and Social Assistance	14.3%	14.3%
	Manufacturing	5.9%	5.9%
	NA	7.5%	7.7%
	No Data	3.5%	2.2%
	Other Services (except Public Administration)	3.7%	3.7%
	Professional, Scientific, and Technical Services	3.3%	3.4%

	Public Administration	6.8%	7.0%
	Retail Trade	5.6%	5.7%
	Transportation and Warehousing	3.3%	3.4%
	Utilities	0.0%	0.0%
Berkshire	Accommodation and Food Services	10%	10%
	Agriculture, Forestry, Fishing and Hunting	0%	0%
	Arts, Entertainment, and Recreation	10%	10%
	Educational Services	8%	8%
	Finance and Insurance	2%	2%
	Health Care and Social Assistance	12%	12%
	Information	0%	0%
	Manufacturing	9%	9%
	Mining, Quarrying, and Oil and Gas Extraction	0%	0%
	NA	10%	11%
	No Data	6%	5%
	Other Services (except Public Administration)	14%	15%
	Professional, Scientific, and Technical Services	9%	10%
	Public Administration	6%	6%
	Retail Trade	5%	6%
	Transportation and Warehousing	6%	6%
	Unknown	8%	8%
	Utilities	0%	0%
Columbia	Accommodation and Food Services	5%	8%
	Administrative and Support and Waste Management and Remediation Services	0%	0%
	Agriculture, Forestry, Fishing and Hunting	26%	27%
	Arts, Entertainment, and Recreation	6%	7%
	Construction	4%	4%
	Educational Services	13%	13%
	Finance and Insurance	3%	3%
	Health Care and Social Assistance	9%	10%
	Information	2%	2%
	Management of Companies and Enterprises	0%	0%
	Manufacturing	3%	3%
	Mining, Quarrying, and Oil and Gas Extraction	4%	4%
	NA	5%	7%
	No Data	4%	3%
	Other Services (except Public Administration)	7%	7%
	Professional, Scientific, and Technical Services	3%	3%
	Public Administration	5%	5%
	Real Estate and Rental and Leasing	4%	4%

	Retail Trade	6%	6%
	Transportation and Warehousing	2%	2%
	Unknown	7%	7%
	Utilities	1%	1%
	Wholesale Trade	0%	0%
Liberty	Accommodation and Food Services	4%	4%
	Arts, Entertainment, and Recreation	2%	2%
	Construction	0%	0%
	Educational Services	0%	0%
	Finance and Insurance	1%	1%
	Health Care and Social Assistance	5%	6%
	Information	0%	0%
	Manufacturing	4%	4%
	No Data	0%	1%
	Other Services (except Public Administration)	4%	4%
	Professional, Scientific, and Technical Services	2%	2%
	Public Administration	5%	5%
	Retail Trade	2%	3%
	Transportation and Warehousing	3%	4%
	Unknown	6%	6%
	Utilities	0%	0%
Statewide	Accommodation and Food Services	20.3%	22.7%
	Administrative and Support and Waste Management and Remediation Services	4.8%	4.8%
	Agriculture, Forestry, Fishing and Hunting	10.4%	10.9%
	Arts, Entertainment, and Recreation	8.0%	8.3%
	Construction	3.0%	3.3%
	Educational Services	10.8%	10.8%
	Finance and Insurance	4.0%	4.1%
	Gas Total	4%	2%
	Health Care and Social Assistance	8.3%	8.2%
	Information	5.4%	5.6%
	Management of Companies and Enterprises	5.5%	6.6%
	Manufacturing	5.7%	6.1%
	Mining, Quarrying, and Oil and Gas Extraction	3.1%	3.2%
	NA	6.9%	8.4%
	Other Services (except Public Administration)	6.0%	6.2%
	Professional, Scientific, and Technical Services	5.0%	5.3%
	Public Administration	6.3%	6.4%
	Real Estate and Rental and Leasing	5.5%	5.7%
	Retail Trade	7.1%	7.4%

	Transportation and Warehousing	2.4%	2.5%
	Unknown	7.2%	7.6%
	Utilities	1.6%	1.8%
	Wholesale Trade	4.8%	5.0%

**Industry sector data could not be matched to all accounts. For the gas programs, the statewide success rate for matching industry sector to accounts was 80% for 2014 data and 88% for 2013 data.

Table 3-3

Electric Yearly Participation Rate – Unweighted			**Year**	
PA	**Industry Sector**	**Size Range (kW)**	**2013**	**2014**
Cape Light Compact	Very Large	> 5,000	0.0%	0.0%
	Large	1,000 to 5,000	60.0%	88.9%
	Medium - Large	300 to 1,000	21.3%	32.2%
	Medium - Small	75 to 300	13.4%	13.8%
	Small	<75	1.4%	2.1%
Eversource	Very Large	> 5,000	51.9%	65.2%
	Large	1,000 to 5,000	23.1%	28.0%
	Medium - Large	300 to 1,000	14.1%	18.6%
	Medium - Small	75 to 300	8.9%	8.0%
	Small	<75	1.6%	1.5%
National Grid	Very Large	> 5,000	65.2%	76.2%
	Large	1,000 to 5,000	33.4%	42.8%
	Medium - Large	300 to 1,000	17.5%	20.2%
	Medium - Small	75 to 300	9.8%	11.2%
	Small	<75	1.1%	1.6%
Unitil	Very Large	> 5,000	0.0%	100.0%
	Large	1,000 to 5,000	50.0%	40.0%
	Medium - Large	300 to 1,000	20.0%	22.2%
	Medium - Small	75 to 300	12.6%	4.9%
	Small	<75	1.4%	1.6%
Statewide	Very Large	> 5,000	53.8%	68.1%
	Large	1,000 to 5,000	27.2%	33.8%
	Medium - Large	300 to 1,000	15.9%	19.7%
	Medium - Small	75 to 300	9.5%	9.7%
	Small	<75	1.3%	1.6%

Table 3-4

Gas Yearly Participation Rate - Unweighted			Year	
PA	**Industry Sector**	**Size Range (Therm)**	**2013**	**2014**
Berkshire	Very Large	>1,000,000	100.0%	0.0%
	Large	80,000 to 1,000,000	9.5%	6.9%
	Medium - Large	40,000 to 80,000	9.8%	12.2%
	Medium - Small	8,000 to 40,000	4.0%	2.7%
	Small	< 8,000	2.5%	1.4%
Columbia	Very Large	>1,000,000	31.3%	28.6%
	Large	80,000 to 1,000,000	7.3%	10.9%
	Medium - Large	40,000 to 80,000	6.3%	6.3%
	Medium - Small	8,000 to 40,000	5.3%	4.2%
	Small	< 8,000	1.3%	0.9%
Eversource	Very Large	>1,000,000	23.8%	39.1%
	Large	80,000 to 1,000,000	11.6%	11.9%
	Medium - Large	40,000 to 80,000	9.5%	6.7%
	Medium - Small	8,000 to 40,000	6.3%	4.2%
	Small	< 8,000	1.9%	1.2%
Liberty	Very Large	>1,000,000	66.7%	33.3%
	Large	80,000 to 1,000,000	6.7%	4.5%
	Medium - Large	40,000 to 80,000	1.7%	7.0%
	Medium - Small	8,000 to 40,000	1.6%	6.8%
	Small	< 8,000	0.4%	1.1%
National Grid	Very Large	>1,000,000	18.6%	23.3%
	Large	80,000 to 1,000,000	17.1%	11.1%
	Medium - Large	40,000 to 80,000	10.0%	7.2%
	Medium - Small	8,000 to 40,000	9.4%	4.3%
	Small	< 8,000	2.6%	1.3%
Unitil	Very Large	>1,000,000	0.0%	0.0%
	Large	80,000 to 1,000,000	3.6%	10.7%
	Medium - Large	40,000 to 80,000	0.0%	4.0%
	Medium - Small	8,000 to 40,000	1.0%	4.5%
	Small	< 8,000	0.5%	1.4%
Statewide	Very Large	>1,000,000	24.7%	28.8%
	Large	80,000 to 1,000,000	12.0%	11.0%
	Medium - Large	40,000 to 80,000	8.4%	7.1%
	Medium - Small	8,000 to 40,000	7.1%	4.3%
	Small	< 8,000	2.0%	1.2%

b. Please see the tables below for each PA for parts (b) and (c) of this Question 3. The Program Administrators made the following assumptions in order to best respond to these questions:

- Since 2013 is the first year of the term, all participants for the 2013 program year are considered to be new.
- Participation is isolated to core initiatives, since PAs count participants separately in each core initiative. For example, if a residential customer participated in Home Energy Services in 2013 and Heating & Cooling in 2014, that customer would be counted as "new" in each initiative.
- PAs used unique account numbers as a proxy for participants for the purpose of this question because unique accounts are the only way to determine if a participant is new or repeat. Therefore, core initiatives that cannot be tracked back to unique account numbers could not be included here. These core initiatives that could not be tracked include: Residential Lighting, Residential Behavior/Feedback, a portion of Residential Consumer Products, the portion of C&I New Construction associated with C&I Upstream Lighting, some true new construction accounts, other various upstream measures and other miscellaneous accounts which may have started or ended service.

Please see Table 3-5 on the following pages, which includes information responding to parts b and c of this Question 3.

Table 3-5: CLC

2013 (Actuals, based on 2013 Plan Year Report)								
Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual MWh) Associated with New Participants	Savings (Annual MWh) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**9,378**	**-**	**100%**	**0%**	**7,490**	**-**	**100%**	**0%**
Residential Whole House	5,003	-	100%	0%	5,892	-	100%	0%
Residential New Construction	98	-	100%	0%	337	-	100%	0%
Residential Multi-Family Retrofit	137	-	100%	0%	284	-	100%	0%
Residential Home Energy Services	4,768	-	100%	0%	5,271	-	100%	0%
Residential Behavior/Feedback	-	-	N/A	N/A	-	-	N/A	N/A
Residential Products	4,375	-	100%	0%	1,598	-	100%	0%
Residential Cooling & Heating Equipment	1,737	-	100%	0%	1,091	-	100%	0%
Residential Lighting *	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Residential Consumer Products *	2,638	-	100%	0%	508	-	100%	0%
Low-Income (total)	**1,066**	**-**	**100%**	**0%**	**1,828**	**-**	**100%**	**0%**
Low-Income Whole House	1,066	-	100%	0%	1,828	-	100%	0%
Low-Income New Construction	5	-	100%	0%	110	-	100%	0%
Low-Income Single Family Retrofit	835	-	100%	0%	1,349	-	100%	0%
Low-Income Multi-Family Retrofit	226	-	100%	0%	369	-	100%	0%
Commercial & Industrial (total)	**384**	**-**	**100%**	**0%**	**7,532**	**-**	**100%**	**0%**
C&I New Construction	17	-	100%	0%	1,076	-	100%	0%
C&I New Construction *	17	-	100%	0%	1,076	-	100%	0%
C&I Retrofit	367	-	100%	0%	6,457	-	100%	0%
C&I Retrofit	40	-	100%	0%	2,140	-	100%	0%
C&I Direct Install	327	-	100%	0%	4,317	-	100%	0%
Grand Total	**10,828**	**-**	**100%**	**0%**	**16,850**	**-**	**100%**	**0%**

2014 (Actuals, based on 2014 Plan Year Report)								
Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual MWh) Associated with New Participants	Savings (Annual MWh) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**10,511**	**536**	**95%**	**5%**	**8,643**	**316**	**96%**	**4%**
Residential Whole House	6,090	277	96%	4%	6,989	218	97%	3%
Residential New Construction	95	-	100%	0%	482	-	100%	0%
Residential Multi-Family Retrofit	367	8	98%	2%	497	49	91%	9%
Residential Home Energy Services	5,628	269	95%	5%	6,011	170	97%	3%
Residential Behavior/Feedback	-	-	N/A	N/A	-	-	N/A	N/A
Residential Products	4,421	259	94%	6%	1,653	98	94%	6%
Residential Cooling & Heating Equipment	1,651	135	92%	8%	1,086	72	94%	6%
Residential Lighting *	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Residential Consumer Products *	2,770	124	96%	4%	568	26	96%	4%
Low-Income (total)	**922**	**167**	**85%**	**15%**	**1,753**	**174**	**91%**	**9%**
Low-Income Whole House	922	167	85%	15%	1,753	174	91%	9%
Low-Income New Construction	50	-	100%	0%	26	-	100%	0%
Low-Income Single Family Retrofit	642	132	83%	17%	1,429	115	93%	7%
Low-Income Multi-Family Retrofit	230	35	87%	13%	299	59	83%	17%
Commercial & Industrial (total)	**448**	**42**	**91%**	**9%**	**14,384**	**2,182**	**87%**	**13%**
C&I New Construction	21	-	100%	0%	1,014	-	100%	0%
C&I New Construction *	21	-	100%	0%	1,014	-	100%	0%
C&I Retrofit	427	42	91%	9%	13,371	2,182	86%	14%
C&I Retrofit	51	11	82%	18%	7,991	1,283	86%	14%
C&I Direct Install	376	31	92%	8%	5,380	899	86%	14%
Grand Total	**11,881**	**745**	**94%**	**6%**	**24,780**	**2,673**	**90%**	**10%**

2015 (Actuals, based on data through August 2015)								
Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual MWh) Associated with New Participants	Savings (Annual MWh) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**6,924**	**730**	**90%**	**10%**	**8,593**	**482**	**95%**	**5%**
Residential Whole House	4,642	448	91%	9%	7,460	377	95%	5%
Residential New Construction	96	-	100%	0%	461	-	100%	0%
Residential Multi-Family Retrofit	412	48	90%	10%	977	22	98%	2%
Residential Home Energy Services	4,134	400	91%	9%	6,022	355	94%	6%
Residential Behavior/Feedback	-	-	N/A	N/A	-	-	N/A	N/A
Residential Products	2,282	282	89%	11%	1,133	104	92%	8%
Residential Cooling & Heating Equipment	1,112	145	88%	12%	851	73	92%	8%
Residential Lighting *	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Residential Consumer Products *	1,170	137	90%	10%	283	31	90%	10%
Low-Income (total)	**586**	**204**	**74%**	**26%**	**992**	**145**	**87%**	**13%**
Low-Income Whole House	586	204	74%	26%	992	145	87%	13%
Low-Income New Construction	33	-	100%	0%	23	-	100%	0%
Low-Income Single Family Retrofit	407	165	71%	29%	789	114	87%	13%
Low-Income Multi-Family Retrofit	146	39	79%	21%	180	31	85%	15%
Commercial & Industrial (total)	**370**	**48**	**89%**	**11%**	**7,025**	**1,760**	**80%**	**20%**
C&I New Construction	19	-	100%	0%	1,227	-	100%	0%
C&I New Construction *	19	-	100%	0%	1,227	-	100%	0%
C&I Retrofit	351	48	88%	12%	5,797	1,760	77%	23%
C&I Retrofit	50	6	89%	11%	2,507	1,262	67%	33%
C&I Direct Install	301	42	88%	12%	3,290	498	87%	13%
Grand Total	**7,880**	**982**	**89%**	**11%**	**16,610**	**2,387**	**87%**	**13%**

* All or portions of these programs have upstream components. These totals exclude any savings or participants associated with upstream participation as they cannot be tied to account numbers.

Table 3-5: Eversource - Electric

2013

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual MWh) Associated with New Participants	Savings (Annual MWh) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**66,118**	**-**	**100%**	**0%**	**46,816**	**-**	**100%**	**0%**
Residential Whole House	45,901	-	100%	0%	35,574	-	100%	0%
Residential New Construction	1,689	-	100%	0%	4,574	-	100%	0%
Residential Multi-Family Retrofit	5,690	-	100%	0%	7,561	-	100%	0%
Residential Home Energy Services	38,522	-	100%	0%	23,439	-	100%	0%
Residential Behavior/Feedback	N/A	N/A	0%	0%	N/A	N/A	0%	0%
Residential Products	20,217	-	100%	0%	11,242	-	100%	0%
Residential Cooling & Heating Equipment	6,434	-	100%	0%	4,287	-	100%	0%
Residential Lighting *	N/A	N/A	0%	0%	N/A	N/A	0%	0%
Residential Consumer Products *	13,783	-	100%	0%	6,955	-	100%	0%
Low-Income (total)	**10,452**	**-**	**100%**	**0%**	**18,125**	**-**	**100%**	**0%**
Low-Income Whole House	10,452	-	100%	0%	18,125	-	100%	0%
Low-Income New Construction	193	-	100%	0%	291	-	100%	0%
Low-Income Single Family Retrofit	4,982	-	100%	0%	5,149	-	100%	0%
Low-Income Multi-Family Retrofit	5,277	-	100%	0%	12,685	-	100%	0%
Commercial & Industrial (total)	**3,829**	**-**	**100%**	**0%**	**0**	**-**	**#DIV/0!**	**#DIV/0!**
C&I New Construction	407	-	100%	0%	0	-	#DIV/0!	#DIV/0!
C&I New Construction *	407	-	100%	0%	60,042	-	100%	0%
C&I Retrofit	3,422	-	100%	0%	0	-	#DIV/0!	#DIV/0!
C&I Retrofit	775	-	100%	0%	190,908	-	100%	0%
C&I Direct Install	2,647	-	100%	0%	63,357	-	100%	0%
Grand Total	**80,399**	**-**	**100%**	**0%**	**64,941**	**-**	**100%**	**0%**

2014

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual MWh) Associated with New Participants	Savings (Annual MWh) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**79,031**	**5,907**	**93%**	**7%**	**53,584**	**4,104**	**93%**	**7%**
Residential Whole House	54,496	4,530	92%	8%	43,882	3,515	93%	7%
Residential New Construction	3,640	-	100%	0%	4,645	-	100%	0%
Residential Multi-Family Retrofit	7,203	386	95%	5%	8,683	562	94%	6%
Residential Home Energy Services	43,653	4,144	91%	9%	30,554	2,954	91%	9%
Residential Behavior/Feedback	N/A	N/A	0%	0%	N/A	N/A	0%	0%
Residential Products	24,535	1,377	95%	5%	9,702	588	94%	6%
Residential Cooling & Heating Equipment	6,752	534	93%	7%	4,042	326	93%	7%
Residential Lighting *	N/A	N/A	0%	0%	N/A	N/A	0%	0%
Residential Consumer Products *	17,783	843	95%	5%	5,660	263	96%	4%
Low-Income (total)	**11,379**	**587**	**95%**	**5%**	**21,157**	**967**	**96%**	**4%**
Low-Income Whole House	11,379	587	95%	5%	21,157	967	96%	4%
Low-Income New Construction	653	-	100%	0%	277	-	100%	0%
Low-Income Single Family Retrofit	5,624	396	93%	7%	5,407	380	93%	7%
Low-Income Multi-Family Retrofit	5,102	191	96%	4%	15,473	587	96%	4%
Commercial & Industrial (total)	**3,673**	**311**	**92%**	**8%**	**222,038**	**92,536**	**71%**	**29%**
C&I New Construction	435	32	93%	7%	43,678	15,214	74%	26%
C&I New Construction *	435	32	93%	7%	43,678	15,214	74%	26%
C&I Retrofit	3,238	279	92%	8%	178,360	77,322	70%	30%
C&I Retrofit	828	34	96%	4%	120,941	70,421	63%	37%
C&I Direct Install	2,410	245	91%	9%	57,419	6,901	89%	11%
Grand Total	**94,083**	**6,805**	**93%**	**7%**	**296,780**	**97,607**	**75%**	**25%**

2015

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual MWh) Associated with New Participants	Savings (Annual MWh) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**53,121**	**3,206**	**94%**	**6%**	**51,572**	**2,762**	**95%**	**5%**
Residential Whole House	38,403	2,255	94%	6%	44,611	2,422	95%	5%
Residential New Construction	973	-	100%	0%	3,522	-	100%	0%
Residential Multi-Family Retrofit	4,049	59	99%	1%	5,801	107	98%	2%
Residential Home Energy Services	33,381	2,196	94%	6%	35,288	2,316	94%	6%
Residential Behavior/Feedback	N/A	N/A	0%	0%	N/A	N/A	0%	0%
Residential Products	14,718	951	94%	6%	6,961	340	95%	5%
Residential Cooling & Heating Equipment	4,926	416	92%	8%	3,138	140	96%	4%
Residential Lighting *	N/A	N/A	0%	0%	N/A	N/A	0%	0%
Residential Consumer Products *	9,792	535	95%	5%	3,823	199	95%	5%
Low-Income (total)	**7,883**	**325**	**96%**	**4%**	**20,284**	**792**	**96%**	**4%**
Low-Income Whole House	7,883	325	96%	4%	20,284	792	96%	4%
Low-Income New Construction	151	-	100%	0%	154	-	100%	0%
Low-Income Single Family Retrofit	4,171	195	96%	4%	5,378	244	96%	4%
Low-Income Multi-Family Retrofit	3,561	130	96%	4%	14,752	548	96%	4%
Commercial & Industrial (total)	**1,663**	**264**	**86%**	**14%**	**61,425**	**26,358**	**70%**	**30%**
C&I New Construction	174	37	82%	18%	11,176	3,204	78%	22%
C&I New Construction *	174	37	82%	18%	11,176	3,204	78%	22%
C&I Retrofit	1,489	227	87%	13%	50,249	23,154	68%	32%
C&I Retrofit	297	64	82%	18%	13,555	17,442	44%	56%
C&I Direct Install	1,192	163	88%	12%	36,694	5,712	87%	13%
Grand Total	**62,667**	**3,795**	**94%**	**6%**	**133,281**	**29,912**	**82%**	**18%**

* All or portions of these programs have upstream components. These totals exclude any savings or participants associated with upstream participation as they cannot be tied to account numbers.

Table 3-5: National Grid - Electric

2013 (Actuals, based on 2013 Plan Year Report)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual MWh) Associated with New Participants	Savings (Annual MWh) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**66,296**		**100%**	**0%**	**57,732**		**100%**	**0%**
Residential Whole House	43,494		100%	0%	46,340		100%	0%
Residential New Construction	2,178		100%	0%	2,949		100%	0%
Residential Multi-Family Retrofit	313		100%	0%	13,218		100%	0%
Residential Home Energy Services	41,003		100%	0%	30,173		100%	0%
Residential Behavior/Feedback								
Residential Products	22,802		100%	0%	11,392		100%	0%
Residential Cooling & Heating Equipment	8,160		100%	0%	6,699		100%	0%
Residential Lighting *								
Residential Consumer Products *	14,642		100%	0%	4,693		100%	0%
Low-Income (total)	**7,220**		**100%**	**0%**	**13,883**		**100%**	**0%**
Low-Income Whole House	7,220		100%	0%	13,883		100%	0%
Low-Income New Construction	194		100%	0%	89		100%	0%
Low-Income Single Family Retrofit	6,857		100%	0%	8,022		100%	0%
Low-Income Multi-Family Retrofit	169		100%	0%	5,772		100%	0%
Commercial & Industrial (total)	**2,981**		**100%**	**0%**	**194,990**		**100%**	**0%**
C&I New Construction	376		100%	0%	37,354		100%	0%
C&I New Construction *	376		100%	0%	37,354		100%	0%
C&I Retrofit	2,605		100%	0%	157,636		100%	0%
C&I Retrofit	977		100%	0%	122,762		100%	0%
C&I Direct Install	1,628		100%	0%	34,874		100%	0%
Grand Total	**76,497**		**100%**	**0%**	**266,605**		**100%**	**0%**

2014 (Actuals, based on 2014 Plan Year Report)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual MWh) Associated with New Participants	Savings (Annual MWh) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**76,586**	**5,580**	**93%**	**7%**	**71,564**	**6,447**	**92%**	**8%**
Residential Whole House	50,762	4,069	93%	7%	61,993	3,172	95%	5%
Residential New Construction	1,949		100%	0%	3,781		100%	0%
Residential Multi-Family Retrofit	283	64	82%	18%	14,847	1,880	89%	11%
Residential Home Energy Services	48,530	4,005	92%	8%	43,365	1,292	97%	3%
Residential Behavior/Feedback								
Residential Products	25,824	1,511	94%	6%	9,571	3,275	75%	25%
Residential Cooling & Heating Equipment	7,105	665	91%	9%	5,296	338	94%	6%
Residential Lighting *								
Residential Consumer Products *	18,719	846	96%	4%	4,275	2,937	59%	41%
Low-Income (total)	**6,532**	**786**	**89%**	**11%**	**20,239**	**1,271**	**94%**	**6%**
Low-Income Whole House	6,532	786	89%	11%	20,239	1,271	94%	6%
Low-Income New Construction	180		100%	0%	119		100%	0%
Low-Income Single Family Retrofit	6,168	758	89%	11%	7,094	877	89%	11%
Low-Income Multi-Family Retrofit	184	28	87%	13%	13,026	394	97%	3%
Commercial & Industrial (total)	**3,296**	**413**	**89%**	**11%**	**148,349**	**58,447**	**72%**	**28%**
C&I New Construction	337	87	79%	21%	31,311	15,082	67%	33%
C&I New Construction *	337	87	79%	21%	31,311	15,082	67%	33%
C&I Retrofit	2,959	326	90%	10%	117,038	43,365	73%	27%
C&I Retrofit	858	216	80%	20%	79,718	40,969	66%	34%
C&I Direct Install	2,101	110	95%	5%	37,320	2,396	94%	6%
Grand Total	**86,414**	**6,779**	**93%**	**7%**	**240,153**	**66,165**	**78%**	**22%**

2015 (Actuals, based on data through August 2015)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual MWh) Associated with New Participants	Savings (Annual MWh) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**37,774**	**6,285**	**86%**	**14%**	**49,675**	**5,662**	**90%**	**10%**
Residential Whole House	28,359	4,585	86%	14%	42,965	4,258	91%	9%
Residential New Construction	2,230		100%	0%	2,103		100%	0%
Residential Multi-Family Retrofit	187	53	78%	22%	8,654	2,133	80%	20%
Residential Home Energy Services	25,942	4,532	85%	15%	32,208	2,125	94%	6%
Residential Behavior/Feedback								
Residential Products	9,415	1,700	85%	15%	6,710	1,404	83%	17%
Residential Cooling & Heating Equipment	3,422	961	78%	22%	3,549	514	87%	13%
Residential Lighting *								
Residential Consumer Products *	5,993	739	89%	11%	3,161	890	78%	22%
Low-Income (total)	**3,907**	**842**	**82%**	**18%**	**12,153**	**2,015**	**86%**	**14%**
Low-Income Whole House	3,907	842	82%	18%	12,153	2,015	86%	14%
Low-Income New Construction	210		100%	0%	103		100%	0%
Low-Income Single Family Retrofit	3,596	829	81%	19%	4,168	978	81%	19%
Low-Income Multi-Family Retrofit	101	13	89%	11%	7,882	1,037	88%	12%
Commercial & Industrial (total)	**1,502**	**453**	**77%**	**23%**	**57,431**	**37,864**	**60%**	**40%**
C&I New Construction	166	80	67%	33%	7,871	8,486	48%	52%
C&I New Construction *	166	80	67%	33%	7,871	8,486	48%	52%
C&I Retrofit	1,336	373	78%	22%	49,560	29,378	63%	37%
C&I Retrofit	407	186	69%	31%	30,968	26,015	54%	46%
C&I Direct Install	929	187	83%	17%	18,592	3,363	85%	15%
Grand Total	**43,183**	**7,580**	**85%**	**15%**	**119,259**	**45,541**	**72%**	**28%**

* All or portions of these programs have upstream components. These totals exclude any savings or participants associated with upstream participation as they cannot be tied to account numbers.

* The Company has historically reported participants for the Residential and Multi-Family core initiatives as the sum of units in a participating facility and cannot parse out the individual accounts associated with new and repeat savings

Table 3-5: Unitil - Electric

2013
(Actuals, based on 2013 Plan Year Report)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual MWh) Associated with New Participants	Savings (Annual MWh) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**735**	**-**	**100%**	**0%**	**741**	**-**	**100%**	**0%**
Residential Whole House	405	-	100%	0%	429	-	100%	0%
Residential New Construction	3		100%	0%	184		100%	0%
Residential Multi-Family Retrofit	8		100%	0%	71		100%	0%
Residential Home Energy Services	394		100%	0%	174		100%	0%
Residential Behavior/Feedback								
Residential Products	330	-	100%	0%	312	-	100%	0%
Residential Cooling & Heating Equipment	89		100%	0%	97		100%	0%
Residential Lighting *								
Residential Consumer Products *	241		100%	0%	215		100%	0%
Low-Income (total)	**106**	**-**	**100%**	**0%**	**275**	**-**	**100%**	**0%**
Low-Income Whole House	106	-	100%	0%	275	-	100%	0%
Low-Income New Construction	-							
Low-Income Single Family Retrofit	103		100%	0%	114		100%	0%
Low-Income Multi-Family Retrofit	3		100%	0%	161		100%	0%
Commercial & Industrial (total)	**76**	**-**	**100%**	**0%**	**5,965**	**-**	**100%**	**0%**
C&I New Construction	4	-	100%	0%	1,009	-	100%	0%
C&I New Construction *	4		100%	0%	1,009		100%	0%
C&I Retrofit	72	-	100%	0%	4,956	-	100%	0%
C&I Retrofit	10		100%	0%	3,331		100%	0%
C&I Direct Install	62		100%	0%	1,625		100%	0%
Grand Total	**917**	**-**	**100%**	**0%**	**6,981**	**-**	**100%**	**0%**

2014
(Actuals, based on 2014 Plan Year Report)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual MWh) Associated with New Participants	Savings (Annual MWh) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**994**	**41**	**96%**	**4%**	**521**	**34.43**	**94%**	**6%**
Residential Whole House	542	29	95%	5%	335	30.54	92%	8%
Residential New Construction	5	1	83%	17%	88	17.66	83%	17%
Residential Multi-Family Retrofit	-	-						#DIV/0!
Residential Home Energy Services	537	28	95%	5%	247	12.88	95%	5%
Residential Behavior/Feedback								
Residential Products	452	12	97%	3%	185	3.89	98%	2%
Residential Cooling & Heating Equipment	79	1	99%	1%	93	1.18	99%	1%
Residential Lighting *								
Residential Consumer Products *	373	11	97%	3%	92	2.71	97%	3%
Low-Income (total)	**156**	**6**	**96%**	**4%**	**217**	**3.28**	**99%**	**1%**
Low-Income Whole House	156	6	96%	4%	217	3.28	99%	1%
Low-Income New Construction	-	-						#DIV/0!
Low-Income Single Family Retrofit	155	6	96%	4%	85	3.28	96%	4%
Low-Income Multi-Family Retrofit	1	-	100%	0%	132	-	100%	0%
Commercial & Industrial (total)	**71**	**6**	**92%**	**8%**	**4,607**	**950.23**	**83%**	**17%**
C&I New Construction	6	2	75%	25%	1,713	570.95	75%	25%
C&I New Construction *	6	2	75%	25%	1,713	570.95	75%	25%
C&I Retrofit	65	4	94%	6%	2,894	379.28	88%	12%
C&I Retrofit	5	1	83%	17%	1,564	312.78	83%	17%
C&I Direct Install	60	3	95%	5%	1,330	66.50	95%	5%
Grand Total	**1,221**	**53**	**96%**	**4%**	**5,344**	**987.93**	**84%**	**16%**

2015
(Actuals, based on data through August 2015)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual MWh) Associated with New Participants	Savings (Annual MWh) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**1,049**	**87**	**92%**	**8%**	**1,048**	**31.08**	**97%**	**3%**
Residential Whole House	739	62	92%	8%	896	19.35	98%	2%
Residential New Construction	10	-	100%	0%	47		100%	0%
Residential Multi-Family Retrofit	9	-	100%	0%	624		100%	0%
Residential Home Energy Services	720	62	92%	8%	225	19.35	92%	8%
Residential Behavior/Feedback								
Residential Products	310	25	93%	7%	152	11.73	93%	7%
Residential Cooling & Heating Equipment	82	6	93%	7%	94	6.89	93%	7%
Residential Lighting *								
Residential Consumer Products *	228	19	92%	8%	58	4.85	92%	8%
Low-Income (total)	**59**	**6**	**91%**	**9%**	**65**	**4.78**	**93%**	**7%**
Low-Income Whole House	59	6	91%	9%	65	4.78	93%	7%
Low-Income New Construction	4	-	100%	0%	9		100%	0%
Low-Income Single Family Retrofit	53	6	90%	10%	42	4.78	90%	10%
Low-Income Multi-Family Retrofit	2	-	100%	0%	14	-	100%	0%
Commercial & Industrial (total)	**35**	**9**	**80%**	**20%**	**2,025**	**1,449.38**	**58%**	**42%**
C&I New Construction	3	3	50%	50%	948	947.50	50%	50%
C&I New Construction *	3	3	50%	50%	948	947.50	50%	50%
C&I Retrofit	32	6	84%	16%	1,077	501.88	68%	32%
C&I Retrofit	3	3	50%	50%	436	435.50	50%	50%
C&I Direct Install	29	3	91%	9%	642	66.38	91%	9%
Grand Total	**1,143**	**102**	**92%**	**8%**	**3,138**	**1,485.23**	**68%**	**32%**

* All or portions of these programs have upstream components. These totals exclude any savings or participants associated with upstream participation as they cannot be tied to account numbers.

Table 3-5: Berkshire

2013 (Actuals, based on 2013 Plan Year Report)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**1,375**	**-**	**100%**	**0%**	**206,349**	**-**	**100%**	**0%**
Residential Whole House	585	-	100%	0%	113,532	-	100%	0%
Residential New Construction	25	-	100%	0%	6,200	-	100%	0%
Residential Multi-Family Retrofit	44	-	100%	0%	2,477	-	100%	0%
Residential Home Energy Services	516	-	100%	0%	104,855	-	100%	0%
Residential Behavior/Feedback								
Residential Products	790	-	100%	0%	92,817	-	100%	0%
Residential Heating & Water Heating	790	-	100%	0%	92,817	-	100%	0%
Low-Income (total)	**145**	**-**	**100%**	**0%**	**64,642**	**-**	**100%**	**0%**
Low-Income Whole House	145	-	100%	0%	64,642	-	100%	0%
Low-Income Single Family Retrofit	95	-	100%	0%	23,747	-	100%	0%
Low-Income Multi-Family Retrofit	50	-	100%	0%	40,895	-	100%	0%
Commercial & Industrial (total)	**176**	**-**	**100%**	**0%**	**241,674**	**-**	**100%**	**0%**
C&I New Construction	83	-	100%	0%	100,133	-	100%	0%
C&I New Construction	83	-	100%	0%	100,133	-	100%	0%
C&I Retrofit	93	-	100%	0%	141,541	-	100%	0%
C&I Retrofit	93	-	100%	0%	141,541	-	100%	0%
C&I Direct Install	-	-	#DIV/0!	#DIV/0!	-	-	#DIV/0!	#DIV/0!
Grand Total	**1,696**	**-**	**100%**	**0%**	**512,665**	**-**	**100%**	**0%**

2014 (Actuals, based on 2014 Plan Year Report)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**1,295**	**68**	**95%**	**5%**	**193,161**	**10,610**	**95%**	**5%**
Residential Whole House	644	37	95%	5%	122,901	8,440	94%	6%
Residential New Construction	35	-	100%	0%	10,670	-	100%	0%
Residential Multi-Family Retrofit	68	3	96%	4%	3,612	287	93%	7%
Residential Home Energy Services	541	34	94%	6%	108,619	8,153	93%	7%
Residential Behavior/Feedback								
Residential Products	651	31	95%	5%	70,260	2,170	97%	3%
Residential Heating & Water Heating	651	31	95%	5%	70,260	2,170	97%	3%
Low-Income (total)	**160**	**6**	**96%**	**4%**	**27,150**	**9,472**	**74%**	**26%**
Low-Income Whole House	160	6	96%	4%	27,150	9,472	74%	26%
Low-Income Single Family Retrofit	57	4	93%	7%	14,773	924	94%	6%
Low-Income Multi-Family Retrofit	103	2	98%	2%	12,377	8,548	59%	41%
Commercial & Industrial (total)	**96**	**4**	**96%**	**4%**	**230,558**	**179,009**	**56%**	**44%**
C&I New Construction	44	2	96%	4%	115,195	20,208	85%	15%
C&I New Construction	44	2	96%	4%	115,195	20,208	85%	15%
C&I Retrofit	52	2	96%	4%	115,363	158,801	42%	58%
C&I Retrofit	38	2	95%	5%	112,220	158,801	41%	59%
C&I Direct Install	14	-	100%	0%	3,143	-	100%	0%
Grand Total	**1,551**	**78**	**95%**	**5%**	**450,869**	**199,091**	**69%**	**31%**

2015 (Actuals, based on data through August 2015)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**848**	**91**	**90%**	**10%**	**96,671**	**12,845**	**88%**	**12%**
Residential Whole House	388	55	88%	12%	54,246	10,676	84%	16%
Residential New Construction	22	2	92%	8%	8,033	518	94%	6%
Residential Multi-Family Retrofit	8	-	100%	0%	3,265	-	100%	0%
Residential Home Energy Services	358	53	87%	13%	42,948	10,158	81%	19%
Residential Behavior/Feedback								
Residential Products	460	36	93%	7%	42,425	2,169	95%	5%
Residential Heating & Water Heating	460	36	93%	7%	42,425	2,169	95%	5%
Low-Income (total)	**77**	**3**	**96%**	**4%**	**37,579**	**720**	**98%**	**2%**
Low-Income Whole House	77	3	96%	4%	37,579	720	98%	2%
Low-Income Single Family Retrofit	48	3	94%	6%	12,128	720	94%	6%
Low-Income Multi-Family Retrofit	29	-	100%	0%	25,451	-	100%	0%
Commercial & Industrial (total)	**78**	**6**	**93%**	**7%**	**56,084**	**14,279**	**80%**	**20%**
C&I New Construction	38	1	97%	3%	36,058	6,845	84%	16%
C&I New Construction	38	1	97%	3%	36,058	6,845	84%	16%
C&I Retrofit	40	5	89%	11%	20,026	7,434	73%	27%
C&I Retrofit	28	5	85%	15%	13,243	7,434	64%	36%
C&I Direct Install	12	-	100%	0%	6,783	-	100%	0%
Grand Total	**1,003**	**100**	**91%**	**9%**	**190,334**	**27,844**	**87%**	**13%**

Table 3-5: CMA

2013 (Actuals, based on 2013 Plan Year Report)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**13,927**	**-**	**100%**	**0%**	**1,401,177**	**-**	**100%**	**0%**
Residential Whole House	8,054	-	100%	0%	791,861	-	100%	0%
Residential New Construction	326	-	100%	0%	97,855	-	100%	0%
Residential Multi-Family Retrofit	928	-	100%	0%	71,623	-	100%	0%
Residential Home Energy Services	6,800	-	100%	0%	622,383	-	100%	0%
Residential Behavior/Feedback	-	-	0%	0%	-	-	0%	0%
Residential Products	5,873	-	100%	0%	609,315	-	100%	0%
Residential Heating & Water Heating	5,873	-	100%	0%	609,315	-	100%	0%
Low-Income (total)	**781**	**-**	**100%**	**0%**	**345,747**	**-**	**100%**	**0%**
Low-Income Whole House	781	-	100%	0%	345,747	-	100%	0%
Low-Income Single Family Retrofit	603	-	100%	0%	146,351	-	100%	0%
Low-Income Multi-Family Retrofit	178	-	100%	0%	199,396	-	100%	0%
Commercial & Industrial (total)	**1,262**	**-**	**100%**	**0%**	**1,960,145**	**-**	**100%**	**0%**
C&I New Construction	238	-	100%	0%	323,077	-	100%	0%
C&I New Construction	238	-	100%	0%	323,077	-	100%	0%
C&I Retrofit	1,024	-	100%	0%	1,637,067	-	100%	0%
C&I Retrofit	899	-	100%	0%	1,619,223	-	100%	0%
C&I Direct Install	125	-	100%	0%	17,844	-	100%	0%
Grand Total	**15,970**	**-**	**100%**	**0%**	**3,707,068**	**-**	**100%**	**0%**

2014 (Actuals, based on 2014 Plan Year Report)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**12,330**	**679**	**95%**	**5%**	**1,541,829**	**94,278**	**94%**	**6%**
Residential Whole House	7,452	451	94%	6%	1,110,450	76,395	94%	6%
Residential New Construction	445		100%	0%	135,685		100%	0%
Residential Multi-Family Retrofit	911	26	97%	3%	132,990	1,999	99%	1%
Residential Home Energy Services	6,096	425	93%	7%	841,775	74,396	92%	8%
Residential Behavior/Feedback			0%	0%			0%	0%
Residential Products	4,878	228	96%	4%	431,379	17,883	96%	4%
Residential Heating & Water Heating	4,878	228	96%	4%	431,379	17,883	96%	4%
Low-Income (total)	**640**	**27**	**96%**	**4%**	**342,102**	**27,210**	**93%**	**7%**
Low-Income Whole House	640	27	96%	4%	342,102	27,210	93%	7%
Low-Income Single Family Retrofit	527	25	95%	5%	129,687	5,848	96%	4%
Low-Income Multi-Family Retrofit	113	2	98%	2%	212,415	21,362	91%	9%
Commercial & Industrial (total)	**1,228**	**50**	**96%**	**4%**	**1,722,077**	**359,332**	**83%**	**17%**
C&I New Construction	173	13	93%	7%	241,842	58,106	81%	19%
C&I New Construction	173	13	93%	7%	241,842	58,106	81%	19%
C&I Retrofit	1,055	37	97%	3%	1,480,235	301,226	83%	17%
C&I Retrofit	982	26	97%	3%	1,466,968	299,426	83%	17%
C&I Direct Install	73	11	87%	13%	13,267	1,800	88%	12%
Grand Total	**14,198**	**756**	**95%**	**5%**	**3,606,008**	**480,820**	**88%**	**12%**

2015 (Actuals, based on data through August 2015)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**6,392**	**600**	**91%**	**9%**	**1,055,507**	**134,691**	**89%**	**11%**
Residential Whole House	3,198	353	90%	10%	757,846	119,367	86%	14%
Residential New Construction	292	-	100%	0%	115,667	-	100%	0%
Residential Multi-Family Retrofit	903	19	98%	2%	93,865	2,268	98%	2%
Residential Home Energy Services	2,003	334	86%	14%	548,314	117,099	82%	18%
Residential Behavior/Feedback			0%	0%			0%	0%
Residential Products	3,194	247	93%	7%	297,661	15,324	95%	5%
Residential Heating & Water Heating	3,194	247	93%	7%	297,661	15,324	95%	5%
Low-Income (total)	**331**	**27**	**92%**	**8%**	**193,301**	**19,156**	**91%**	**9%**
Low-Income Whole House	331	27	92%	8%	193,301	19,156	91%	9%
Low-Income Single Family Retrofit	301	23	93%	7%	73,002	5,226	93%	7%
Low-Income Multi-Family Retrofit	30	4	88%	12%	120,299	13,930	90%	10%
Commercial & Industrial (total)	**576**	**30**	**95%**	**5%**	**385,626**	**108,952**	**78%**	**22%**
C&I New Construction	113	10	92%	8%	147,449	8,053	95%	5%
C&I New Construction	113	10	92%	8%	147,449	8,053	95%	5%
C&I Retrofit	463	20	96%	4%	238,178	100,900	70%	30%
C&I Retrofit	393	18	96%	4%	231,624	100,662	70%	30%
C&I Direct Install	70	2	97%	3%	6,554	238	96%	4%
Grand Total	**7,299**	**657**	**92%**	**8%**	**1,634,435**	**262,800**	**86%**	**14%**

Table 3-5: Eversource - Gas

2013								
Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**17,145**	**-**	**100%**	**0%**	**1,694,044**	**-**	**100%**	**0%**
Residential Whole House	11,698	-	100%	0%	1,237,827	-	100%	0%
Residential New Construction	688	-	100%	0%	168,601	-	100%	0%
Residential Multi-Family Retrofit	717	-	100%	0%	165,384	-	100%	0%
Residential Home Energy Services	10,293	-	100%	0%	903,841	-	100%	0%
Residential Behavior/Feedback	N/A	N/A	0%	0%	N/A	N/A	0%	0%
Residential Products	5,447	-	100%	0%	456,218	-	100%	0%
Residential Heating & Water Heating	5,447	-	100%	0%	456,218	-	100%	0%
Low-Income (total)	**568**	**-**	**100%**	**0%**	**402,666**	**-**	**100%**	**0%**
Low-Income Whole House	568	-	100%	0%	402,666	-	100%	0%
Low-Income Single Family Retrofit	44	-	100%	0%	154,176	-	100%	0%
Low-Income Multi-Family Retrofit	524	-	100%	0%	248,490	-	100%	0%
Commercial & Industrial (total)	**1,241**	**-**	**100%**	**0%**	**4,542,150**	**-**	**100%**	**0%**
C&I New Construction	308	-	100%	0%	1,785,933	-	100%	0%
C&I New Construction	308	-	100%	0%	1,785,933	-	100%	0%
C&I Retrofit	933	-	100%	0%	2,756,217	-	100%	0%
C&I Retrofit	418	-	100%	0%	2,626,116	-	100%	0%
C&I Direct Install	515	-	100%	0%	130,101	-	100%	0%
Grand Total	**18,954**	**-**	**100%**	**0%**	**6,638,860**	**-**	**100%**	**0%**

2014								
Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**19,190**	**2,289**	**89%**	**11%**	**1,541,553**	**164,747**	**90%**	**10%**
Residential Whole House	13,200	1,735	88%	12%	1,151,820	128,702	90%	10%
Residential New Construction	1,233	-	100%	0%	221,110	-	100%	0%
Residential Multi-Family Retrofit	840	46	95%	5%	129,582	7,096	95%	5%
Residential Home Energy Services	11,127	1,689	87%	13%	801,128	121,606	87%	13%
Residential Behavior/Feedback	N/A	N/A	0%	0%	N/A	N/A	0%	0%
Residential Products	5,990	554	92%	8%	389,732	36,045	92%	8%
Residential Heating & Water Heating	5,990	554	92%	8%	389,732	36,045	92%	8%
Low-Income (total)	**517**	**30**	**95%**	**5%**	**596,529**	**24,103**	**96%**	**4%**
Low-Income Whole House	517	30	95%	5%	596,529	24,103	96%	4%
Low-Income Single Family Retrofit	121	26	82%	18%	88,278	18,969	82%	18%
Low-Income Multi-Family Retrofit	396	4	99%	1%	508,251	5,134	99%	1%
Commercial & Industrial (total)	**1,179**	**46**	**96%**	**4%**	**3,791,932**	**583,906**	**87%**	**13%**
C&I New Construction	301	9	97%	3%	1,344,007	37,803	97%	3%
C&I New Construction	301	9	97%	3%	1,344,007	37,803	97%	3%
C&I Retrofit	878	37	96%	4%	2,447,924	546,103	82%	18%
C&I Retrofit	442	26	94%	6%	2,361,912	543,933	81%	19%
C&I Direct Install	436	11	98%	2%	86,012	2,170	98%	2%
Grand Total	**20,886**	**2,365**	**90%**	**10%**	**5,930,014**	**772,755**	**88%**	**12%**

2015								
Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**14,022**	**889**	**94%**	**6%**	**1,036,352**	**58,653**	**95%**	**5%**
Residential Whole House	9,943	608	94%	6%	766,299	40,049	95%	5%
Residential New Construction	300	-	100%	0%	119,294	-	100%	0%
Residential Multi-Family Retrofit	519	25	95%	5%	82,223	3,961	95%	5%
Residential Home Energy Services	9,124	583	94%	6%	564,783	36,088	94%	6%
Residential Behavior/Feedback	N/A	N/A	0%	0%	N/A	N/A	0%	0%
Residential Products	4,079	281	94%	6%	270,052	18,604	94%	6%
Residential Heating & Water Heating	4,079	281	94%	6%	270,052	18,604	94%	6%
Low-Income (total)	**332**	**22**	**94%**	**6%**	**211,411**	**17,798**	**92%**	**8%**
Low-Income Whole House	332	22	94%	6%	211,411	17,798	92%	8%
Low-Income Single Family Retrofit	290	18	94%	6%	70,424	4,371	94%	6%
Low-Income Multi-Family Retrofit	42	4	91%	9%	140,987	13,427	91%	9%
Commercial & Industrial (total)	**870**	**57**	**94%**	**6%**	**2,560,245**	**541,106**	**83%**	**17%**
C&I New Construction	238	18	93%	7%	751,811	20,867	97%	3%
C&I New Construction	238	18	93%	7%	751,811	20,867	97%	3%
C&I Retrofit	632	39	94%	6%	1,808,435	520,239	78%	22%
C&I Retrofit	290	29	91%	9%	1,741,369	518,278	77%	23%
C&I Direct Install	342	10	97%	3%	67,066	1,961	97%	3%
Grand Total	**15,224**	**968**	**94%**	**6%**	**3,808,008**	**617,557**	**86%**	**14%**

Table 3-5: Liberty

2013
(Actuals, based on 2013 Plan Year Report)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**1,146**	**-**	**100%**	**0%**	**121,832**	**-**	**100%**	**0%**
Residential Whole House	579	-	100%	0%	70,479	-	100%	0%
Residential New Construction	8	-	100%	0%	1,104	-	100%	0%
Residential Multi-Family Retrofit	4	-	100%	0%	4,630	-	100%	0%
Residential Home Energy Services	567	-	100%	0%	64,745	-	100%	0%
Residential Behavior/Feedback	-	-	#DIV/0!	#DIV/0!	-	-	#DIV/0!	#DIV/0!
Residential Products	567	-	100%	0%	51,353	-	100%	0%
Residential Heating & Water Heating	567	-	100%	0%	51,353	-	100%	0%
Low-Income (total)	**110**	**-**	**100%**	**0%**	**33,310**	**-**	**100%**	**0%**
Low-Income Whole House	110	-	100%	0%	33,310	-	100%	0%
Low-Income Single Family Retrofit	41	-	100%	0%	9,759	-	100%	0%
Low-Income Multi-Family Retrofit	69	-	100%	0%	23,551	-	100%	0%
Commercial & Industrial (total)	**80**	**-**	**100%**	**0%**	**149,531**	**-**	**100%**	**0%**
C&I New Construction	30	-	100%	0%	17,305	-	100%	0%
C&I New Construction	30	-	100%	0%	17,305	-	100%	0%
C&I Retrofit	50	-	100%	0%	132,226	-	100%	0%
C&I Retrofit	37	-	100%	0%	130,386	-	100%	0%
C&I Direct Install	13	-	100%	0%	1,840	-	100%	0%
Grand Total	**1,336**	**-**	**100%**	**0%**	**304,673**	**-**	**100%**	**0%**

2014
(Actuals, based on 2014 Plan Year Report)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**1,446**	**12**	**99%**	**1%**	**155,564**	**1,259**	**99%**	**1%**
Residential Whole House	779	8	99%	1%	103,903	1,039	99%	1%
Residential New Construction	135		100%	0%	20,515		100%	0%
Residential Multi-Family Retrofit	22		100%	0%	1,901		100%	0%
Residential Home Energy Services	622	8	99%	1%	81,488	1,039	99%	1%
Residential Behavior/Feedback	-		#DIV/0!	#DIV/0!	-		#DIV/0!	#DIV/0!
Residential Products	667	4	99%	1%	51,661	220	100%	0%
Residential Heating & Water Heating	667	4	99%	1%	51,661	220	100%	0%
Low-Income (total)	**86**	**1**	**99%**	**1%**	**31,192**	**263**	**99%**	**1%**
Low-Income Whole House	86	1	99%	1%	31,192	263	99%	1%
Low-Income Single Family Retrofit	72	1	99%	1%	18,705	263	99%	1%
Low-Income Multi-Family Retrofit	14		100%	0%	12,487		100%	0%
Commercial & Industrial (total)	**96**	**6**	**94%**	**6%**	**94,552**	**22,058**	**81%**	**19%**
C&I New Construction	58	-	100%	0%	68,821	-	100%	0%
C&I New Construction	58		100%	0%	68,821		100%	0%
C&I Retrofit	38	6	86%	14%	25,731	22,058	54%	46%
C&I Retrofit	27	6	82%	18%	23,607	22,058	52%	48%
C&I Direct Install	11		100%	0%	2,124		100%	0%
Grand Total	**1,628**	**19**	**99%**	**1%**	**281,308**	**23,580**	**92%**	**8%**

2015
(Actuals, based on data through August 2015)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**1,115**	**4**	**100%**	**0%**	**88,908**	**935**	**99%**	**1%**
Residential Whole House	650	3	100%	0%	55,912	782	99%	1%
Residential New Construction	11		100%	0%	4,927		100%	0%
Residential Multi-Family Retrofit	36		100%	0%	6,946		100%	0%
Residential Home Energy Services	603	3	100%	0%	44,039	782	98%	2%
Residential Behavior/Feedback	-		#DIV/0!	#DIV/0!			#DIV/0!	#DIV/0!
Residential Products	465	1	100%	0%	32,996	153	100%	0%
Residential Heating & Water Heating	465	1	100%	0%	32,996	153	100%	0%
Low-Income (total)	**80**	**-**	**100%**	**0%**	**20,265**	**-**	**100%**	**0%**
Low-Income Whole House	80	-	100%	0%	20,265	-	100%	0%
Low-Income Single Family Retrofit	80		100%	0%	20,265		100%	0%
Low-Income Multi-Family Retrofit	-		#DIV/0!	#DIV/0!	-		#DIV/0!	#DIV/0!
Commercial & Industrial (total)	**26**	**1**	**96%**	**4%**	**33,204**	**119**	**100%**	**0%**
C&I New Construction	13	-	100%	0%	7,647	-	100%	0%
C&I New Construction	13		100%	0%	7,647		100%	0%
C&I Retrofit	13	1	93%	7%	25,557	119	100%	0%
C&I Retrofit	11		100%	0%	25,318		100%	0%
C&I Direct Install	2	1	67%	33%	239	119	67%	33%
Grand Total	**1,221**	**5**	**100%**	**0%**	**142,377**	**1,054**	**99%**	**1%**

Table 3-5: National Grid - Gas

2013
(Actuals, based on 2013 Plan Year Report)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**36,747**		**100%**	**0%**	**5,143,922**		**100%**	**0%**
Residential Whole House	18,504		100%	0%	3,083,515		100%	0%
Residential New Construction	1,780		100%	0%	708,747		100%	0%
Residential Multi-Family Retrofit	106		100%	0%	350,598		100%	0%
Residential Home Energy Services	16,618		100%	0%	2,024,170		100%	0%
Residential Behavior/Feedback								
Residential Products	18,243		100%	0%	2,060,407		100%	0%
Residential Heating & Water Heating	18,243		100%	0%	2,060,407		100%	0%
Low-Income (total)	**1,728**		**100%**	**0%**	**1,150,634**		**100%**	**0%**
Low-Income Whole House	1,728		100%	0%	1,150,634		100%	0%
Low-Income Single Family Retrofit	1,593		100%	0%	440,879		100%	0%
Low-Income Multi-Family Retrofit	135		100%	0%	709,755		100%	0%
Commercial & Industrial (total)	**2,931**		**100%**	**0%**	**3,201,690**		**100%**	**0%**
C&I New Construction	534		100%	0%	1,126,534		100%	0%
C&I New Construction	534		100%	0%	1,126,534		100%	0%
C&I Retrofit	2,397		100%	0%	2,075,156		100%	0%
C&I Retrofit	1,990		100%	0%	2,000,884		100%	0%
C&I Direct Install	407		100%	0%	74,272		100%	0%
Grand Total	**41,406**		**100%**	**0%**	**9,496,246**		**100%**	**0%**

2014
(Actuals, based on 2014 Plan Year Report)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**40,415**	**2,578**	**94%**	**6%**	**5,205,328**	**291,204**	**95%**	**5%**
Residential Whole House	22,553	1,549	94%	6%	3,524,167	196,759	95%	5%
Residential New Construction	2,857		100%	0%	873,579		100%	0%
Residential Multi-Family Retrofit	140	18	89%	11%	397,432	11,775	97%	3%
Residential Home Energy Services	19,556	1,531	93%	7%	2,253,156	184,984	92%	8%
Residential Behavior/Feedback								
Residential Products	17,862	1,029	95%	5%	1,681,161	94,445	95%	5%
Residential Heating & Water Heating	17,862	1,029	95%	5%	1,681,161	94,445	95%	5%
Low-Income (total)	**1,462**	**80**	**95%**	**5%**	**1,429,197**	**107,617**	**93%**	**7%**
Low-Income Whole House	1,462	80	95%	5%	1,429,197	107,617	93%	7%
Low-Income Single Family Retrofit	1,327	76	95%	5%	357,664	18,823	95%	5%
Low-Income Multi-Family Retrofit	135	4	97%	3%	1,071,533	88,794	92%	8%
Commercial & Industrial (total)	**1,715**	**107**	**94%**	**6%**	**3,583,404**	**669,517**	**84%**	**16%**
C&I New Construction	467	14	97%	3%	1,151,792	26,436	98%	2%
C&I New Construction	467	14	97%	3%	1,151,792	26,436	98%	2%
C&I Retrofit	1,248	93	93%	7%	2,431,612	643,081	79%	21%
C&I Retrofit	894	84	91%	9%	2,384,707	642,137	79%	21%
C&I Direct Install	354	9	98%	2%	46,905	944	98%	2%
Grand Total	**43,592**	**2,765**	**94%**	**6%**	**10,217,929**	**1,068,338**	**91%**	**9%**

2015
(Actuals, based on data through August 2015)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**22,584**	**2,524**	**90%**	**10%**	**2,289,142**	**327,439**	**87%**	**13%**
Residential Whole House	12,972	1,456	90%	10%	1,407,988	250,851	85%	15%
Residential New Construction	2,859		100%	0%	521,113		100%	0%
Residential Multi-Family Retrofit	53	18	75%	25%	74,664	34,831	68%	32%
Residential Home Energy Services	10,060	1,438	87%	13%	812,211	216,020	79%	21%
Residential Behavior/Feedback								
Residential Products	9,612	1,068	90%	10%	881,154	76,588	92%	8%
Residential Heating & Water Heating	9,612	1,068	90%	10%	881,154	76,588	92%	8%
Low-Income (total)	**763**	**72**	**91%**	**9%**	**815,367**	**67,203**	**92%**	**8%**
Low-Income Whole House	763	72	91%	9%	815,367	67,203	92%	8%
Low-Income Single Family Retrofit	712	65	92%	8%	189,142	16,447	92%	8%
Low-Income Multi-Family Retrofit	51	7	88%	12%	626,225	50,756	93%	7%
Commercial & Industrial (total)	**774**	**89**	**90%**	**10%**	**1,213,329**	**387,219**	**76%**	**24%**
C&I New Construction	262	9	97%	3%	741,397	10,749	99%	1%
C&I New Construction	262	9	97%	3%	741,397	10,749	99%	1%
C&I Retrofit	512	80	86%	14%	471,932	376,470	56%	44%
C&I Retrofit	389	60	87%	13%	420,854	373,210	53%	47%
C&I Direct Install	123	20	86%	14%	51,078	3,260	94%	6%
Grand Total	**24,121**	**2,685**	**90%**	**10%**	**4,317,838**	**781,861**	**85%**	**15%**

* The Company has historically reported participants for the Residential and Multi-Family core initiatives as the sum of units in a participating facility and cannot parse out the individual accounts associated with new and repeat savings

Table 3-5: Unitil - Gas

2013 (Actuals, based on 2013 Plan Year Report)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**293**	**-**	**100%**	**0%**	**43,657**	**-**	**100%**	**0%**
Residential Whole House	127	-	100%	0%	25,280	-	100%	0%
Residential New Construction	2	-	100%	0%	3,453		100%	0%
Residential Multi-Family Retrofit	7	-	100%	0%	485		100%	0%
Residential Home Energy Services	118	-	100%	0%	21,342		100%	0%
Residential Behavior/Feedback								
Residential Products	166	-	100%	0%	18,377	-	100%	0%
Residential Heating & Water Heating	166	-	100%	0%	18,377		100%	0%
Low-Income (total)	**36**	**-**	**100%**	**0%**	**23,326**	**-**	**100%**	**0%**
Low-Income Whole House	36	-	100%	0%	23,326	-	100%	0%
Low-Income Single Family Retrofit	31	-	100%	0%	9,034		100%	0%
Low-Income Multi-Family Retrofit	5	-	100%	0%	14,292		100%	0%
Commercial & Industrial (total)	**28**	**-**	**100%**	**0%**	**56,405**	**-**	**100%**	**0%**
C&I New Construction	16	-	100%	0%	17,686	-	100%	0%
C&I New Construction	16	-	100%	0%	17,686		100%	0%
C&I Retrofit	12	-	100%	0%	38,719	-	100%	0%
C&I Retrofit	3	-	100%	0%	26,118		100%	0%
C&I Direct Install	9	-	100%	0%	12,601		100%	0%
Grand Total	**357**	**-**	**100%**	**0%**	**123,388**	**-**	**100%**	**0%**

2014 (Actuals, based on 2014 Plan Year Report)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**311**	**-**	**100%**	**0%**	**46,700**	**2,755**	**94%**	**6%**
Residential Whole House	177	12	94%	6%	34,246	2,290	94%	6%
Residential New Construction	3	-	100%	0%	1,043	-	100%	0%
Residential Multi-Family Retrofit	-	-			-	-		
Residential Home Energy Services	174	12	94%	6%	33,203	2,290	94%	6%
Residential Behavior/Feedback								
Residential Products	134	5	96%	4%	12,454	465	96%	4%
Residential Heating & Water Heating	134	5	96%	4%	12,454	465	96%	4%
Low-Income (total)	**54**	**-**	**100%**	**0%**	**33,604**	**255**	**99%**	**1%**
Low-Income Whole House	54	1	98%	2%	33,604	255	99%	1%
Low-Income Single Family Retrofit	51	1	98%	2%	13,007	255	98%	2%
Low-Income Multi-Family Retrofit	3	-	100%	0%	20,597	-	100%	0%
Commercial & Industrial (total)	**37**	**-**	**100%**	**0%**	**290,191**	**1,500**	**99%**	**1%**
C&I New Construction	21	-	100%	0%	35,184	-	100%	0%
C&I New Construction	21	-	100%	0%	35,184	-	100%	0%
C&I Retrofit	16	1	94%	6%	255,007	1,500	99%	1%
C&I Retrofit	5		100%	0%	238,512	-	100%	0%
C&I Direct Install	11	1	92%	8%	16,495	1,500	92%	8%
Grand Total	**402**	**-**	**100%**	**0%**	**370,496**	**4,509**	**99%**	**1%**

2015 (Actuals, based on data through August 2015)

Core Initiative	Number of New Participants	Number of Repeat Participants	% of New Participants	% of Repeat Participants	Savings (Annual Therms) Associated with New Participants	Savings (Annual Therms) Associated with Repeat Participants	% Of Savings Associated with New Participants	% Of Savings Associated with Repeat Participants
Residential (total)	**244**	**-**	**100%**	**0%**	**41,841**	**1,025**	**98%**	**2%**
Residential Whole House	122	6	95%	5%	31,107	585	98%	2%
Residential New Construction	12	-	100%	0%	20,389		100%	0%
Residential Multi-Family Retrofit	-	-			-			
Residential Home Energy Services	110	6	95%	5%	10,718	585	95%	5%
Residential Behavior/Feedback								
Residential Products	122	5	96%	4%	10,734	440	96%	4%
Residential Heating & Water Heating	122	5	96%	4%	10,734	440	96%	4%
Low-Income (total)	**48**	**-**	**100%**	**0%**	**13,182**	**799**	**94%**	**6%**
Low-Income Whole House	48	1	98%	2%	13,182	799	94%	6%
Low-Income Single Family Retrofit	46	-	100%	0%	11,585		100%	0%
Low-Income Multi-Family Retrofit	2	1	67%	33%	1,597	799	67%	33%
Commercial & Industrial (total)	**11**	**-**	**100%**	**0%**	**53,433**	**15,629**	**77%**	**23%**
C&I New Construction	8	-	100%	0%	19,371	-	100%	0%
C&I New Construction	8	-	100%	0%	19,371	-	100%	0%
C&I Retrofit	3	1	75%	25%	34,062	15,629	69%	31%
C&I Retrofit	2	1	67%	33%	31,258	15,629	67%	33%
C&I Direct Install	1	-	100%	0%	2,804		100%	0%
Grand Total	**303**	**-**	**100%**	**0%**	**108,457**	**17,452**	**86%**	**14%**

c. Please see the response to part (b) above.

d. For the residential sector, in 2013, 4.2 percent of customers participated in multiple core initiatives; a total of 58,906 residential premises (inclusive of both fuels) participated in two or more initiatives out of a total of 1,410,742 premises that participated in any initiative. This data is provided from the Residential Customer Profile Study, completed in October of 2015. Because it was the first year that this type of study was completed in the residential sector and took longer than expected to complete, this data is only available for 2013. As a result, the data above is most likely understating the number and percentage of customers participating in multiple core initiatives over the three-year period and would be more meaningful if we had additional years of data available.

Note that this data does not include low-income participants. Because there are only two core initiatives in the Low-Income sector and they are based on housing type (single family or multi-family), the question of multi-initiative participation does not apply.

Data for the C&I Sector is also provided by the C&I Customer Profile Studies. The C&I Customer Profile Study for 2014 is currently underway, so the data provided is preliminary. The PAs do not currently have a reliable method to tie electric and gas accounts for a single premise, so the data shown in Table 3-6 below provides separate gas and electric information. The “Total Accounts” represents the total number of accounts in the population, whether they participated in the programs or not, including customers who participated in upstream programs. Note that this definition differs from that used in the residential sector, which used “Participating Customers” as the denominator. The definition of multi-initiative also varies slightly here, as the data represents Multi-Year Participants, or those participants who participated in both 2013 and 2014, regardless of core initiative. Because upstream participant data usually cannot be tied to a specific account, it is often not possible to determine if an upstream customer has participated in multiple years. Because the total accounts do include upstream customers, but the multi-year participants do not include all upstream customers, the resulting percentages are underestimated.

The C&I core initiatives are highly correlated with the type of equipment being replaced. For example, new or end of useful life equipment goes through the new construction program, while most existing equipment would go through retrofit. Therefore, since a customer could have both existing and end of useful life equipment at the same facility, it is possible to participate in multiple core initiatives.

Table 3-6: Multi-Year Participation

Fuel	Total Accounts	Multi-year Participants	Percentage
Statewide Electric	39,293	1,009	2.6%
Statewide Gas	7,901	280	3.5%

e. HEAT Loan eligibility is determined by the energy efficiency measures or services a customer installs or receives; therefore, the PAs used HEAT loan eligible measures as a proxy for determining participation rates for the HEAT Loan. For the purpose of this question, eligible measures were defined as: heating equipment, water heating equipment, central AC/air source heat pumps, and insulation. Statewide, 26% of HEAT Loan eligible measures were financed using the HEAT Loan. This number was calculated by dividing the total number of measures that were financed by a HEAT Loan by the total number of measures eligible for a HEAT Loan. This number, however, may not accurately represent the impact of the HEAT Loan for several reasons, including:

- Only measures with a co-pay of over $500 are eligible for a HEAT Loan. As an example, some insulation jobs may have required a co-pay of under $500 after all applicable incentives were applied. In this case, although insulation is technically a HEAT Loan eligible measure, this specific job would not be eligible for a HEAT Loan.
- Some measures may be eligible for HEAT Loan financing as part of a package but not necessarily as an individual measure. An example of this is a Wi-Fi enabled thermostat. A participant that installs a new heating system and receives insulation may also install a Wi-Fi thermostat and finance the whole package with a HEAT Loan. However, a customer may not finance a Wi-Fi thermostat by itself with the HEAT Loan. For this reason, smaller measures like Wi-Fi thermostats are not included in the denominator (number of HEAT Loan eligible measures) of this calculation.

f. In the residential table below, the Program Administrators have defined the HES close rate as customers who participated in a Home Energy Assessment (“HEA”) and received turn-key weatherization retrofit work. The table provides Program Administrator HEA to weatherization retrofit close rates, as well as the approximate average weatherization recommendation rate from January 2013 through August 2015. PAs note that not all customers receiving an HEA are good retrofit candidates and thus do not receive a recommendation. Calculating the close rate using recommendation to completed retrofit provides additional insight. Open market, downstream equipment rebates are not included in the retrofit calculation.

For the C&I Direct Install initiative, savings shown in the table below are based on gross savings recorded for projects proposed or completed in the given year. As such, installed figures may not exactly match PA-reported savings due to timing and claiming of savings protocols, in addition to any differences between net and gross savings. All dollar amounts are Customer Incentive dollars.

Table 3-7

Statewide HES Close Rates:

	Close Rate 2013	Close Rate 2014	Close Rate 2015 (YTD August 2015)	Average Rate of Retrofit Recommendation (2013 - YTD August 2015)*	Avg. Adjusted Close Rate (recommended to completed)
CLC	63%	64%	39%	87%	64%
EVERSOURCE (NSTAR Elec)	37%	37%	37%	82%	45%
EVERSOURCE (WMECo)	24%	30%	41%	86%	36%
NGRID Electric	31%	37%	37%	83%	42%
Unitil Electric**	55%	61%	33%		
Berkshire	27%	30%	38%	50%	61%
Columbia	29%	35%	43%	77%	46%
EVERSOURCE (NSTAR Gas)	31%	29%	31%	71%	43%
Liberty	18%	24%	18%	60%	33%
NGRID Gas	25%	31%	32%	71%	42%
Unitil Gas**	65%	75%	25%		

* Retrofit defined as turn-key, weatherization retrofit. Recommendation rates include HEAs that identified pre-weatherization barriers that require mitigation prior to weatherization implementation. Eversource (WMECo) recommendation rate calculation comprised of Jan-August 2015, additional historical recommendation rates unavailable due to lead vendor transition.

**Unitil did not require its Home Performance Contractors (“HPCs”) to collect or report data regarding the estimated retrofit recommendations until late 2014 when it adopted the lead vendor model. Therefore, Unitil is not able to accurately calculate or report the rate at which recommended measures were adopted by customers for the time period in question.

Please see Table 3-8, the C&I Direct Install tables, on the following pages.

Table 3-8 (Question 3F) - C&I Direct Install - by Program Administrator

Table 3-8 (Question 3F) - Cape Light Compact Electric Measures	2013 kWh Savings	2013 $ Incentives	2014 kWh Savings	2014 $ Incentives	2015 YTD August kWh Savings	2015 YTD August $ Incentives	2013-2015 YTD August kWh Savings	2013-2015 YTD August $ Incentives
For Measures Installed	4,110,107	$2,470,931.21	6,687,854	$3,775,317.36	3,958,512	$2,588,226.14	14,756,473	$8,834,474.71
For Measures Proposed but Not Installed	2,197,645	$1,267,125.13	1,616,031	$1,017,593.16	2,043,940	$1,136,094.77	5,857,616	$3,420,813.06
Total Proposed - Installed and Not Installed	6,307,752	$3,738,056.34	8,303,885	$4,792,910.52	6,002,452	$3,724,321	20,614,089	$12,255,288
Installed as a % of Total Proposed	65%	66%	81%	79%	66%	69%	72%	72%

Gas Measures	2013 Therm Savings	2013 $ Incentives	2014 Therm Savings	2014 $ Incentives	2015 YTD August Therm Savings	2015 YTD August $ Incentives	2013-2015 YTD August Therm Savings	2013-2015 YTD August $ Incentives
For Measures Installed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
For Measures Proposed but Not Installed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Proposed - Installed and Not Installed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Installed as a % of Total Proposed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Savings and incentive $ shown here are based on gross savings and dollars recorded for projects proposed or completed in the given year. As such, installed figures may not exactly match PA-reported savings and $, because of timing and claiming of savings prototocols, in addition to any differences between net and gross

Table 3-8 (Question 3F) - EVERSOURCE Electric Measures	2013 kWh Savings	2013 $ Incentives	2014 kWh Savings	2014 $ Incentives	2015 YTD August kWh Savings	2015 YTD August $ Incentives	2013-2015 YTD August kWh Savings	2013-2015 YTD August $ Incentives
For Measures Installed	65,244,714	$33,873,030.92	60,393,237	$33,053,740.71	38,287,383	$18,750,728.16	163,925,333	$85,677,499.79
For Measures Proposed but Not Installed	16,683,727	$10,128,144.87	20,940,684	$10,396,337.04	14,391,428	$7,014,435.38	52,015,839	$27,538,917.29
Total Proposed - Installed and Not Installed	81,928,441	$44,001,175.79	81,333,920	$43,450,077.74	52,678,811	$25,765,164	215,941,172	$113,216,417
Installed as a % of Total Proposed	80%	77%	74%	76%	73%	73%	76%	76%

Gas Measures	2013 Therm Savings	2013 $ Incentives	2014 Therm Savings	2014 $ Incentives	2015 YTD August Therm Savings	2015 YTD August $ Incentives	2013-2015 YTD August Therm Savings	2013-2015 YTD August $ Incentives
For Measures Installed	130,101	$175,291.00	88,180	$111,592.00	69,028	$142,121.00	287,309	$429,004.00
For Measures Proposed but Not Installed	47,581	$57,483.00	48,851	$66,496.00	20,308	$59,367.00	116,740	$183,346.00
Total Proposed - Installed and Not Installed	177,682	$232,774.00	137,031	$178,088.00	89,336	$201,488	404,049	$612,350
Installed as a % of Total Proposed	73%	75%	64%	63%	77%	71%	71%	70%

Note: Savings and incentive $ shown here are based on gross savings and dollars recorded for projects proposed or completed in the given year. As such, installed figures may not exactly match PA-reported savings and $, because of timing and claiming of savings prototocols, in addition to any differences between net and

Table 3-8 (Question 3F) - NATIONAL GRID Electric Measures	2013 kWh Savings	2013 $ Incentives	2014 kWh Savings	2014 $ Incentives	2015 YTD August kWh Savings	2015 YTD August $ Incentives	2013-2015 YTD August kWh Savings	2013-2015 YTD August $ Incentives
For Measures Installed	36,649,974	$19,496,100.14	41,313,429	$23,486,846.92	21,868,557	$14,734,426.74	99,831,960	$57,717,373.80
For Measures Proposed but Not Installed	15,983,778	$8,832,385.11	26,382,919	$16,655,082.41	24,779,362	$17,649,360.48	67,146,059	$43,136,828.00
Total Proposed - Installed and Not Installed	52,633,752	$28,328,485.25	67,696,348	$40,141,929.33	46,647,919	$32,383,787.22	166,978,019	$100,854,201.80
Installed as a % of Total Proposed	70%	69%	61%	59%	47%	45%	60%	57%

Gas Measures	2013 Therm Savings	2013 $ Incentives	2014 Therm Savings	2014 $ Incentives	2015 YTD August Therm Savings	2015 YTD August $ Incentives	2013-2015 YTD August Therm Savings	2013-2015 YTD August $ Incentives
For Measures Installed	45,055	$54,179.24	69,458	$124,982.22	29,594	$72,719.29	144,107	$251,880.75
For Measures Proposed but Not Installed	71,656	$8,220.60	77,222	$61,719.72	20,512	$36,494.50	169,390	$106,434.82
Total Proposed - Installed and Not Installed	116,711	$62,399.84	146,680	$186,701.94	50,106	$109,213.79	313,497	$358,315.57
Installed as a % of Total Proposed	39%	87%	47%	67%	59%	67%	46%	70%

Note: Savings and incentive $ shown here are based on gross savings and dollars recorded for projects proposed or completed in the given year. As such, installed figures may not exactly match PA-reported savings and $, because of timing and claiming of savings prototocols, in addition to any differences between net and

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Table 3-8 (Question 3F) - UNITIL Electric Measures	2013 kWh Savings	2013 $ Incentives	2014 kWh Savings	2014 $ Incentives	2015 YTD August kWh Savings	2015 YTD August $ Incentives	2013-2015 YTD August kWh Savings	2013-2015 YTD August $ Incentives
For Measures Installed	660,788	$310,590	985,368	$407,284	722,683	$310,247	2,368,839	$1,028,121
For Measures Proposed but Not Installed								
Total Proposed - Installed and Not Installed								
Installed as a % of Total Proposed								

Gas Measures	2013 Therm Savings	2013 $ Incentives	2014 Therm Savings	2014 $ Incentives	2015 YTD August Therm Savings	2015 YTD August $ Incentives	2013-2015 YTD August Therm Savings	2013-2015 YTD August $ Incentives
For Measures Installed	4,158	$7,290.00	4,081	$1,350.00	3,703	$165.00	11,942	$8,805
For Measures Proposed but Not Installed								
Total Proposed - Installed and Not Installed								
Installed as a % of Total Proposed								

Note: Installed savings and incentive $ shown here are based on gross savings and dollars recorded by SB vendor(s) for installations completed in the given year. As such, installed figures may not exactly match PA-reported savings and $, because of differences in timing between the PA's accounting systems and the vendors', in addition to any differences between net and gross savings.
The PA's vendors do not record line numbers 2 and 3 above, therefore, line number 4 cannot be calculated.

g. For percentage of HES oil heating participants receiving either weatherization of heating system upgrades, please see Table 3-9 below.

Table 3-9

Electric PAs – HES Oil Heating Participants			
	Number of oil customers with HEAs, 2013-2015	Number of oil HES participants that have received weatherization and/or heating system upgrades, 2013-2015	Percentage of HES oil heating participants receiving either weatherization or heating system upgrades
Cape Light Compact	4941	3318	67%
Eversource - NSTAR	25212	15125	60%
Eversource - WMECO	8136	3200	39%
National Grid	53952	23918	44%
Unitil	1047	545	52%

Please note that some oil customers have opted to initiate a conversion (outside of energy efficiency) to other fuels as the primary heating source (*e.g.*, heat pumps, natural gas). Heating equipment numbers are comprised of those who took advantage of oil heating rebates.

Unitil notes that it does not have data on the heating type of some customers who received a home energy assessment in 2013 and 2014. These customers comprise about 13% of Unitil's total number of HEAs from 2013-2015.

4. Provide pre-filed testimony describing how the Program Administrators intend to engage outside organizations (e.g., trade allies and community organizations) to enhance program delivery during the 2016-2018 term. Provide examples of outside organizations that may be so engaged.

Response:

Please see Pre-Filed Testimony of each Program Administrator (available at Exhibit 2 to each PA's Petition). See also Section III.K of the Plan for similar information on community engagement and Appendix L for additional information on individual PA efforts.

5. Provide pre-filed testimony describing how the Program Administrators intend to overcome barriers to serve hard-to-reach/underserved communities during the 2016-2018 term.

Response:

Please see Pre-Filed Testimony of each Program Administrator (available at Exhibit 2 to each PA's Petition).

6. Identify and describe new technologies and initiatives that the Program Administrators have included in their respective 2016-2018 plans. Explain how the Program Administrators evaluate new technologies and initiatives to determine cost-effectiveness and savings potential.

Response:

The Program Administrators have been national leaders in their commitment to innovation, and the development and deployment of cutting-edge new technologies. The PAs are committed to studying and implementing new technologies and initiatives in 2016-2018. Please see Section III of the Plan for a full description of the PAs' program designs, which include discussions regarding the PAs' ongoing commitment to innovation and technology in their programs in 2016-2018.

Among the newer technologies under review for 2016-2018 program inclusion are the following:

- Air source and water source gas engine driven heat pumps;
- Several proprietary gas fired heat pumps with variable refrigerant flows;
- Removable jackets for valves, fittings and specialty piping in boiler rooms and other mechanical spaces;
- Advanced rooftop unit controllers that may have application in big box stores;
- A pipe, valve and tank insulation tool that can be used to calculate savings for insulating steam or hot water piping, valves and tanks for customers with usage of less than 50,000 therms per year;
- Distributed refrigeration that can reduce the pounds of refrigerant used and increase usable floor space in supermarket applications;
- Electrically commutated motors for pumping applications;
- Drain water heat recovery;
- Heat pump dryers;
- Automatic temperature control which provides thermostat optimization, load shifting and demand response control as well as communication and bill estimation capabilities;
- Thermal storage optimization control strategies to shift hot water load;
- A boiler QI tool which optimizes the heating system performance and boiler sizing;
- Smart communicating appliances which allow communication and utility control of appliances;
- Advanced buildings net energy optimizer (NEO) building energy modeling;
- Analytics to assess post construction zero energy building performance;
- Existing building HVAC retrofit controls;

- Emerging HVAC technologies;
- Automated window shades;
- Exterior performance lighting;
- Existing space performance lighting;
- LED integrated control logic;
- Smart grid controlled street lighting;
- A variety of emerging lighting technologies
- Window glazing;
- Highly efficiency filtered fume hoods;
- Smart plugs;
- Ozone laundry;
- Air operated double diaphragm (AODD) pump control;
- Washing with polymer beads;
- Hand dryers;
- Building insulation;
- Energy recovery filters

Some of the new initiatives described in the Plan include:

- Renter specific visit
- Moderate income program enhancement
- Project point of contact multi-family program optimization
- Customer experience streamlining deep review
- Home-automation technologies exploration
- Promoting value of net-zero and renewable-ready measures
- "Path to Zero" option
- Sustainable Office Design
- Retrocommissioning
- Expanding education and training for customers, trade allies, contractors
- Initiatives to engage the real estate development community

The Program Administrators solicit and accept new technologies as potential candidates for inclusion in their programs from a variety of sources, including through the Massachusetts

Technical Advisory Committee ("MTAC"). MTAC reviews new technologies that have the potential to cost-effectively save energy. MTAC is both a proactive and a reactive body, and consists of key technical staff from among the PAs. The committee addresses both residential and commercial/industrial technologies, drawing on the subject matter experts from the committee, PA staff, or outside expertise as necessary. It establishes and publishes threshold technical requirements that must be met to qualify products or processes as eligible for program incentives. It documents its findings in a standardized manner and disseminates them to the PA program managers, technical staff, account managers, and outside parties such as vendors, customers, and other interested parties, as appropriate. The PAs welcome vendors and manufacturers to submit products directly for review. A portal on the Mass Save website provides criteria and instructions for direct submittal to the MTAC. The clearly-articulated and open process by which MTAC reviews submitted technologies provides a level playing field for all. Any manufacturer or vendor of an emerging or newly-commercialized efficiency technology can make a science-based case for acceptance of their product into the PA incentive offerings.

PAs also review incremental advancements in traditional and proven energy efficiency measures, such as the integration of smart technology to known mechanical equipment. Such incremental improvements may not require a full MTAC assessment, but rather may be implemented by each PA on a case by case basis, with results shared amongst all.

Additionally, new products often emerge from the field, when proposed by customers or vendors to address a unique efficiency opportunity, or address a more common opportunity in a unique way. When a technical review shows promise, these emerging technologies are often vetted in real-world application through a custom application or in a structured field trial.

The PAs have established formal and informal working relationships with such organizations as: the Consortium for Energy Efficiency ("CEE"), the Northwest Energy Efficiency Alliance (NEEA), the California Emerging Technologies Coordinating Council ("ETCC"), the Northwest Regional Technical Forum ("RTF"), NYSERDA's Emerging Technologies Accelerated Commercialization initiative, Southern California Edison's Lighting Research Program, the Fraunhofer Center for Sustainable Energy Systems, the Food Service Technology Center, and several of the Department of Energy's National Research Laboratories. These relationships can involve a continuum of activities from simple information exchange to participation in jointly funded and managed research, technology assessments, or field tests.

PAs also examine new technologies, initiatives, and strategies in their management committees, including the RMC, C&IMC, EMC, and related working groups. New initiatives may arise in response to changes in market conditions or the appearance of new savings opportunities during the course of Plan implementation, and PAs are able to review these circumstances in management committees and respond in order to take advantage of the changes. An example may be an initiative to partner with the college and university sector to install LED lighting when the technology reaches a price point that makes retrofits at scale economical. PAs also welcome non-technology proposals from stakeholders through the structured Proposal Process, by which any third-party organization can propose a program concept or proposal to supplement or enhance the PAs approved programs to the management committees. This process and related forms is available on MassSave.com.

New technologies and initiatives are evaluated to determine cost-effectiveness and savings potential using the approved statewide custom screening tool by each PA in accordance with project specific inputs. The PAs have also established protocols through the EMC to review new product cost-effectiveness, including establishing the roles and responsibilities of implementers and evaluators, the process for screening, end-of-year review, and application of evaluation results.

7. Provide a table that summarizes evaluation, measurement, and evaluation ("EM&V") study recommendations and indicates whether the Program Administrator has implemented the recommendation, to date, for each study completed during the 2013-2015 term. If a recommendation has not been implemented, explain why not.

Response:

Please see Table 7-1 on the following pages.

Table 7-1 (EM&V Study Recommendations)

Rec #	Study Name	Sector	Filing/Docket	Study Location and Number	Fuel	Recommendation ID (Year - Study # - Rec #)	Recommendation	PA Specific / Statewide	Did the Program Administrator implement the recommendation (Yes, No & Explain Why not, Currently Under Consideration, Will Consider for Future Studies, N/A))	National Grid	Eversource	CMA	Liberty	Berkshire	CLC	Unitil
1	Massachusetts Residential Lighting Cross-Sector Sales Research	Residential	2015 Plan Year	App. U, Study 1	Electric	2015-1-1	The evaluation team recommends using a placeholder value of 7% to be applied to the Massachusetts upstream lighting program sales to reflect the proportion of residential program lighting used in commercial settings.	Statewide	Currently Under Consideration.							
2	Multistage Lighting Net-to-Gross Assessment: Overall Report	Residential	2015 Plan Year	App. U, Study 2	Electric	2015-2-1	The evaluators recommend using the NTG values identified in the study to estimate program impacts.	Statewide	Currently Under Consideration.							
3	Multistage Lighting Net-to-Gross Assessment: Overall Report	Residential	2015 Plan Year	App. U, Study 2	Electric	2015-2-2	The evaluation team recommends that PAs closely monitor the market, and periodically revisit and if necessary revise the 2016-2018 NTG estimates. If these NTG estimates change substantially, the evaluation team recommends that policy makers allow PAs to apply the new NTG estimates to develop revised savings targets for the 2016-2018 period.	Statewide	Currently Under Consideration.							
4	Lighting Market Assessment and Saturation Stagnation Overall Report	Residential	2015 Plan Year	App. U, Study 3	Electric	2015-3-1	The PAs should continue to provide incentives and educate consumers about LEDs in the next program cycle. At the same time, the PAs should monitor any new information that becomes available from future evaluations or other sources regarding delta Watts, measure life, price trends, and incremental costs, and be ready to shift LED strategy if providing incentives ceases to be cost effective.	Statewide	Currently Under Consideration.							
5	Lighting Market Assessment and Saturation Stagnation Overall Report	Residential	2015 Plan Year	App. U, Study 3	Electric	2015-3-2	The PAs and EEAC consultants should continue to fund regular on-site saturation studies—including the continued annual panel study—at least through the early 2020s in order to track the impact of Energy Independence and Security Act (EISA), changes in LED pricing and availability, and possible changes in effectiveness of incentives for standard and specialty CFLs and LEDs.	Statewide	Currently Under Consideration.							
6	Lighting Market Assessment and Saturation Stagnation Overall Report	Residential	2015 Plan Year	App. U, Study 3	Electric	2015-3-3	The PAs should work with the residential evaluation team to develop a methodology for identifying the diameter and length of fluorescent tubes in use in homes.	Statewide	Currently Under Consideration.							
7	Baseline Sensitivity Analysis 2016 - 2018	Residential	2015 Plan Year	App. U, Study 4	Electric/Gas	2015-4-1	No formal recommendations were made in this evaluation		N/A							
8	Lighting Interactive Effects Study Preliminary Results	Residential	2015 Plan Year	App. U, Study 5	Electric	2015-5-1	The evaluation team recommends reassessing the preliminary results by incorporating multi-family building types using recent data developed during the low income multi-family billing analysis and HVAC saturations and building types from the Residential Customer Profiling study.	Statewide	Currently Under Consideration.							
9	Program Assessment Tube TV Recycling	Residential	2015 Plan Year	App. U, Study 6	Electric	2015-6-1	The evaluation team recommends not expanding the existing recycling program to CRT-TVs.	Statewide	The PAs will adopt recommendation to not expand the existing recycling program.							
10	Program Assessment Tube TV Recycling	Residential	2015 Plan Year	App. U, Study 6	Electric	2015-6-2	Consider a follow up study to measure natural TV replacement in the Massachusetts market.	Statewide	Currently Under Consideration.							
11	Program Assessment Tube TV Recycling	Residential	2015 Plan Year	App. U, Study 6	Electric	2015-6-3	Future studies should be conducted in 4-6 years to measure whether CRT-TVs are indeed being replaced naturally.	Statewide	Currently Under Consideration.							
12	Cool Smart Incremental Cost Study	Residential	2015 Plan Year	App. U, Study 7	Electric	2015-7-1	No formal recommendations were made in this evaluation		Although this study did not make any formal recommendations, the PAs are using the study's incremental cost results to update its evaluation of the cost effectiveness of the COOL SMART program.							
13	Home Energy Services Initiative and HEAT Loan Delivery Assessment	Residential	2015 Plan Year	App. U, Study 8	Electric/Gas	2015-8-1	To encourage HPCs to further promote non-HES Mass Save offerings, consider exploring approaches for holding all HPCs accountable for cross-promoting programs and providing additional clarity to HPCs about non-HES program offerings.	Statewide	Currently Under Consideration							
14	Home Energy Services Initiative and HEAT Loan Delivery Assessment	Residential	2015 Plan Year	App. U, Study 8	Electric/Gas	2015-8-2	Conduct additional research with customers to test their receptivity to a customized web portal	Statewide	Currently Under Consideration							
15	Home Energy Services Initiative and HEAT Loan Delivery Assessment	Residential	2015 Plan Year	App. U, Study 8	Electric/Gas	2015-8-3	Explore approaches for optimizing assessment delivery to more effectively disseminate information, encourage cross-program participation, and increase close rates	Statewide	Currently Under Consideration							
16	Home Energy Services Initiative and HEAT Loan Delivery Assessment	Residential	2015 Plan Year	App. U, Study 8	Electric/Gas	2015-8-4	Streamline program materials by identifying needs for summary additional program materials and improving clarity and salience in program materials provided to customers in advance of home energy assessments	Statewide	Currently Under Consideration							
17	Home Energy Services Initiative and HEAT Loan Delivery Assessment	Residential	2015 Plan Year	App. U, Study 8	Electric/Gas	2015-8-5	Explore opportunities to further promote the HEAT Loan outside of the HES program.	Statewide	Currently Under Consideration							
18	Residential Customer Profile Study	Residential	2015 Plan Year	App. U, Study 9	Electric/Gas	2015-9-1	No formal recommendations were made in this evaluation		N/A							
19	Multifamily Impact Findings Memo	Residential	2015 Plan Year	App. U, Study 10	Electric/Gas	2015-10-1	Placeholder results from the study should not be used by the Massachusetts Program Administrators (PAs) due to concerns with data sufficiency, sample representation and broader concerns stemming from analysis performed at the premise level.	Statewide	Currently Under Consideration.							
20	Multifamily Impact Findings Memo	Residential	2015 Plan Year	App. U, Study 10	Electric/Gas	2015-10-2	A new analysis at the facility level should be performed for National Grid, where facility level activity is understood to be reliably tracked in a way that allows the aggregation of consumption and tracking data for each treated building.	Statewide	Currently Under Consideration.							
21	Ductless Mini-Split Heat Pump (DMSHP) Final Heating Season Results	Residential	2015 Plan Year	App. U, Study 11	Electric	2015-11-1	Evaluators have made no final recommendations at this time, except to adopt a lower heating FLH value.	Statewide	The PAs plan to adopt the recommendations							

Rec #	Study Name	Sector	Filing/Docket	Study Location and Number	Fuel	Recommendation ID (Year - Study # - Rec #)	Recommendation	PA Specific / Statewide	Did the Program Administrator implement the recommendation (Yes, No & Explain Why not, Currently Under Consideration, Will Consider for Future Studies, N/A))	National Grid	Eversource	CMA	Liberty	Berkshire	CLC	Unitil
22	Ductless Mini-Split Heat Pump (DMSHP) Baseline Determination	Residential	2015 Plan Year	App. U, Study 12	Electric	2015-12-1	The evaluation team has made no formal recommendations at this time, except to present a possible baseline mix consistent with the draft scenarios presented.		N/A							
23	Massachusetts Low-Income Multifamily Initiative Impact Evaluation	Residential	2015 Plan Year	App. U, Study 13	Electric/Gas	2015-13-1	No formal recommendations were made in this evaluation.		N/A							
24	Comprehensive Review of Non-Residential Training and Education Programs, with a Focus on Building Operator Certification	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 14	Electric/Gas	2015-14-1	The Massachusetts PAs should employ multiple channels to promote BOC and the subsidies.	Statewide	Currently Under Consideration.							
25	Comprehensive Review of Non-Residential Training and Education Programs, with a Focus on Building Operator Certification	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 14	Electric/Gas	2015-14-2	The PAs should craft BOC messaging that conveys the value proposition of certification and maintenance of certification to high-level managers.	Statewide	Currently Under Consideration.							
26	Comprehensive Review of Non-Residential Training and Education Programs, with a Focus on Building Operator Certification	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 14	Electric/Gas	2015-14-3	The PAs should encourage high-level managers who take the training to also send their operators with day-to-day O&M responsibilities.	Statewide	Currently Under Consideration.							
27	Comprehensive Review of Non-Residential Training and Education Programs, with a Focus on Building Operator Certification	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 14	Electric/Gas	2015-14-4	The PAs should promote BOC to participants of other energy efficiency programs.	Statewide	Currently Under Consideration.							
28	Comprehensive Review of Non-Residential Training and Education Programs, with a Focus on Building Operator Certification	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 14	Electric/Gas	2015-14-5	The PAs should claim savings for each subsidized customer for eight years from the initial year of certification – that is, for the year of certification plus seven additional years.	Statewide	Currently Under Consideration.							
29	Comprehensive Review of Non-Residential Training and Education Programs, with a Focus on Building Operator Certification	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 14	Electric/Gas	2015-14-6	The PAs should *not* claim additional savings for an individual's Level 2 certification beyond those claimed for Level 1 certification.	Statewide	Currently Under Consideration.							
30	Comprehensive Review of Non-Residential Training and Education Programs, with a Focus on Building Operator Certification	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 14	Electric/Gas	2015-14-7	The PAs should claim two-thirds of the recommended per-operator savings for a second subsidized operator at a given workplace.	Statewide	Currently Under Consideration.							
31	Comprehensive Review of Non-Residential Training and Education Programs, with a Focus on Building Operator Certification	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 14	Electric/Gas	2015-14-8	The PAs should consider designing and implementing additional adult efficiency education/ training programs.	Statewide	Currently Under Consideration.							
32	Comprehensive Review of Behavior and Education Programs	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 15	Electric/Gas	2015-15-1	Test alternative residential behavior-based program offerings. Programs relying on web portals and smartphone applications can provide lower cost opportunities with comparable savings to the HER program.	Statewide	Currently Under Consideration.							
33	Comprehensive Review of Behavior and Education Programs	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 15	Electric/Gas	2015-15-2	Consider conducting an opportunity assessment of existing program offerings to identify opportunities for employing behavioral strategies, such as commitments and framing, to further enhance program participation.	Statewide	Currently Under Consideration.							
34	Comprehensive Review of Behavior and Education Programs	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 15	Electric/Gas	2015-15-3	Further explore opportunities for addressing barriers faced by PAs serving small markets in delivering behavior-based programs, particularly around partnership, evaluation methods and requirements for claiming savings, and assumptions regarding measure life.	Statewide	Currently Under Consideration.							
35	Comprehensive Review of Behavior and Education Programs	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 15	Electric/Gas	2015-15-4	Consider testing a workplace engagement program to initiate experience with small and medium commercial behavior programs.	Statewide	Currently Under Consideration.							
36	Comprehensive Review of Behavior and Education Programs	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 15	Electric/Gas	2015-15-5	Consider implementing kit-based education programs. Involve appropriate stakeholders in design and implementation to ensure behavioral savings can be quantified and claimed.	Statewide	Currently Under Consideration.							
37	Comprehensive Review of Behavior and Education Programs	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 15	Electric/Gas	2015-15-6	Monitor the outcome of K-12 programs promoting school-wide energy-saving through culture change in similar jurisdictions with periodic, targeted reviews of key programs cited in this research.	Statewide	Currently Under Consideration.							
38	Comprehensive Review of Behavior and Education Programs	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 15	Electric/Gas	2015-15-7	Consider the possibility of path-breaking, targeted research around behavior-based programs in higher education.	Statewide	Currently Under Consideration.							
39	Massachusetts Behavioral Programs Process Evaluation	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 16	Electric/Gas	2015-16-1	The PAs and EEAC should consider mechanisms to balance the "costs" of cross-program effects to avoid undue burden on the HER program where cross-program savings are substantial.	Statewide	Currently Under Consideration.							
40	Massachusetts Behavioral Programs Process Evaluation	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 16	Electric/Gas	2015-16-2	PAs should continue with the current treatment for these customers without concern of negative customer satisfaction side effects.	Statewide	Currently Under Consideration.							
41	Massachusetts Behavioral Programs Process Evaluation	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 16	Electric/Gas	2015-16-3	The PAs should consider conducting more comprehensive exploratory research, such as in-home ethnography, to identify the potential for home automation solutions to target plug load.	Statewide	Currently Under Consideration.							

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42	2014-2015 Commercial and Industrial Natural Gas Programs Free-ridership and Spillover Study	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 17	Gas	2015-17-1	Results from this study are used by the PAs in setting prospective NTGRs in their three-year plans. When results are based on more than 10 survey records, the PAs should use PA-specific results. When sample sizes are not sufficient (10 completed surveys or less), PAs should use statewide figures. The report contains the recommended NTGR values for filing purposes.	Statewide	The PAs plan to adopt the recommendations.							
43	Efficient Neighborhoods + Incremental Cost Assessment	Special & Cross Sector Studies	2015 Plan Year	App. U, Study 18	Electric/Gas	2015-18-1	No formal recommendations were made in this evaluation.		N/A							
44	Prescriptive Gas Impact Evaluation - Steam Trap Evaluation Phase 1	Commercial & Industrial	2015 Plan Year	App. U, Study 19	Gas	2015-19-1	Continue providing two steam trap programs, prescriptive and custom, to accommodate the wide variation in steam pressures and sizes, types, and number of steam traps; facility size; processes by which steam traps are repaired; and applicable savings methods and values.	Statewide	Currently Under Consideration.							
45	Prescriptive Gas Impact Evaluation - Steam Trap Evaluation Phase 1	Commercial & Industrial	2015 Plan Year	App. U, Study 19	Gas	2015-19-2	Increase measure lifetime from three to six years based on the evaluation team's literature review and analysis of MA gas customer survey data.	Statewide	The PAs are adopting the study's recommended measure life of six years.							
46	Prescriptive Gas Impact Evaluation - Steam Trap Evaluation Phase 1	Commercial & Industrial	2015 Plan Year	App. U, Study 19	Gas	2015-19-3	Convene a steam trap stakeholder group—composed of PA staff members directly involved with steam traps, program implementation subcontractors, and steam trap repair/replacement vendors—to identify common assumptions/inputs to use in the savings algorithm, with the goal of improving program accuracy and consistency at the state-wide level.	Statewide	Currently Under Consideration.							
47	Prescriptive Gas Impact Evaluation - Steam Trap Evaluation Phase 1	Commercial & Industrial	2015 Plan Year	App. U, Study 19	Gas	2015-19-4	Develop a new prescriptive steam trap deemed savings value using the savings algorithm developed in Phase 2.	Statewide	Currently Under Consideration.							
48	Prescriptive Gas Impact Evaluation - Steam Trap Evaluation Phase 1	Commercial & Industrial	2015 Plan Year	App. U, Study 19	Gas	2015-19-5	Leverage the steam trap stakeholder group to identify approaches to increase program participation and savings.	Statewide	Currently Under Consideration.							
49	Prescriptive Programmable Thermostats	Commercial & Industrial	2015 Plan Year	App. U, Study 20	Gas	2015-20-1	Perform analysis on the 2014 program data.	Statewide	Currently Underway. The PAs have adopted the deemed savings value of 32 therms per year per programmable thermostats for the time being, until the analysis of the 2014 program (and if initiated, 2014 billing) data is complete.							
50	Prescriptive Programmable Thermostats	Commercial & Industrial	2015 Plan Year	App. U, Study 20	Gas	2015-20-2	Undertake a second participant survey that is focused on the 2014 program participants to identify and examine important consistencies, variances, and changes between the 2013 and 2014 program years, as well as to clarify the use of PTs, the pre-installed condition, and the savings.	Statewide	Currently Under Consideration.							
51	Prescriptive Programmable Thermostats	Commercial & Industrial	2015 Plan Year	App. U, Study 20	Gas	2015-20-3	Conduct a billing analysis using data from both the 2013 and 2014 program years to increase the precision of the savings estimates results from a future billing analysis.	Statewide	Currently Under Consideration.							
52	Prescriptive Programmable Thermostats	Commercial & Industrial	2015 Plan Year	App. U, Study 20	Gas	2015-20-4	Consider modifications to the billing analysis that would better account for exogenous change in the participant population such as including a matched sample of small businesses, collecting some additional business-level information in the survey (e.g., hours worked by or paid to employees).	Statewide	Currently Under Consideration.							
53	Prescriptive Programmable Thermostats	Commercial & Industrial	2015 Plan Year	App. U, Study 20	Gas	2015-20-5	Given the inherent difficulties of billing analyses, continue to investigate methods to better quantify the savings achieved by PT installations, such as pre/post PT installation metering.	Statewide	Currently Under Consideration.							
54	Impact Evaluation of PY2013 Custom Gas Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 21	Gas	2015-21-1	Realization rates should be utilized for the purposes of planning and reporting as follows: Eversource (91.8%), National Grid (77.9%), Columbia Gas (72.7%) and statewide (88.3%).	Statewide	The PAs have adopted the revised realization rates.							
55	Impact Evaluation of PY2013 Custom Gas Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 21	Gas	2015-21-2	A single guidance document that codifies the various protocols, principles, and practices used for applying realization rates across all programs, both gas and electric, in all sectors, should be developed as a common reference and to minimize ambiguity.	Statewide	Currently Under Consideration.							
56	Impact Evaluation of PY2013 Custom Gas Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 21	Gas	2015-21-3	Follow the recommendation of the "Massachusetts 2013 Prescriptive Gas Impact Evaluation Steam Trap Evaluation Phase I" to commence with a Phase II activity to standardize algorithms.	Statewide	Currently Under Consideration.							
57	Impact Evaluation of PY2013 Custom Gas Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 21	Gas	2015-21-4	Further explore the role of the DRB method in impact evaluation planning, as future impact evaluations may benefit from a structured data collection of the M&V sample for ongoing measurement of program characteristics.	Statewide	Currently Under Consideration.							
58	Impact Evaluation of PY2013 Custom Gas Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 21	Gas	2015-21-5	Comprehensive Design Analysis (CDA) natural gas tracking savings included the interactive gas penalty from electric measures. The electric measure penalties should be reported as a resource penalty to the electric program and not reported as a gas program penalty.	Statewide	Currently Under Consideration.							
59	Impact Evaluation of PY2013 Custom Gas Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 21	Gas	2015-21-6	The application reviewers should cross-check the fraction of the natural gas bills a project is expected to save against typical savings fractions, particularly those that are high.	Statewide	Currently Under Consideration.							

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60	Impact Evaluation of PY2013 Custom Gas Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 21	Gas	2015-21-7	Confirm existing condition ventilation rates and the efficient operation of the installed equipment, given the erratic and often poor savings rates of ventilation control measures (including ventilation heat recovery, demand controlled ventilation [DCV], and ventilation related EMS measures).	Statewide	Currently Under Consideration.							
61	Impact Evaluation of PY2013 Custom Gas Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 21	Gas	2015-21-8	The PAs should be diligent in gathering the technical assistance studies, spreadsheets, and models used to develop the project and include them in the electronic documentation, given that the application files are not always complete and sometimes miss significant information. Particular attention should be paid to the documentation of baseline conditions.	Statewide	Currently Under Consideration.							
62	Impact Evaluation of PY2013 Custom Gas Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 21	Gas	2015-21-9	Consider evaluating projects consisting of only deemed measures with deemed savings as part of technology specific evaluations.	Statewide	Currently Under Consideration.							
63	Impact Evaluation of PY2013 Custom Gas Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 21	Gas	2015-21-10	An error ratio of 0.60 is recommended for future evaluations.	Statewide	Currently Under Consideration.							
64	Massachusetts Commercial New Construction Energy Code Compliance Follow-Up Study	Commercial & Industrial	2015 Plan Year	App. U, Study 22	Electric/Gas	2015-22-1	Adopt modified code baselines that reflect standard practices as the basis for determining energy efficiency incentives.	Statewide	Currently Under Consideration.							
65	Massachusetts Commercial New Construction Energy Code Compliance Follow-Up Study	Commercial & Industrial	2015 Plan Year	App. U, Study 22	Electric/Gas	2015-22-2	Promote a focus on installation quality to realize greater savings from energy efficiency.	Statewide	Currently Under Consideration.							
66	Massachusetts Commercial New Construction Energy Code Compliance Follow-Up Study	Commercial & Industrial	2015 Plan Year	App. U, Study 22	Electric/Gas	2015-22-3	Promote high-performance building strategies to achieve additional energy savings.	Statewide	Currently Under Consideration.							
67	Massachusetts Commercial New Construction Energy Code Compliance Follow-Up Study	Commercial & Industrial	2015 Plan Year	App. U, Study 22	Electric/Gas	2015-22-4	Target code training at specific provisions to achieve additional savings from improved compliance.	Statewide	Currently Under Consideration.							
68	Massachusetts Commercial New Construction Energy Code Compliance Follow-Up Study	Commercial & Industrial	2015 Plan Year	App. U, Study 22	Electric/Gas	2015-22-5	Streamline future code compliance studies to enable more frequent, cost-effective compliance assessments.	Statewide	Currently Under Consideration.							
69	Massachusetts LED Spillover Analysis	Commercial & Industrial	2015 Plan Year	App. U, Study 23	Electric	2015-23-1	The PAs should take steps to ensure that smaller customers are exposed to opportunities to purchase incented LED lamps through Direct Install programs and strong promotions via large home improvement stores and electronics retailers.	Statewide	Currently Under Consideration.							
70	Massachusetts LED Spillover Analysis	Commercial & Industrial	2015 Plan Year	App. U, Study 23	Electric	2015-23-2	Focus program efforts on the promotion of LED linear fixtures, which account for a very high portion (roughly 80 percent) of total commercial lighting energy consumption currently.	Statewide	Currently Under Consideration.							
71	Impact Evaluation of Prescriptive Chiller and Compressed Air Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 24	Electric	2015-24-1	This evaluation recommends that Eversource-NSTAR utilize its own PA specific retrospective realization rates, and that all remaining PAs use the non-Eversource-NSTAR combined retrospective realization rates.	Statewide	The PAs have adopted the revised retrospective and prospective realization rates and savings factors produced in this study.							
72	Impact Evaluation of Prescriptive Chiller and Compressed Air Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 24	Electric	2015-24-2	Consider more research around the key finding that many chillers operate at very low part loads (i.e., not cycling, and therefore operating below the manufacturer-recommended part load values), particularly the implications for reliability, efficiency, and energy savings.	Statewide	Currently Under Consideration.							
73	Impact Evaluation of Prescriptive Chiller and Compressed Air Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 24	Electric	2015-24-3	Consider a closer review of chiller project applications, taking into account how chillers are currently rebated, whether they are used for comfort or data center cooling, and whether the custom track may be more appropriate for multiple chiller installations.	Statewide	Currently Under Consideration.							
74	Impact Evaluation of Prescriptive Chiller and Compressed Air Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 24	Electric	2015-24-4	Encourage vendors to look for additional chiller savings opportunities such as changing control set points (e.g., lower condenser water temperature, higher chilled water temperature or chilled water temperature reset).	Statewide	Currently Under Consideration.							
75	Impact Evaluation of Prescriptive Chiller and Compressed Air Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 24	Electric	2015-24-5	Update the air compressor baseline from the current modulating with blowdown to load/unload, even though the savings calculated from these two different baselines did not vary significantly.	Statewide	Currently Under Consideration.							
76	Impact Evaluation of Prescriptive Chiller and Compressed Air Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 24	Electric	2015-24-6	The retrospective realization rates for air compressors produced in this study are intended to be used by all PAs for their 2015 projects. The new prospective savings factors for air compressors and refrigerated dryers produced by this study, which are calculated based on the average operating kW of the sample of air compressors and dryers, may be used to update the values in the TRM.	Statewide	The PAs have adopted the revised retrospective and prospective realization rates and savings factors produced in this study.							
77	Impact Evaluation of Prescriptive Chiller and Compressed Air Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 24	Electric	2015-24-7	Recommend that compressed air vendors conduct simple short term metering to better understand their operation during off-shift periods and help improve the accuracy of the annual hours of operation.	Statewide	Currently Under Consideration.							

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78	Impact Evaluation of Prescriptive Chiller and Compressed Air Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 24	Electric	2015-24-8	Consider a review of interval load data prior to finalizing applications, given that in many cases the actual operating hours were observed to be significantly higher, resulting in unclaimed savings.	Statewide	Currently Under Consideration.							
79	Impact Evaluation of Prescriptive Chiller and Compressed Air Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 24	Electric	2015-24-9	Encourage vendors to look for additional compressed air savings opportunities such as lowering the discharge pressure, and inspecting for and reducing air leaks.	Statewide	Currently Under Consideration.							
80	Impact Evaluation of 2012 Custom HVAC Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 25	Electric	2015-25-1	Improve Baseline or Pre-Retrofit Documentation	Statewide	Currently Under Consideration.							
81	Impact Evaluation of 2012 Custom HVAC Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 25	Electric	2015-25-2	Provide Sufficient Documentation	Statewide	Currently Under Consideration.							
82	Impact Evaluation of 2012 Custom HVAC Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 25	Electric	2015-25-3	Clearly Document Calculations of Peak Demand Savings	Statewide	Currently Under Consideration.							
83	Impact Evaluation of 2012 Custom HVAC Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 25	Electric	2015-25-4	Encourage More Comprehensive Commissioning and Updating of Tracking Estimates with Findings from Commissioning	Statewide	Currently Under Consideration.							
84	Impact Evaluation of 2012 Custom HVAC Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 25	Electric	2015-25-5	Conduct Pre-Installation Metering for More Retrofit Projects	Statewide	Currently Under Consideration.							
85	Impact Evaluation of 2012 Custom HVAC Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 25	Electric	2015-25-6	Improve use of Post Inspection to Verify Measure Operation	Statewide	Currently Under Consideration.							
86	Impact Evaluation of 2012 Custom HVAC Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 25	Electric	2015-25-7	Require Trend Data Acquisition	Statewide	Currently Under Consideration.							
87	Impact Evaluation of 2012 Custom HVAC Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 25	Electric	2015-25-8	Use of Desk Review Methodology	Statewide	Currently Under Consideration.							
88	Impact Evaluation of 2012 Custom HVAC Installations	Commercial & Industrial	2015 Plan Year	App. U, Study 25	Electric	2015-25-9	Consider Other Evaluation Methodologies	Statewide	Currently Under Consideration.							
89	Massachusetts Spring 2014 Survey Results: FINAL Report	Residential	2014 Plan year	App. 4D, Study 14-1	Electric	2014-1-1	Future surveys should explore the reasons behind satisfaction with—and preferences for—LEDs versus CFLs among those who use both types of bulbs to understand why CFL satisfaction continues to decline. This analysis may also inform potential future trends in LED satisfaction, particularly if the results point to driving factors related to LED timing and rate of adoption.	Statewide	No: The next study is still in process, therefore the recommendation has not been adopted into the next study							
90	Massachusetts Spring 2014 Survey Results: FINAL Report	Residential	2014 Plan year	App. 4D, Study 14-1	Electric	2014-1-2	To increase survey response rate, the Team recommends that future replications of this survey also send a pre-paid incentive with the advance letter alerting possible respondents to the study.	Statewide	No: The next study is still in process, therefore the recommendation has not been adopted into the next study							
91	Massachusetts Spring 2014 Survey Results: FINAL Report	Residential	2014 Plan year	App. 4D, Study 14-1	Electric	2014-1-3	To explore more fully the reasons why web respondents differ from phone respondents, the Team recommends that the next iteration of this survey again offer a web/phone response option along with a phone-only response option. We believe that the offering of a web-based response platform may be more conducive to current social norms. . If the length of the survey allows, the evaluators should also add questions to help characterize web and phone respondents by their technology, lighting, and environmental opinions. Finally, if the programming of the survey allows, the strongest study design would show pictures of various bulb types to only a portion of the web respondents to assess the extent to which these visual cues affect response.	Statewide	No: The next study is still in process, therefore the recommendation has not been adopted into the next study							
92	Residential Lighting Shelf Survey and Pricing Analysis	Residential	2014 Plan year	App. 4D, Study 14-2	Electric	2014-2-1	No formal recommendations were made in this evaluation.		N/A							
93	Baseline Sensitivity Analysis Spreadsheet, 2014	Residential	2014 Plan year	App. 4D, Study 14-3	Electric/Gas	2014-3-1	No formal recommendations were made in this evaluation.		N/A							
94	Market Lift Assessment FINAL Report	Residential	2014 Plan year	App. 4D, Study 14-4	Electric	2014-4-1	In negotiations with retail partners, stress the continuation of previous incentives to help alleviate their concerns about the additional risk involved with market lift design.	Statewide	No: We are not planning on using the market-lift model for lighting products.							
95	Market Lift Assessment FINAL Report	Residential	2014 Plan year	App. 4D, Study 14-4	Electric	2014-4-2	Take into account the capabilities of manufacturers and retailers in collecting and providing the necessary data	Statewide	Yes.							
96	Market Lift Assessment FINAL Report	Residential	2014 Plan year	App. 4D, Study 14-4	Electric	2014-4-3	The Team recommends more in-store events and potential in-store field events to boost sales of CFLs.	Statewide	Yes.							
97	Results of the Massachusetts On-site Lighting Inventory 2014	Residential	2014 Plan year	App. 4D, Study 14-5	Electric	2014-5-1	Continue pursuit of panel study, adding in 2014 saturation study participants. The panel study results helped to answer questions regarding drivers of saturation changes and bulb replacement behavior that have been valuable in assessing the ever-changing residential lighting market. Repeating this study and expanding on the panel size will reveal whether the results observed this year represent a pattern of behavior or whether they were limited to a particular group at a specific time.	Statewide	No: The study currently is in stage 1 and has not yet been fully scoped, however the intention is to fully adopt the recommendation.							
98	Supplier and Retailer Perspectives on the Massachusetts Residential Lighting Market Final Report	Residential	2014 Plan year	App. 4D, Study 14-6	Electric	2014-6-1	No formal recommendations were made in this evaluation.		N/A							

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99	Saturation Comparison of Massachusetts, California, and New York: Final Report	Residential	2014 Plan year	App. 4D, Study 14-7	Electric	2014-7-1	No formal recommendations were made in this evaluation.		N/A							
100	Ductless Mini-Split Heat Pump Customer Survey Results	Residential	2014 Plan year	App. 4D, Study 14-8	Electric	2014-8-1	No formal recommendations were made in this evaluation.		N/A							
101	Mass Save Multifamily Program Process Evaluation Report	Residential	2014 Plan year	App. 4D, Study 14-9	Electric/Gas	2014-9-1	Create a Single Point of Contact. The PAs and EEAC should consider creating a single point of contact for each project to ensure a customer deals with one entity throughout the project cycle, regardless of the sector (residential and/or commercial) and fuels (gas and/or electric) present at the project site. This could be achieved by using an outside vendor or a network of vendors.	Statewide	For the 2016-2018 Plan, the Program Administrators (PAs) have proposed a Project Point of Contact ("PPC") as described in Residential Multi-Family Retrofit description of the Plan.							
102	Mass Save Multifamily Program Process Evaluation Report	Residential	2014 Plan year	App. 4D, Study 14-9	Electric/Gas	2014-9-2	Improve Program Tracking Systems. The PAs should consider the following two steps to address the data issues: • Create a unique premise ID for multifamily properties that is implemented across all PAs, fuels and programs. • Consider splitting out tracking and planning for C&I multifamily from the rest of the C&I portfolio, similar to the process currently implemented for multifamily residential activity.	PA Specific		For 2016-2018 the PAs will be tracking C&I multi-family gas and electric separately, similar to the process currently implemented for multi-family residential activity. The PAs are still assessing the practical considerations of creating unique premise IDs for multifamily properties across all PAs, fuels and programs.	Regarding a unique premise ID, this is under consideration. Regarding splitting out tracking and planning for C&I multifamily, this is planned for January 2016.	For 2016-2018 the PAs will be tracking C&I multi-family gas and electric separately, similar to the process currently implemented for multi-family residential activity. The PAs are still assessing the practical considerations of creating unique premise IDs for multifamily properties across all PAs, fuels and programs.	Currently under consideration	Currently under consideration	For 2016-2018 the PAs will be tracking C&I multi-family gas and electric separately, similar to the process currently implemented for multi-family residential activity. The PAs are still assessing the practical considerations of creating unique premise IDs for multifamily properties across all PAs, fuels and programs.	For 2016-2018 the PAs will be tracking C&I multi-family gas and electric separately, similar to the process currently implemented for multi-family residential activity. The PAs are still assessing the practical considerations of creating unique premise IDs for multifamily properties across all PAs, fuels and programs.
103	Mass Save Multifamily Program Process Evaluation Report	Residential	2014 Plan year	App. 4D, Study 14-9	Electric/Gas	2014-9-3	Ensure a Consistent Energy Assessment Process. A consistent assessment process is key to ensuring that there are no lost opportunities and that any forgone opportunities are recorded for future follow-up with the customer. Improvement of the process can be achieved through the training of auditors in completing a comprehensive job including a review of all the systems in common areas and major systems within unit areas. Program auditors should also be trained to involve technical engineers when required to offer an advanced engineering perspective for more customized measures.	Statewide	The PAs have created a common form, called the Energy Action Plan, or EAP, to record all facility energy efficiency opportunities found during an assessment, including a review of all the systems in common areas and major systems in units. The PPC will be responsible for using the EAP to guide the coordination of additional vendors as appropriate.							
104	Mass Save Multifamily Program Process Evaluation Report	Residential	2014 Plan year	App. 4D, Study 14-9	Electric/Gas	2014-9-4	Feasibility of Future Impact Evaluation. Considering all aspects of the data reviewed in this study, we believe a billing analysis is a feasible approach to determining savings among participating accounts. This approach can be expected to provide electric and gas overall and PA level results, although we note that for the smaller PAs such as Berkshire, Unitil and CLC, the impact results are not likely to be reliable due to the small populations that appear to be available for the analysis. We also note that while this approach can provide a realization rate against the savings predicted at the program and PA level, it will not provide realization rates at the measure level.	Statewide	A statewide billing analysis was conducted in mid-2015 and yielded inconclusive results due to unforeseen methodological issues. The team is working to determine if an alternative analysis method will be more successful.							
105	High Efficiency Heating Equipment Impact Evaluation	Residential	2014 Plan year	App. 4D, Study 14-10	Gas	2014-10-1	Use evaluation heating loads for HEHE-installed furnaces and boilers in calculating deemed savings. Previous deemed savings had used the same annual heating loads.	Statewide	Yes							
106	High Efficiency Heating Equipment Impact Evaluation	Residential	2014 Plan year	App. 4D, Study 14-10	Gas	2014-10-2	Adjust baseline equipment efficiency assumptions to account for standby and cycling losses using evaluation determined adjustment factors.	Statewide	Yes							
107	High Efficiency Heating Equipment Impact Evaluation	Residential	2014 Plan year	App. 4D, Study 14-10	Gas	2014-10-3	Consider and research ways to improve boiler operating efficiency through quality installation and contractor and homeowner education.	Statewide	Currently Under Consideration							
108	High Efficiency Heating Equipment Impact Evaluation	Residential	2014 Plan year	App. 4D, Study 14-10	Gas	2014-10-4	Use the revised early retirement baselines applied in this study and consider additional early retirement baseline research for units less than thirty years old if early retirement participation increases.	Statewide	Yes							
109	High Efficiency Heating Equipment Impact Evaluation	Residential	2014 Plan year	App. 4D, Study 14-10	Gas	2014-10-5	Consider conducting additional baseline research and/or requiring information on the application indicating the equipment that is being replaced by combination systems.	Statewide	No, but the PAs have adjusted the baseline for combination systems to represent the current mix of baselines that was discovered during the evaluation. These results were implemented into the 2014 planning report and will continue to be used for future reporting.							
110	Furnace Baseline	Residential	2014 Plan year	App. 4D, Study 14-11	Gas	2014-11-1	No formal recommendations were made in this evaluation.		N/A							
111	Variable Speed Drive Loadshape Project	Commercial & Industrial Program Studies	2015 Plan year	App. 4D, Study 14-12	Electric	2014-12-1	Continue to promote the installation of VSDs on existing equipment	Statewide	Yes							
112	Variable Speed Drive Loadshape Project	Commercial & Industrial Program Studies	2015 Plan year	App. 4D, Study 14-12	Electric	2014-12-2	PAs should integrate VSD control and commissioning requirements into program implementation activities. PAs should require specifications of the intended control strategy in their application forms, and post inspection should include verification of commissioned VSD control sequences.	PA Specific		National Grid's prescriptive VSD program is subject to a random sample of sites having post inspections, where control strategies and equipment are verified.	Eversource's prescriptive VSD program is subject to post inspection on a larger sample of installs after the study findings where what is suggested is verified.		N/A	N/A	Yes	Unitil's prescriptive VSD measures are subject to sites having post inspections, where control strategies and equipment are verified.

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113	Variable Speed Drive Loadshape Project	Commercial & Industrial Program Studies	2015 Plan year	App. 4D, Study 14-12	Electric	2014-12-3	To support evaluation efforts, the PAs should add pre-retrofit data collection requirements to program application forms. At a minimum, the PAs should require customers to specify the type, working conditions, and operating schedule of their pre-retrofit baseline equipment.	Statewide	Yes							
114	Massachusetts Existing Buildings Market Characterization: Commercial and Industrial Customer Telephone Survey Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-13	Electric/Gas	2014-13-1	No formal recommendations were made in this evaluation.		N/A							
115	Retrofit Lighting Controls Measures Summary of Findings FINAL REPORT	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-14	Electric	2014-14-1	The Team recommends that the PAs focus on the following high potential technologies: advanced lighting controls, wireless controls, LED with controls, and daylight dimming.	Statewide	Yes							
116	Retrofit Lighting Controls Measures Summary of Findings FINAL REPORT	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-14	Electric	2014-14-2	The Team recommends that the PAs focus on the following high potential sectors: Offices, Small Business (<300 kW).	Statewide	Yes							
117	Retrofit Lighting Controls Measures Summary of Findings FINAL REPORT	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-14	Electric	2014-14-3	DNV GL recommends adjusting the lighting controls savings algorithm to include "% saved" rather than the currently used "delta hours" value. We recommend using the weighted average values from an LBNL study of 24% saved for occupancy sensors and 28% saved for daylight dimming.	Statewide	Yes							
118	Whole Systems Energy Efficiency Programs - Literature Review	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-15	Electric/Gas	2014-15-1	The evaluation team identified a number of next steps for further research into understanding how to capture additional energy and demand savings through whole system programs, including: • Conduct interviews/brainstorming session with MA PAs	Statewide	No. N/A. The recommendation pertains to suggestions for further research to be conducted by the evaluation consultant. It does not specifically pertain to action on the part of PAs. No further research has been planned at this time.							
119	Whole Systems Energy Efficiency Programs - Literature Review	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-15	Electric/Gas	2014-15-2	• Conduct interviews with program managers and market actors involved in successful programs in other states	Statewide	No. N/A. The recommendation pertains to suggestions for further research to be conducted by the evaluation consultant. It does not specifically pertain to action on the part of PAs. No further research has been planned at this time.							
120	Whole Systems Energy Efficiency Programs - Literature Review	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-15	Electric/Gas	2014-15-3	• Conduct interviews with the architects and engineers (A&E) community	Statewide	No. N/A. The recommendation pertains to suggestions for further research to be conducted by the evaluation consultant. It does not specifically pertain to action on the part of PAs. No further research has been planned at this time.							
121	Whole Systems Energy Efficiency Programs - Literature Review	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-15	Electric/Gas	2014-15-4	• Conduct focus groups with new construction building owners	Statewide	No. N/A. The recommendation pertains to suggestions for further research to be conducted by the evaluation consultant. It does not specifically pertain to action on the part of PAs. No further research has been planned at this time.							
122	Final Report of Massachusetts LED Market Effects: Baseline Characterization	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-16	Electric	2014-16-1	Maintain incentives for LED lamps and fixtures. PAs should continue to incentivize LEDs to reduce the first cost barrier and increase the saturation of LEDs across the Massachusetts market. Program managers should continue to monitor the decrease in LED prices to ensure incentives are at the optimal level.	Statewide	Yes							
123	Final Report of Massachusetts LED Market Effects: Baseline Characterization	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-16	Electric	2014-16-2	Continue to support the development of product standards and testing programs. Given the number of manufacturers entering the LED market each year and consumer unfamiliarity and concerns with LED quality and performance, the need for quality standards and consumer education is even more important.	Statewide	Yes							
124	Final Report of Massachusetts LED Market Effects: Baseline Characterization	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-16	Electric	2014-16-3	Promote programs that educate consumers on LED products and applications. We recommend that PAs continue to support educational efforts to assist consumers in selecting the LED product that best meets their needs.	Statewide	Yes							
125	Final Report of Massachusetts LED Market Effects: Baseline Characterization	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-16	Electric	2014-16-4	Promote lighting controls through programs as a way to increase lighting savings. Tying controls and LEDs together will increase the savings potential of each measure and the associated cost-effectiveness.	Statewide	Yes							
126	2012 C&I Customer Profile Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-17	Electric/Gas	2014-17-1	Investigate the geographic data at more detailed granularity. Additional analysis into geographic clusters may be useful in identifying similar C&I markets across the state that have not experienced the same depth of efficiency savings as well as yield insights into market saturation levels and the drivers behind these differences.	Statewide	Yes							
127	2012 C&I Customer Profile Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-17	Electric/Gas	2014-17-2	Investigate customer segmentation though utilization of multiple attribute filters. The categorical analysis presented in this report confirms many of the high level trends first identified in the 2011 customer profile, as well as identifies opportunities for deeper analysis. Further investigation into the data by applying multiple segmentation filters (e.g. building type, consumption size, and end use) may provide greater insight into untapped opportunities for energy efficiency that are currently masked by the high level analysis.	Statewide	Yes							

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128	2012 C&I Customer Profile Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-17	Electric/Gas	2014-17-3	Investigate in greater depth why load factor appears correlated with savings. For the second year in a row, low load factor accounts had the highest average percent savings. The level of granularity used to evaluate load factor is relatively coarse, and a more detailed investigation of how load factor and average savings are correlated may provide valuable insight into how PAs can target offerings to a large customer segment by population.	Statewide	Yes							
129	2012 C&I Customer Profile Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-17	Electric/Gas	2014-17-4	Investigate methods to improve PA specific match rates using PA supplied ID data. The ability to reliably and robustly link the PA tracking and billing data is a critical element of the customer profile report, and an important input into many other studies. The assumption inherent in scoping the 2011 and 2012 data is that account and other unique ID links are consistently formatted both within PA and year over year, and that minimal manipulations would be needed to link the data. However, this has proven more difficult than anticipated, and given the establishment and analysis of time series datasets, undertaking a deeper analysis of the data will be necessary to improve its value . Through the QA/QC process DNV GL believes that match rates can be further improved with PA specific explorations into how to effectively link data, and this standardization may be useful in improving the ability to link a customer between separate gas and electric service providers.	Statewide	Yes							
130	2012 C&I Customer Profile Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-17	Electric/Gas	2014-17-5	Further investigate multi-end use and multi-year participants and trends. The 2012 customer profile confirmed the presence and impact of participants that undertook multiple end use projects, and participants that participated over multiple years. Additional analysis guided by these summary level participant findings, for example evaluating drivers behind why certain segments have higher savings from multiple end use projects – may yield a greater understanding of end use trends, scale of effort, and – should national account flags become available – corporate adoption rates.	Statewide	Yes							
131	2012 C&I Customer Profile Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-17	Electric/Gas	2014-17-6	Further investigate the retail business participation between gas and electric. The 2012 customer profile indicated that businesses classified as retail had higher participation for electric PAs relative to gas PAs. Additional analysis into potential drivers of this – for example, do most retail sites focus on measures that are not applicable to gas (e.g. lighting), and what specific measures are being undertaken at retail locations that have a gas provider, will help to evaluate if there is an opportunity to increase participation at retail locations or if this business type constitutes a harder to serve sector for gas PAs.	Statewide	Yes							
132	Learning from Successful Projects Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-18	Electric/Gas	2014-18-1	Leverage trade ally customer relationships to increase customer engagement and communication. The PAs can continue to leverage trade allies to increase the likelihood of achieving any number of the success factors related to customer engagement and communication.	Statewide	Yes. Please reference the C&I Retrofit section within the C&I Program and Core Initiative Descriptions section of the 2016-2018 energy efficiency plan for more details.							
133	Learning from Successful Projects Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-18	Electric/Gas	2014-18-2	Increase emphasis of vendor training. By increasing the emphasis on the use of training vendors and other technical staff, the PAs will encourage and support more frequent installation of energy saving measures. Also, increased trade ally training, support and competency are important because of their strong direct relationships with customers.	Statewide	Yes. Please reference the C&I Retrofit section within the C&I Program and Core Initiative Descriptions section of the 2016-2018 energy efficiency plan for more details.							
134	Learning from Successful Projects Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-18	Electric/Gas	2014-18-3	Promote and leverage incentives. Program implementers can educate customers about all the incentives that are being provided and offered to increase the depth and breadth of their energy efficiency projects. When customers realize they are being offered additional discounting, they are more likely to feel more successful, decide to act, and install more measures and/or projects.	Statewide	Yes.							
135	Learning from Successful Projects Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-18	Electric/Gas	2014-18-4	Explore ways for customers to build internal expertise. This may take the form of a shared energy manager position to serve a group of multiple small- and mid-sized customers.	Statewide	Yes, though not specifically on a shared energy manager. Please reference the C&I Retrofit section within the C&I Program and Core Initiative Descriptions section of the 2016-2018 energy efficiency plan for more details on learnings, trainings, etc. geared at building customer expertise.							
136	Learning from Successful Projects Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-18	Electric/Gas	2014-18-5	Emphasize the Value of NEBs and "Being Green". By marketing the NEBs and other intangibles associated with specific projects or specific project types, the PAs will increase the potential for project success. Such marketing can take the form of case studies, which both PAs and customers noted as training and education tactics that lead to project success.	Statewide	Yes, though not specifically case studies. It's worth noting that in the C&I space, NEBs are often unique or project specific, which somewhat mutes the effectiveness of marketing a generic NEB to a given customer.							

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137	Learning from Successful Projects Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-18	Electric/Gas	2014-18-6	Ensure the Accuracy of Technical Review and Assistance. By ensuring that the aspects of a project are technically sound and appropriate, the PAs will ensure that the project is set up for success at the outset. Even though a project that grossly overestimates project savings could still save a significant amount of energy, a customer may not view it as a success given its high expectations.	Statewide	Yes. Installation inspections and project commissioning are examples of how PAs are conducting additional work to ensure the accuracy of review and savings estimates. Accuracy is further enhanced by the evaluation-implementation feedback loop.							
138	Learning from Successful Projects Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-18	Electric/Gas	2014-18-7	Leverage the results of EM&V site reports. For PAs not doing so already, the results of individual EM&V site evaluations may be used as a mechanism for quality assurance, accuracy and project specific feedback. For example the PAs could follow up with a project receiving a particularly low (or high) realization rate to determine if there were any issues with the project that went unaddressed. It should be noted, however, that the EM&V work is driven by a random sample of projects and this type of exercise would not replace and program existing QA/QC efforts.	Statewide	Yes. EM&V site reports provide project specific feedback which can be leveraged to make larger programmatic changes if appropriate. Such information has produced valuable information on the performance of such measures as retro-commissioning and variable frequency drives, for example.							
139	Learning from Successful Projects Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-18	Electric/Gas	2014-18-8	Focus on Eliminating Project Delays and Intrusions. While the PAs can only exert so much control over the participation process, it is worth assessing participation at regular intervals to determine if there are any improvements that can be made. PAs could explore what causes project delays and develop tracking mechanisms and processes to monitor and continually improve services to ensure customer schedules and expectations are met and preferably exceeded.	Statewide	Yes. This is a consideration of PAs as alleviating project delays results in increased project execution which equates to higher savings and improved customer satisfaction. Factors affecting project execution and within PAs' control are examined during the year.							
140	Learning from Successful Projects Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-18	Electric/Gas	2014-18-9	Small PAs should adopt a simpler form of the MOUs used successfully by larger PAs. Having a signed memorandum of understanding (MOU) was one of the metrics used to identify customers with successful projects, and it was cited as a criterion for success during PA interviews. The PA Differences project found that the smaller PAs have very few large customers that can implement large projects, which are historically a key to achieving savings goals. To increase the critical savings stream from these large customers, we recommend that smaller PAs consider adopting a process similar to the formalized MOU that focuses on planning for energy efficiency over time.	Statewide	No. Small PAs will consider this recommendation for future efforts.							
141	How PA Differences Affect Outcomes Phase 2 Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-19	Electric/Gas	2014-19-1	Small PAs should consider how to increase technical expertise relevant to their largest customers and strike long-term efficiency deals with their largest customers, perhaps in the form of memorandums of understanding (MOUs).	PA Specific		N/A	N/A	N/A	Currently under consideration	Currently under consideration	Yes	Currently under consideration
142	How PA Differences Affect Outcomes Phase 2 Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-19	Electric/Gas	2014-19-2	Whenever possible, comparisons between PAs should be based on multiple years of data and focus on medium- or long-term trends.	Statewide	Yes							
143	How PA Differences Affect Outcomes Phase 2 Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-19	Electric/Gas	2014-19-3	Large and small PAs should attempt to get greater savings from the small and mid-sized customers.	Statewide	Yes							
144	How PA Differences Affect Outcomes Phase 2 Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-19	Electric/Gas	2014-19-4	Expand use of subcontractors to increase PA reach to smaller customers.	PA Specific		Yes	Yes. As an example, Eversource has engaged a subcontractor to identify additional gas opportunities in the small business segment.		Currently under consideration	Currently under consideration	Yes	Yes
145	How PA Differences Affect Outcomes Phase 2 Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-19	Electric/Gas	2014-19-5	Use targeted initiatives to achieve savings from specific measure types such as National Grid's spray valve initiative in 2012.	PA Specific		Yes	Yes. Please refer to the Commercial & Industrial Programs description narrative as part of the 2016-2018 energy efficiency plan for more details.		Upstream and targeted promotional activities	upstream, and considering targeted promotional activities	Yes	Yes
146	Massachusetts Commercial Real Estate Survey Analysis - Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-20	Electric/Gas	2014-20-1	Increase outreach to building managers and owners. Additional efforts to deepen and maintain relationships with building managers and owners can provide an avenue to promote energy efficiency programs in the commercial real estate market.	Statewide	Yes							

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147	Massachusetts Commercial Real Estate Survey Analysis - Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-20	Electric/Gas	2014-20-2	Leverage the role of account managers. The PAs should consider leveraging the role of their account managers. Account managers can continue to play a critical role in working with commercial real estate businesses as they can more readily communicate energy efficiency program information and assist customers in navigating through the participation process.	PA Specific		Yes	Yes.	CMA does not have "account managers", we do however leverage program managers and vendors to fill this role	No - Limited opportunities due to Liberty's territory. The PA participates in statewide offerings and marketing efforts.	No - Limited opportunities due to Berkshire's territory. The PA participates in statewide offerings and marketing efforts.	No/NA. Due to the unique CLC service territory and customer base on Cape Cod and Martha's Vineyard, there is not a traditional CRE market with large developers owning significant commercial property volumes. Nor does CLC have traditional account managers like a utility. CLC does however maintain a very active presence in our communities through ongoing outreach to local chambers, boards of selectmen, energy committees and other community venues.	Yes.
148	Massachusetts Commercial Real Estate Survey Analysis - Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-20	Electric/Gas	2014-20-3	Target marketing to commercial real estate businesses based on building vintage. The PAs should consider target marketing to commercial real estate businesses based on building vintage. The analysis showed that 65% of buildings built before 1990 have not undergone a renovation within the past five years and therefore may offer opportunities for energy savings.	PA Specific		Yes	Yes	No. CMA is reaching out to the market segment, but not by age of buildings as the study suggest. The PA does not have enough market intelligence to be able to target buildings by how old they are.	No. Limited opportunity in our service territory. PA targets these customers through statewide marketing efforts.	Currently Under Consideration	No. Due to the nature of CLC's customer base on Cape Cod and Martha's Vineyard, we do not have a traditional CRE market with large developers owning significant commercial property volumes.	No, The PA has limited opportunities in this target market and includes the small number of customers in its usual marketing efforts. The PA participates in statewide offerings or marketing efforts.
149	Small Business Program Process Evaluation Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-21	Electric/Gas	2014-21-1	Contracting Process: • Find ways to build achievement of non-lighting and gas savings into the contracting process.	Statewide	Currently Under Consideration							
150	Small Business Program Process Evaluation Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-21	Electric/Gas	2014-21-2	Contracting Process: • Make the contract process more consistent across PAs and eliminate duplication of effort.	Statewide	Currently Under Consideration							
151	Small Business Program Process Evaluation Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-21	Electric/Gas	2014-21-3	Measure List, Checklist, and Assessment Process: • Strengthen the comprehensiveness checklist and implement a common electronic tool or app for all vendors.	Statewide	Currently Under Consideration							
152	Small Business Program Process Evaluation Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-21	Electric/Gas	2014-21-4	Measure List, Checklist, and Assessment Process: • Clearly define and document the measures covered by the program.	Statewide	Currently Under Consideration							
153	Small Business Program Process Evaluation Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-21	Electric/Gas	2014-21-5	Measure List, Checklist, and Assessment Process:• Require vendors to report and promptly share the specifications of major heating and water-heating systems for all assessments with the relevant gas PA.	Statewide	Currently Under Consideration							
154	Small Business Program Process Evaluation Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-21	Electric/Gas	2014-21-6	Measure List, Checklist, and Assessment Process:• Consider sending in two assessors at once; one focused on lighting (similar to current practice) and one focused on gas-related measures.	Statewide	No, the PAs expect to be able to get at the same point with a single assessment in order to keep cost down. We will search for a more elegant solution.							
155	Small Business Program Process Evaluation Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-21	Electric/Gas	2014-21-7	Measure List, Checklist, and Assessment Process:• Consider providing SB vendors with additional training to increase their knowledge of non-lighting and gas-saving measures.	Statewide	Yes							
156	Small Business Program Process Evaluation Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-21	Electric/Gas	2014-21-8	Data Handling: • Tracking databases should be clearer and more consistent within and across PAs. Databases should include: clear indication of which (sub-)program measures were incented through (e.g.: SB/Direct Install, Large Retrofit, New Construction), clear indication of whether a measure was custom or prescriptive, the SB vendor associated with the measure or an explicit indication of none, and which customers received assessments, even if they did not install any measures.	PA Specific		Yes	Yes. Eversource tracking databases already provide this level of detail.	See plan	See plan	See plan	Yes	Yes.
157	Small Business Program Process Evaluation Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-21	Electric/Gas	2014-21-9	Data Handling: • PAs should automate their electronic data entry.	PA Specific	Yes, to the extent practicable	Yes	No. This recommendation is vague.		See plan	See plan	Yes	Yes, to the extent practicable
158	Small Business Program Process Evaluation Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-21	Electric/Gas	2014-21-10	Data Handling: • PAs should have the capability to obtain and log the assessment details from their SB vendors into a data tracking system. This would help PAs identify additional potential savings from SB participants, especially from those that do not install all recommended measures.	PA Specific		Currently Under Consideration	Yes	See plan	See plan	See plan	Yes	See plan
159	Small Business Program Process Evaluation Final Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-21	Electric/Gas	2014-21-11	Data Handling: • Formalize the process to reconcile cross-PA measure tracking if one is not already in place.	Statewide	Currently Under Consideration							
160	Massachusetts Boiler Market Characterization Study	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-22	Gas	2014-22-1	Seek voluntary non-confidential feedback from boiler manufacturers who expressed an interest.	Statewide	Currently Under Consideration							

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161	Massachusetts Boiler Market Characterization Study	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-22	Gas	2014-22-2	Conduct comparative research on boiler programs in the Northeast region.	Statewide	Currently Under Consideration							
162	Massachusetts Boiler Market Characterization Study	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-22	Gas	2014-22-3	Initiate "boiler product line mapping" by creating a simple matrix where 90 - 2,000 MBH boiler units provided by various manufacturers are identified .	Statewide	Currently Under Consideration							
163	Massachusetts Boiler Market Characterization Study	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-22	Gas	2014-22-4	Provide an overview of DOE's current NPRM for Commercial Boiler Standards (U.S. Department of Energy Notice of Proposed Rulemaking), which may mandate federal efficiency requirements for pre-packaged commercial boilers.	Statewide	Currently Under Consideration							
164	Massachusetts Boiler Market Characterization Study	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-22	Gas	2014-22-5	Conduct a "Massachusetts Boiler Roundtable" (a small-group forum discussion) with a select Massachusetts market-savvy boiler panel that can more effectively provide information on the evolving complex boiler market.	Statewide	Currently Under Consideration							
165	Impact Evaluation of Massachusetts Prescriptive Gas Pre-Rinse Spray Valve Measure	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-23	Gas	2014-23-1	Recommendations to Increase Savings: Results showed that a percentage of change-outs (approximately 20%) resulted in small energy savings because of either low spray valve use at a site or old valves already having low flow rates. However, solutions to address these "small-savers" in the program population do not seem practical at this time, as explained below: • There is no practical method for accurately identifying low use sites. Adopting a free change-out program would quickly become very complex and un-manageable if eligibility rules were changed to target certain commercial businesses. Site level monitoring proved that spray valve use and savings are site-specific even within the same facility, business, or building type. • No practical method exists to stop a current practice of easily modifying older spray valves to increase their flow rate. The existing program implementation practice of changing all valves to the high efficiency "tamper-proof" model appears to be prudent program administration.	Statewide	Yes							
166	Impact Evaluation of Massachusetts Prescriptive Gas Pre-Rinse Spray Valve Measure	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-23	Gas	2014-23-2	Recommendation for additional spray valve research to aid future program planning: The Massachusetts program implementation of the spray valve program utilizing direct installation contractors has resulted in the change-out of two to three thousand spray valves per year with substantial gas savings. However, given that the total state-wide inventory of spray valves and its future savings potential are finite, we developed the following key questions for future research: 1. Identify the Statewide PRSV inventory, how many PRSV's are there? 2. How many program change-outs have occurred from historic program data? 3. How many more can be done? 4. What PRSV gas savings exists for each PA?	Statewide	Will Consider for Future Studies							
167	Impact Evaluation of Massachusetts Prescriptive Gas Pre-Rinse Spray Valve Measure	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-23	Gas	2014-23-3	Currently there are synergies achieved by common program implementation occurring between multiple PAs. Further investigation of the state-wide inventory of spray valves and historic program data analysis will provide meaningful planning details for the remaining overall gas savings potential and will lead to the development of feasible future strategies for this measure. The assessment can also provide greater details specific to each PA.	Statewide	Will Consider for Future Studies							
168	T12 Phaseout Market Research	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-24	Electric	2014-24-1	No formal recommendations were made in this evaluation. Because this was a market characterization study it did not contain any explicit recommendations.		N/A							
169	2013 Commercial & Industrial Customer Profile Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-25	Electric/Gas	2014-25-1	Given the increasing interest in the Customer Profile study, refine and prioritize the metrics used to expedite analyses and increase the actionable insights generated. Among other benefits, this would provide the opportunity to assess the best approach to incorporating metrics developed through other studies—such as the PA Differences and Mid-Size Customer Needs Assessment studies—to ensure that those projects continue to deliver maximum value.	Statewide	Currently Under Consideration							
170	2013 Commercial & Industrial Customer Profile Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-25	Electric/Gas	2014-25-2	Examine how to best continue engaging small and mid-size gas customers that may have undertaken an electric PA installed gas measure. For example, we recommend exploring whether participants view the gas spray valves as "all they would do" or "the start of something bigger." This may help smaller PAs in particular refine their approaches to ensure that small and mid-size customers continue to represent cost effective savings opportunities—rather than higher-cost converts to bring back into the efficiency space. Engaging smaller customers will become increasingly important as larger customers exhaust their savings appetite.	Statewide	Currently Under Consideration							

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171	2013 Commercial & Industrial Customer Profile Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-25	Electric/Gas	2014-25-3	Further explore ways to engage sectors where account proportion and consumption-weighted participation are low in order to identify avenues for new offerings. We recommend further study to identify sub groupings of smaller customers within these sectors—particularly the Other Services sector—in order to inform the development of new programmatic offerings. These customers may be too small to merit the assignment of an account manager, but may benefit from a somewhat standard operating nature (e.g., a car wash, or a flashing light at the top of a cell phone tower) or a sector-specific strategy that would allow a “templatized” type offering to generate savings through bulk of measures—similar to what gas spray valves have accomplished in the Accommodation and Food Service sector.	Statewide	Currently Under Consideration							
172	2013 Commercial & Industrial Customer Profile Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-25	Electric/Gas	2014-25-4	Continue to integrate third party data by leveraging geographic data captured in the PA billing systems. There is potential to further expand and integrate the use of tax parcel data to help PAs target customer subsets. Consider continued refinement of how the Massachusetts PAs can leverage the geographic element of their data for actionable findings. One element of feedback received in response to the 2013 Customer Profile draft was: How do we make the maps more actionable? A strong first step towards developing more predictive and actionable geographic outputs would be to identify: 1) priority questions such as “where is participation lagging,” and 2) the predictor variables that the implementation teams suspect most influence the priority questions (e.g., energy use, building vintage, square footage, etc.).	Statewide	Currently Under Consideration							
173	2013 Commercial & Industrial Customer Profile Report	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-25	Electric/Gas	2014-25-5	Expand linking electric and gas accounts to effectively evaluate dual-PA served customers to get a complete accounting of their true energy intensity for each fuel.	Statewide	Currently Under Consideration							
174	Massachusetts Commercial and Industrial Upstream Lighting Program: "In Storage" Lamps Follow-Up Study	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-26	Electric	2014-26-1	The Team recommends that the PAs use the results of the Year 3 analysis to replace the results of the Year 1 analysis for LED and fluorescent lamps. The PAs may instead decide to use all of the individual components of the realization rates.	Statewide	Yes							
175	Massachusetts Commercial and Industrial Upstream Lighting Program: "In Storage" Lamps Follow-Up Study	Commercial & Industrial Program Studies	2014 Plan year	App. 4D, Study 14-26	Electric	2014-26-2	The PAs and EEAC may consider conducting a follow-up impact evaluation to assess the effectiveness of their ongoing efforts to improve the installation rate.	Statewide	Yes							
176	2013 Commercial and Industrial Electric Programs Free-ridership and Spillover Study	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-27	Electric	2014-27-1	No formal recommendations were made in this evaluation.		N/A							
177	Stage 1 Results and Stage 2 Detailed Research Plan - Commercial and Industrial New Construction Non-Energy Impacts Study	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-28	Electric/Gas	2014-28-1	• The analysis of NEIs associated with NC measures should focus on true new construction only.	Statewide	Yes							
178	Stage 1 Results and Stage 2 Detailed Research Plan - Commercial and Industrial New Construction Non-Energy Impacts Study	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-28	Electric/Gas	2014-28-2	• Self-reports by end users would not provide an effective means for estimating NEIs associated with most NC measures.	Statewide	Yes							
179	Stage 1 Results and Stage 2 Detailed Research Plan - Commercial and Industrial New Construction Non-Energy Impacts Study	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-28	Electric/Gas	2014-28-3	• Self-reports by engineering firms will provide valuable insights to estimating NEIs across the range of projects for which they perform engineering services.	Statewide	Yes							
180	Stage 1 Results and Stage 2 Detailed Research Plan - Commercial and Industrial New Construction Non-Energy Impacts Study	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-28	Electric/Gas	2014-28-4	• An engineering-based approach is warranted to estimate NEIs.	Statewide	Yes							
181	Stage 1 Results and Stage 2 Detailed Research Plan - Commercial and Industrial New Construction Non-Energy Impacts Study	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-28	Electric/Gas	2014-28-5	• (Optional) Various individuals may be able to serve on a Delphi panel to provide valuable information regarding NEI estimates, and to ensure their soundness.	Statewide	No, the PAs did not choose to incur the optional, added expense of a Delphi panel. Instead, the study contractor conducted a series of in-depth interviews with government officials, engineering firms and contractors, and building owners to obtain information that helped guide its engineering-based analysis and validate the results.							

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182	Stage 1 Results and Stage 2 Detailed Research Plan - Commercial and Industrial New Construction Non-Energy Impacts Study	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-28	Electric/Gas	2014-28-6	• A limited survey effort may be suitable for select measures. o Natural replacement o Industrial process measures	Statewide	No. In Phase 2 of this project, the study contractor ultimately did not recommend a separate survey estimate for these two groups of measures because it found that: 1) only one of the PAs distinguishes natural replacement measures in its tracking data, and NEIs associated with some natural replacement measures had already been estimated as part of the 2012 C&I NEI Retrofit study, and 2) self-reported results are unlikely to result in improved benefits over the engineering-based approach adopted in the Stage 2 study, as the sample size is likely to be small.							
183	Top-down Modeling Methods Study - Final Report	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-29	Electric/Gas	2014-29-1	Continue refinement of the PA-muni model to investigate the stability of models and possible changes to model specification that may reduce confidence intervals.	Statewide	Yes							
184	Top-down Modeling Methods Study - Final Report	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-29	Electric/Gas	2014-29-2	Investigate the possibility of a national or multi-state model that builds on the lessons learned from the PA-muni model, but using non-program states as a comparison area.	Statewide	Will Consider for Future Studies							
185	Top-down Modeling Methods Study - Final Report	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-29	Electric/Gas	2014-29-3	For the PA-data model, continue to collect data through the C&I and residential databases to extend the available data series to include five years of consumption and program tracking data, then continue collecting the necessary data going forward for future analysis. Continue to refine the existing models to incorporate multiple lag periods of the program and consumption variables.	Statewide	Yes							
186	Code Compliance Results for Single-Family Non-Program Homes in Massachusetts	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-30	Electric/Gas	2014-30-1	Future statewide compliance estimates will need to account for stretch code homes. Stretch code homes were just beginning to be built at the time of the 2009 IECC inspections and thus represented a very small portion of the overall population. As a result, they were excluded from this analysis.	Statewide	Yes							
187	Massachusetts Cross Cutting Evaluation Home Energy Report Decay Analysis	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-31	Electric/Gas	2014-31-1	Given the limitations of this study (e.g., the electric and gas cohorts experienced differing incremental levels of treatment reduction), the Team recommends that the PAs undertake further research to help inform the design of treatment reduction strategies. We recommend that future experiments plan the timing of treatment reductions to further test the potential impact of the following factors: • Treatment duration prior to the experiment: Within the same fuel, or even within a larger cohort, how does decay change when the first reduction occurs after one, two, or three years? • Seasonality of reduction: How does a treatment gap in the winter compare with one in the summer? Is there a way to optimize winter gaps to achieve greater persistence? • Duration of the reduction: How does persistence vary with the length of the treatment reduction period? • Fuel-specific differences: Test similar reductions with participants at the same "program maturity" level between electric and gas.	Statewide	Will Consider for Future Studies							
188	Efficient Neighborhoods + Initiative Evaluation Report	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-32	Electric/Gas	2014-32-1	The survey results showed that participants were more likely to learn of the initiative through door-to-door outreach, phone calls, and family and friends than from non-participants. Since learning about the initiative from a trusted source also appears to be effective, the PAs could encourage participants to tell their neighbors about the initiative or provide additional incentives for referrals. Participants were also more likely than non-participants to have learned about the initiative through multiple sources. The PAs should consider conducting a high volume marketing campaign that uses multiple tactics.	Statewide	Yes							
189	Efficient Neighborhoods + Initiative Evaluation Report	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-32	Electric/Gas	2014-32-2	The PAs should consider using messaging that ties the assessment and improvements to current customer needs. One such way is aligning initiative messaging with seasonal needs (e.g., messaging about increased comfort due to energy efficiency during the winter months), which some PAs already do.	Statewide	Yes							
190	Efficient Neighborhoods + Initiative Evaluation Report	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-32	Electric/Gas	2014-32-3	A barrier apparent from the survey results is the belief among many assessment participants that the recommended improvements were unnecessary. Additional research could suggest alternative information or messaging that might help convince customers that the recommendations are worth doing.	Statewide	Yes							

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191	Massachusetts Cross-Cutting Behavioral Program Evaluation Opower Results	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-33	Electric/Gas	2014-33-1	The evaluation team recommends that the PAs adopt the following savings estimate ratios in future years when third-party impact evaluations are not completed. o National Grid Electric: 95% o National Grid Gas: 98% o NSTAR Electric: 104% o NSTAR Gas: 98% o WMECo Electric: 104%	PA Specific	Yes	National Grid has adopted the recommended realization rates.	Yes		N/A	N/A	N/A. CLC is not specified in this recommendation.	N/A
192	Methods for Measuring Market Effects of Massachusetts Energy Efficiency Programs	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-34	Electric/Gas	2014-34-1	The market effects cross-cutting team should identify specific methods and data needed for measuring market effects in the high-priority program-market intersections identified through this work.	Statewide	Yes							
193	Methods for Measuring Market Effects of Massachusetts Energy Efficiency Programs	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-34	Electric/Gas	2014-34-2	Market effects work should use the established evaluation approaches identified in this document.	Statewide	Yes							
194	Recommended Methods for Assessing Market Effects of HVAC Programs	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-35	Electric/Gas	2014-35-1	Market effects studies should proceed for Residential HVAC and C&I Upstream HVAC program-market intersections.	Statewide	Yes							
195	Recommended Methods for Assessing Market Effects of HVAC Programs	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-35	Electric/Gas	2014-35-2	PAs should consider establishing a panel of HVAC manufacturers from which to collect market share and other data, as appropriate, for manufacturer-controlled sales channels. The panel would supplement residential Heating, Air-conditioning & Refrigeration Distributors International (HARDI) data (Recommendation 3) and provide some data for commercial equipment other than rooftop units (RTUs). PA program staff could play an active role in helping to design, recruit and retain market actors for this or any other HVAC market actor panel the PAs may want to establish. PA program planning staff and PA and contractor evaluation staff should also provide input to design in addition to market effects. Involving these diverse groups of staff increases the likelihood that manufacturers will participate, that future program plans will leverage market effects or utilize market effects research findings, that data collected through market actor panels will be useful to program design and marketing, and that the data will meet a broader range of evaluation needs beyond just market effects. Additionally, including a diverse group of program and evaluation staff will help ensure that long term relationships are established and well maintained between PAs and manufacturers.	Statewide	Yes							
196	Recommended Methods for Assessing Market Effects of HVAC Programs	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-35	Electric/Gas	2014-35-3	Residential HVAC market effects research can proceed with HARDI data, supplemented by market actor panel and interview data as available and appropriate (Recommendation 2). HARDI data acquisition will need to be renegotiated to ensure that the data to be purchased align with market effects research needs.	Statewide	Currently Under Consideration							
197	Recommended Methods for Assessing Market Effects of HVAC Programs	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-35	Electric/Gas	2014-35-4	PAs should build on the C&I Upstream HVAC Program's existing distributor data collection activities in order to obtain market share data for commercial RTUs. RTU market effects research can proceed with these data as well as additional data that may be collected by market actor panels and interviews. PAs may also wish to explore the viability of obtaining other kinds of market data through a panel of C&I distributors, most likely building on the Upstream HVAC program's existing relationships with distributors. Any data collection involving HVAC distributors would need to be carefully planned to complement, not duplicate or conflict with, market share or other market data to be obtained through HARDI or manufacturers, and not jeopardize the PAs' ability to obtain HARDI data.	Statewide	Currently Under Consideration							
198	Recommended Methods for Assessing Market Effects of C&I Lighting and Controls Programs	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-36	Electric	2014-36-1	C&I Lighting market effects research can proceed with a study of the market effects of programs that promote high-performance (HP) T8 lamps and ballasts, including quantification of net savings attributable to those programs.	Statewide	Yes							
199	Recommended Methods for Assessing Market Effects of C&I Lighting and Controls Programs	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-36	Electric	2014-36-2	The PAs should assess the potential value of developing a baseline study on lighting controls. C&I Lighting Controls should be monitored for any significant uptick in activity, which would suggest value to a market effects study. However, no market effects study is warranted at this time.	Statewide	Yes							
200	Recommended Methods for Assessing Market Effects of Non-residential New Construction Programs	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-37	Electric/Gas	2014-37-1	The PAs should consider conducting prospective work involving the tracking of indicators that would support theory-based evaluation.	Statewide	Will Consider for Future Studies							
201	Recommended Methods for Assessing Market Effects of Non-residential New Construction Programs	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-37	Electric/Gas	2014-37-2	The PAs should consider using the net-to-gross estimates from the electric and gas net-to-gross (NTG) studies for the 2016-18 prospective estimate that is required for planning purposes. The NTG estimates from these studies are based on self-reporting by program participants and address only free ridership and some form of spillover, not including market effects.	Statewide	Yes							

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202	Recommended Methods for Assessing Market Effects of Non-residential New Construction Programs	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-37	Electric/Gas	2014-37-3	PAs should gather C&I "True" New Construction data through 2017, and aim to complete a retrospective market effects evaluation by early 2018, and at the same time develop a prospective NTG estimate for the 2019-2021 period. Coordination with Codes & Standards evaluation research is essential in this market space, and any resulting savings should be split between the C&I New Construction Program and Codes & Standards, with above-code or above-prevailing practice savings attributed to the former and savings from getting buildings closer to code or prevailing practice attributed to the latter.	Statewide	Will Consider for Future Studies							
203	Cross-Cutting Code Compliance Support Initiative Evaluation Reports	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-38	Electric/Gas	2014-38-1	Provide handouts of the slides used in the trainings to the attendees.	Statewide	Yes							
204	Cross-Cutting Code Compliance Support Initiative Evaluation Reports	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-38	Electric/Gas	2014-38-2	Continue to monitor response times to Circuit Rider calls and work to improve them; response times will become more important as more calls come in concerning current projects.	Statewide	Yes							
205	Cross-Cutting Code Compliance Support Initiative Evaluation Reports	Special & Cross Sector Studies	2014 Plan year	App. 4D, Study 14-38	Electric/Gas	2014-38-3	Encourage the use of telephone calls rather than email to submit Circuit Rider questions and receive responses whenever possible.	Statewide	Yes							
206	Northeast Residential Lighting Hours-of-Use Study	Residential	2013 Plan Year	App. 4D, Study 13-1	Electric/Gas	2013-1-1	The Team recommends that the Sponsors consider adopting the HOU room-by-room estimates from the overall hierarchical model for all households regardless of income or home type.	Statewide	No, The PAs are investigating the cost and capability of adopting and tracking the data required to adopt this recommendation at this time. The PAs will continue to explore opportunities to improve data and reporting on lighting in the 2016-2018 plan, but since all available sockets are targeted, they do not intend to track bulbs by room at this time.							
207	Northeast Residential Lighting Hours-of-Use Study	Residential	2013 Plan Year	App. 4D, Study 13-1	Electric/Gas	2013-1-2	As with HOU estimates, the team recommends that the Sponsors consider adopting the Overall load curve and resulting coincidence factors across Connecticut, Massachusetts, Rhode Island, and Upstate New York.	Statewide	Yes							
208	Northeast Residential Lighting Hours-of-Use Study	Residential	2013 Plan Year	App. 4D, Study 13-1	Electric/Gas	2013-1-3	Consider higher HOU estimates for retrospective studies.	Statewide	Yes							
209	Massachusetts Residential New Construction Net Impacts Report	Residential	2013 Plan Year	App. 4D, Study 13-2	Electric/Gas	2013-2-1	Assess the net impacts of the Program's multifamily component.	Statewide	Currently Under Consideration							
210	Massachusetts Residential New Construction Net Impacts Report	Residential	2013 Plan Year	App. 4D, Study 13-2	Electric/Gas	2013-2-2	Continue to conduct baseline studies of non-program homes.	Statewide	Currently Under Consideration							
211	Massachusetts Residential New Construction Net Impacts Report	Residential	2013 Plan Year	App. 4D, Study 13-2	Electric/Gas	2013-2-3	Continue to emphasize practices such as quality insulation installation in trainings.	Statewide	Yes							
212	Massachusetts Residential New Construction Net Impacts Report	Residential	2013 Plan Year	App. 4D, Study 13-2	Electric/Gas	2013-2-4	Continue to carefully document any and all program actions that may affect the market.	Statewide	Yes							
213	Massachusetts Low Income Metering Study	Low-Income	2013 Plan Year	App. 4D, Study 13-3	Electric/Gas	2013-3-1	No formal recommendations were made by the evaluators conducting this study.		N/A							
214	Massachusetts Combined Heat and Power Program Impact Evaluation 2011-2012	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-4	Electric	2013-4-1	The PAs should continue to develop and implement a consistent modeling protocol for all sites and across all PAs.	Statewide	Yes							
215	Massachusetts Combined Heat and Power Program Impact Evaluation 2011-2012	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-4	Electric	2013-4-2	The PAs and EEAC Consultant(s) should continue to work together to define the attribution of savings to CHP systems.	Statewide	The attribution of savings have been defined since the publication of this study. PAs are currently operating under common agreement.							
216	Massachusetts Combined Heat and Power Program Impact Evaluation 2011-2012	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-4	Electric	2013-4-3	The PAs should collect metered data for at least two years after system commissioning. Data collected during the second year would provide a sufficient buffer for any metering outages during the first year and ensure twelve months of valid data would be collected.	PA Specific		Yes	No. While Eversource will continue to make metering a requirement for CHP participation, the requirement for data collection will be shifted from the program administrator to the customer.	N/A, electric only	N/A	N/A	Currently Under Consideration	The Company does very few CHP projects, and will consider recommendation on case by case basis.
217	Massachusetts Combined Heat and Power Program Impact Evaluation 2011-2012	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-4	Electric	2013-4-4	The PAs and EEAC Consultant(s) should consider conducting a future evaluation focused on medium, large, and district sized systems. These planned systems may significantly change realization rates for the program when they become operational.	Statewide	No. PAs will consider this for future studies.							
218	Massachusetts Combined Heat and Power Program Impact Evaluation 2011-2012	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-4	Electric	2013-4-5	In order to obtain a more thorough understanding of the engineering analysis and the commissioning process, the PAs and EEAC Consultant(s) should consider conducting a process evaluation of the CHP program.	Statewide	Yes. This has been considered and PAs are scoping this as a study during the 2016-2018 timeframe.							
219	Mid-size Customer Needs Assessment	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-5	Electric/Gas	2013-5-1	Increase recruitment and training of energy services firms able to provide comprehensive solutions - The PAs could better serve this market by establishing a system for recruiting and training qualified vendors to service mid-size customers. PAs should look for ways to facilitate partnerships between firms to get the right skill sets, or to develop a broader internal base of expertise.	PA Specific	PAs plan to incorporate recommendations	Yes	Yes. Eversource regularly utilizes energy services firms referred to as project expeditors as one way to reach the mid-sized customer segment.		Currently under consideration	Currently under consideration	Yes	Currently under consideration

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220	Mid-size Customer Needs Assessment	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-5	Electric/Gas	2013-5-2	Develop a statewide process for qualifying and coordinating energy services firms to provide comprehensive solutions – There is a need for greater access to qualified contractors to service the diverse needs of mid-size customers.	Statewide	Currently Under Consideration							
221	Mid-size Customer Needs Assessment	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-5	Electric/Gas	2013-5-3	Lower capital and administrative costs for mid-size customers and/or contractors to improve payback and margin on energy efficiency investment- While higher incentives may not be possible on many custom projects, the PAs could establish programs that increase financing options and qualifying costs to energy services firms.	PA Specific		Yes	Yes	Yes	Yes	Yes	Yes	Yes
222	Mid-size Customer Needs Assessment	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-5	Electric/Gas	2013-5-4	Increase multi-measure (comprehensive) program offerings – The PAs should review their existing comprehensive program offerings to ensure they offer incentives for multiple measures, or change the program offerings to address untapped measures.	Statewide	Yes							
223	Mid-size Customer Needs Assessment	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-5	Electric/Gas	2013-5-5	Continue to improve marketing strategies for mid-market – These efforts should include use of PEX contractors to assist in identifying the appropriate solutions for customers. In addition, these strategies should focus staff on strategic segments of customers with similar energy needs. Segmenting by industry is one approach to creating a targeted marketing process.	Statewide	Yes							
224	Mid-size Customer Needs Assessment	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-5	Electric/Gas	2013-5-6	Support energy services firms by obtaining qualifying information – The PAs could require contractors to administer simplified system inventory and gas service provider surveys when scheduling visits. Information collected by these surveys could be used to rate contractors on their thoroughness in marketing programs.	Statewide	No, the PAs do not agree with this recommendation and we will look for more cost-effective ways to optimize trade ally management							
225	Mid-size Customer Needs Assessment	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-5	Electric/Gas	2013-5-7	Standardize approaches to marketing to multi-account customers – Identifying a successful approach and standardizing it will improve the PA's ability to effectively market to those customers.	Statewide	Yes							
226	Mid-size Customer Needs Assessment	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-5	Electric/Gas	2013-5-8	There is a need to link electric and gas customers – Because identification and marketing to Direct Install customers is handled through the electric PAs, the gas-only PAs lose some autonomy regarding how their customers are marketed.	statewide	Currently Under Consideration							
227	Impact Evaluation of the Massachusetts Upstream Lighting Program	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-6	Electric	2013-6-1	LED Delta Watts –Wattage for baseline bulbs/lamps was found to be significantly higher than tracking estimates, mostly due to the fact that tracking estimates assumed a higher mix of CFLs than was found. As market penetration of LEDs increase baseline wattage will decrease. A follow-up evaluation should consider this shifting baseline as a factor in deciding when the next one should take place.	Statewide	Yes							
228	Impact Evaluation of the Massachusetts Upstream Lighting Program	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-6	Electric	2013-6-2	Quantity - This study found that approximately 82% of the purchased LED lamps and approximately 80% of the purchased fluorescent lamps were installed at the time of the evaluation. It was common to find many of these not yet installed lamps in storage at each of the facilities. It is unclear what the lag time will be for the installation of these remaining lamps, and therefore, a follow-up study should be designed to revisit sites from this study that had a large number of units still in storage or not yet installed.	Statewide	Yes							
229	Impact Evaluation of the Massachusetts Upstream Lighting Program	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-6	Electric	2013-6-3	Hours of Use - This study found that the hours of use realization rate was 88% for LEDs and 103% for fluorescent lamps. Based on lighting logger data at each of the sites, the average hours of use for LED lamps were found to be 3,979 hours per year and 3,559 hours per year for fluorescent lamps. It is recommended that the hours of use for each technology be adjusted appropriately to account for this finding for the near term.	Statewide	Yes							
230	Impact Evaluation of the Massachusetts Upstream Lighting Program	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-6	Electric	2013-6-4	Increase the Customer's Awareness of the Program - Many customers were aware that they had received discounted lamps from this program, but not all were aware that the discounts came from the PAs. Many customers were under the impression that their electrical contractors were offering the deep discounts. It is recommended that the PAs consider utilizing a program sticker or label that participating distributors would attach to a customers' shipping/purchase order.	Statewide	Currently Under Consideration							
231	Impact Evaluation of the Massachusetts Upstream Lighting Program	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-6	Electric	2013-6-5	Additional Supporting Information for Large Purchases - It is recommended that electrical contractors or end users be required to provide more information to support extremely large purchases so that it would be more likely that the program bulbs are installed earlier.	Statewide	Yes							

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232	Impact Evaluation of the Massachusetts Upstream Lighting Program	Commercial & Industrial Program Studies	2013 Plan Year	App. 4D, Study 13-6	Electric	2013-6-6	Follow-up Impact Evaluation - This impact evaluation provides important feedback to the PAs for reporting savings, and improving savings estimates. However, due to the relatively large error ratios found in this study, the targeted 90/10 precision was not achieved. Depending on PA needs, a follow-up study may be considered to improve the evaluation results, or to obtain statistically valid factors for some of the building types where a majority of LED and Fluorescent lamps are being installed. The PAs and EEAC may want to consider performing a third phase of impact evaluation, which could be designed in consideration of the error ratios that were found with this study to try to achieve a combined 90/10 precision at the measure category, or targeted at a measure category and building type. Alternatively, the PAs and EEAC may consider following up on those sites with lower installation rates. Follow-up discussion and long-term planning should take place to determine what the evaluation needs are on an ongoing basis, and also what the target precision levels should be based on the needs of the PAs and EEAC.	Statewide	Yes							
233	Evaluation of the Northampton Leading the Way and Powering Pittsfield Initiatives	Special & Cross Sector Studies	2013 Plan Year	App. 4D, Study 13-7	Electric/Gas	2013-7-1	No formal recommendations were made in this evaluation.		N/A							
234	2013 Massachusetts Statewide Marketing Campaign Evaluation Report	Special & Cross Sector Studies	2013 Plan Year	App. 4D, Study 13-8	Electric/Gas	2013-8-1	There were no recommendations from this report, as it was designed to assess the performance of the marketing campaign and attitudes toward the aforementioned statewide brands.		N/A							
235	Abbreviated Review of Methods for the Draft Top-Down Modeling Methods Study	Special & Cross Sector Studies	2013 Plan Year	App. 4D, Study 13-9	Electric/Gas	2013-9-1	No formal recommendations were made in this literature review. Instead, the pros and cons of various methods were reviewed.		N/A							
236	Efficient Neighborhoods+SM – Summary of Evaluation Results	Special & Cross Sector Studies	2013 Plan Year	App. 4D, Study 13-10	Electric/Gas	2013-10-1	No formal recommendations were made.		N/A							
237	2013 Massachusetts Statewide COOL SMART/GasNetworks Brand Assessment	Special & Cross Sector Studies	2013 Plan Year	App. 4D, Study 13-11	Electric/Gas	2013-11-1	There were no recommendations from this report as it was designed to explore awareness and associations between the three subject statewide brands, and assess effectiveness of branding efforts.		N/A							
238	MA RNC Program Incremental Cost Report	Residential	2012 Annual Report	App. C, Study 1	Electric/Gas	2012-1-1	No recommendations were offered. The report provides estimates of the incremental costs per square foot involved in building high efficiency homes that meet the criteria of the 2013 MA Residential New Construction (RNC) Program.		N/A							
239	2012 Residential Heating, Water Heating and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing	Residential	2012 Annual Report	App. C, Study 2	Electric/Gas	2012-2-1	The evaluators want to acknowledge the lack of consensus on NTG algorithms, and recommend that the PAs and EEAC develop clear protocols across all residential and non-residential program categories to look at NTG issues more holistically.	Statewide	No, however the PAs have improved methods in subsequent studies and are considering undergoing an initiative in the Cross Cutting Sector to encourage methodological consensus.							
240	HES Realization Rate Results Memo	Residential	2012 Annual Report	App. C, Study 3	Electric/Gas	2012-3-1	No recommendations were offered. The objective of the evaluation was to develop realization rates (the ratio of ex ante and ex post savings) that each Program Administrator (PA) could use to adjust insulation and air-sealing savings.		N/A							
241	Massachusetts Consumer Survey Results Winter-2007	Residential	2012 Annual Report	App. C, Study 4	Electric	2012-4-1	The evaluators suggest continued tracking of CFL satisfaction throughout future consumer surveys in order to see if satisfaction remains stable in the post-EISA period, when CFLs will face serious competition from less efficient screw-in halogen bulbs and very efficient and long-lasting screw-in LED bulbs.	Statewide	Yes							
242	Massachusetts Consumer Survey Results Winter-2007	Residential	2012 Annual Report	App. C, Study 4	Electric	2012-4-2	Despite evidence that some consumers are having difficulties finding 100-Watt incandescent bulbs on store shelves, one-half of shoppers for these bulbs were able to buy them. Therefore, if they are not already doing so, when developing energy and demand savings assumptions post-EISA, the PAs should consider assuming that the former "baseline" incandescent bulbs will remain available for at least one year and not adjust their delta Watts to account for lower energy use of halogens or other bulb types until after that year.	Statewide	Yes							
243	Residential Lighting Shelf Survey and Pricing Analysis	Residential	2012 Annual Report	App. C, Study 5	Electric	2012-5-1	This study did not offer any recommendations. The evaluation involved the performance of a light bulb shelf-stocking survey and a hedonic pricing regression analysis. The results of the shelf-stocking survey demonstrated that participating stores carry a greater proportion of energy-efficient CFLs and LEDs over incandescent or halogen bulbs.		N/A							

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244	Lighting Retailer, Supplier Perspectives on the Massachusetts ENERGY STAR Lighting Program	Residential	2012 Annual Report	App. C, Study 6	Electric	2012-6-1	The study did not offer any recommendations. There are no recommendation conclusions, the study relied on ten in-depth interviews with lighting manufacturers and high-level retail buyers as well as telephone surveys with 240 participating store managers. Interviewees and survey respondents were asked questions about the lighting market, their experience with the program, changing lighting technology, and their estimation of the impacts of EISA.		N/A							
245	Results of the Massachusetts Onsite Lighting Inventory	Residential	2012 Annual Report	App. C, Study 7	Electric/Gas	2012-7-1	Continue tracking the Massachusetts lighting market through regular consumer surveys, onsite saturation studies, shelf stocking surveys, and supplier interviews.	Statewide	Yes							
246	Results of the Massachusetts Onsite Lighting Inventory	Residential	2012 Annual Report	App. C, Study 7	Electric/Gas	2012-7-2	The PAs should perform a net-to-gross study as one has not been performed since 2010. This study will help to clarify whether current program-supported sales are helping to prevent backsliding to incandescents or incandescent halogen bulbs or whether they represent a high amount of free ridership.	Statewide	Yes							
247	Massachusetts ENERGY STAR® Lighting Program: Early Impacts of EISA	Residential	2012 Annual Report	App. C, Study 8	Electric	2012-8-1	The PAs should track the lighting markets in select comparison areas with varying levels and models of residential lighting programs.	Statewide	Yes							
248	Massachusetts ENERGY STAR® Lighting Program: Early Impacts of EISA	Residential	2012 Annual Report	App. C, Study 8	Electric	2012-8-2	The PAs should continue rebates for standard CFLs and LEDs at least through 2015 (one year after 40- and 60-Watt incandescent phase-out) in order to keep more energy-efficient bulbs on shelves and prevent backsliding of the market to halogen incandescents.	Statewide	Yes							
249	Massachusetts ENERGY STAR® Lighting Program: Early Impacts of EISA	Residential	2012 Annual Report	App. C, Study 8	Electric	2012-8-3	The PAs should continue efforts to educate consumers about new lighting terminology such as lumens and light temperature, how to select the best bulb, and the variety of highly energy-efficient light bulbs available to meet residential lighting needs.	Statewide	Yes							
250	2012 Home Energy Services Pre-Weatherization Initiative Evaluation	Residential	2012 Annual Report	App. C, Study 9	Electric/Gas	2012-9-1	The evaluators suggest that the PAs should work closely with their lead vendors to determine the long-term viability and effectiveness of the turnkey option.	Statewide	The PAs worked with their lead vendors to determine the long-term viability of a turnkey option. Due to a lack of interest in the contractor community, as noted in the evaluation, the PAs determined that a turnkey option was not the optimal long-term solution. The incentive is now customer driven.							
251	2012 Home Energy Services Pre-Weatherization Initiative Evaluation	Residential	2012 Annual Report	App. C, Study 9	Electric/Gas	2012-9-2	The evaluators suggest that the PAs identify ways to better communicate what the cost of checking knob and tube actually covers and how it differs from the cost to actually replace the knob and tube wiring.	Statewide	The PAs worked with their lead vendors to provide further training on these incentives for the energy specialists and electricians.							
252	2012 Home Energy Services Pre-Weatherization Initiative Evaluation	Residential	2012 Annual Report	App. C, Study 9	Electric/Gas	2012-9-3	The evaluators suggest that the PAs consider a compromise deadline of 45 or 60 days that keeps some of the benefits of the immediacy of the deadline, but makes it more realistic for customers to meet the deadline.	Statewide	In an effort to standardize design and delivery, the PAs have adopted a 60 day deadline for acceptance of the incentive.							
253	2012 Home Energy Services Pre-Weatherization Initiative Evaluation	Residential	2012 Annual Report	App. C, Study 9	Electric/Gas	2012-9-4	While some variation may be necessary, the evaluators suggest that the PAs should discuss these variations, determine best practices, and standardize design and delivery as much as possible across the state.	Statewide	The PAs have standardized both the levels and the timing of pre-weatherization barrier incentives across the state.							
254	Residential Lighting Controls Initiative Evaluation	Residential	2012 Annual Report	App. C, Study 10	Electric	2012-10-1	Due to the inconclusive findings, the evaluation did not include formal recommendations.		N/A							
255	Status of Ongoing Low Income Lighting and Heating Metering Study	Low-Income	2012 Annual Report	App. C, Study 11	Electric/Gas	2012-11-1	No recommendations were offered, but the status memo does state that future low income impact evaluations should include secondary heating fuels when estimating total program savings.		N/A							
256	Massachusetts Small Business Direct Install: 2010-2012 Impact Evaluations	Commercial & Industrial	2012 Annual Report	App. C, Study 12	Electric/Gas	2012-12-1	Based on the Pre- and Post-Installation Lighting Occupancy Sensor study: the wide-ranging patterns of pre-installation HOU, including some lighting systems that operated less frequently before the controls were installed, were a surprise to the PAs and the evaluators, and were only detected with pre-installation metering. For future evaluations of control-based efficiency measures, the PAs should continue to perform pre- and post-installation metering studies in order to capture the true impacts.	Statewide	The PAs will consider this recommendation for future studies.							
257	Massachusetts Small Business Direct Install: 2010-2012 Impact Evaluations	Commercial & Industrial	2012 Annual Report	App. C, Study 12	Electric/Gas	2012-12-2	Based on the Billing Analysis: If the PAs are to continue using billing analysis as a method for estimating savings achieved by the SBDI Program, we strongly recommend that more detailed information be collected from program participants, particularly building occupancy and vacancy. If obtaining such data is not feasible, the evaluators recommends that the PAs consider only using billing analyses in cases where it is highly unlikely that any exogenous factors correlate with the implementation of energy conservation measures. In practice, billing analyses would likely only be appropriate in cases where participants are highly homogenous and have consistent patterns of consumption (e.g., all participant buildings are government offices).	Statewide	The PAs will consider this recommendation for future studies.							

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258	Impact Evaluation of 2011-2012 Prescriptive VSDs	Commercial & Industrial	2012 Annual Report	App. C, Study 13	Electric	2012-13-1	Many VSDs are installed but never utilized. The motors were observed to operate at 60 Hz after the installation. Post-inspections should be performed to ensure that automatic controls are installed as required by the prescriptive applications.	Statewide	Yes. PAs have increased post-inspection efforts on drive installs in light of these recommendations.							
259	Impact Evaluation of 2011-2012 Prescriptive VSDs	Commercial & Industrial	2012 Annual Report	App. C, Study 13	Electric	2012-13-2	VSD installation dates were found to vary significantly from installation of control sequences. In the majority of installations, the VSD was installed several weeks or months before any type of control sequence was implemented. During this period VSDs would typically operate at 60 Hz. The standard protocol for this evaluation was to await confirmation of the controls installation rather than encourage the installation by calling for updates. In some cases DMI installed kW meters for the pre-retrofit condition, but VSDs were never installed. It is recommended that a six-month follow-up is performed before the full incentive is paid so that proper operation can be confirmed.	Statewide	No. PAs have increased post-inspection efforts in an effort to ensure proper drive installation and operation, however, PAs feel that this issue can be remedied without withholding incentive payments.							
260	Impact Evaluation of 2011-2012 Prescriptive VSDs	Commercial & Industrial	2012 Annual Report	App. C, Study 13	Electric	2012-13-3	Multiple instances were observed in which the VSD retrofit was replacing an existing drive. In all of these cases, the facility operator reported that the existing drives were failing and had operational issues. It appeared that these failing VSDs were approximately 15 years old or more. The prescriptive VSD application states that incentives are not available to VSDs replacing existing drives. Evaluated savings for two of these installations were found to be small or even zero based on metering data. It is recommended that a pre-inspection is done to identify whether or not an existing VSD is being replaced.	Statewide	Yes. Pre-inspections are frequently done as part of prescriptive drive project execution though inspecting all applications received for prescriptive drives is not currently done.							
261	Impact Evaluation of 2011-2012 Prescriptive VSDs	Commercial & Industrial	2012 Annual Report	App. C, Study 13	Electric	2012-13-4	In at least one case energy savings resulted primarily due to proper balancing rather than VSD control of the motor. Prior to the VSD retrofit, a chilled water pump was providing an excess of water to end users and the motor was observed to operate at over 100% load. The VSD installation was used to essentially balance the chilled water flow. This resulted in significant energy savings, the majority of which could have been achieved simply through balancing and without installation of a VSD. It is recommended that a pre-inspection be done to identify cases in which a VSD might not be the most economical solution.	Statewide	Yes. Pre-inspections are frequently done as part of prescriptive drive project execution though inspecting all applications received for prescriptive drives is not currently done.							
262	Impact Evaluation of 2011-2012 Prescriptive VSDs	Commercial & Industrial	2012 Annual Report	App. C, Study 13	Electric	2012-13-5	Even though the energy realization rate of 94% was good for a program like this, the individual metered VSD energy realization rates varied from -2% to 407%. The -2% case was the only one that was negative, but 15 drives had a realization rate less than 100%. The remaining 10 drives had a realization rate greater than 100%, and in most cases, they were significantly greater. It is recommended that this realization rate be applied to the TRM energy savings estimates as an immediate step.	Statewide	Yes.							
263	Impact Evaluation of 2011-2012 Prescriptive VSDs	Commercial & Industrial	2012 Annual Report	App. C, Study 13	Electric	2012-13-6	The MA PAs and EEAC should also look to improve upon the motor level savings assumptions following the completion of the current Load Shape study expected to be completed in late 2013. This study includes post-installation metering on hundreds of drives, which would help to refine the TRM savings assumptions for certain motor, and possibly building types.	Statewide	Yes. The results of the VSD loadshape study were incorporated into prescriptive VSD savings algorithms for purposes of determining coincident winter and summer kW savings.							
264	Impact Evaluation of 2011-2012 Prescriptive VSDs	Commercial & Industrial	2012 Annual Report	App. C, Study 13	Electric	2012-13-7	The TRM claims summer kW reductions for hot water pumps and winter kW reductions for chilled water pumps. In most cases, hot water pumps were observed to be shut down for the summer months and chilled water pumps shut down for winter months. It is not expected that this would apply to all of these motor types, but based on the sample observed in this evaluation, it appears that the TRM should be adjusted downwards. Currently, it appears that the TRM assumes 100% of these motors will operate during their off-seasons. It is recommended that the TRM be reviewed, and appropriate adjustments be made to ensure that demand savings are realistic for certain measure types. Consider near-zero summer kW reduction for hot water pumps and near-zero winter kW reduction for chilled water pumps.	Statewide	No. The results of the VSD loadshape study were leveraged for purposes of revising summer and winter kW reductions.							
265	Impact Evaluation of 2011-2012 Prescriptive VSDs	Commercial & Industrial	2012 Annual Report	App. C, Study 13	Electric	2012-13-8	Summer On-Peak kW reductions in the TRM are generally very close to zero for motor types not related to heating. This seems to be a reasonable assumption for motors with automatic controls as it would be expected that an appropriately-sized motor would operate near full load on a design day; however, the evaluation observed significantly more motors with manual controls than expected, with the motors operating below full-load input kW. Since the TRM predicts near-zero summer kW reductions, this results in very high realization ratios. . It is recommended the PA's examine the TRM summer On-Peak kW reduction values for accuracy.	Statewide	Yes. Summer kW values were examined and consequently updated. The VSD loadshape study was leveraged for this purpose.							

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266	Impact Evaluation of 2011-2012 Prescriptive VSDs	Commercial & Industrial	2012 Annual Report	App. C, Study 13	Electric	2012-13-9	It is not recommended that the realization rates for demand savings from this study are applied to the TRM due to the poor precisions. However, we think that the observations noted above can be used to improve upon the savings estimates in the TRM.	Statewide	Yes. The VSD loadshape study was leveraged for purposes of developing kW reduction values.							
267	Impact Evaluation of 2010 Prescriptive Lighting Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 14	Electric	2012-14-1	For future lighting impact evaluations, three month data collection should be sufficient to estimate annual energy savings. It is recommended that the PAs consider monitoring for a minimum of three months. Also consider including a winter or summer month in that period if possible.	Statewide	Yes							
268	Impact Evaluation of 2010 Prescriptive Lighting Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 14	Electric	2012-14-2	It is recommended that the lighting systems component of the TRM be updated to reflect these new results.	Statewide	Yes							
269	Impact Evaluation of 2010 Prescriptive Lighting Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 14	Electric	2012-14-3	It is recommended that the PAs continue to use site specific data when estimating lighting hours of use.	Statewide	Yes							
270	Impact Evaluation of 2010 Prescriptive Lighting Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 14	Electric	2012-14-4	Depending on the outcome of the current lighting controls market study, a pre/post metering lighting controls study may be needed in the future.	Statewide	The PAs will consider this recommendation for future studies.							
271	Impact Evaluation of 2010 Prescriptive Lighting Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 14	Electric	2012-14-5	To help implementation and TA vendors and produce more reliable estimates of hours reduced, it is recommended that the PAs consider requiring pre-installation metering to establish an estimate of baseline hours.	Statewide	No, The PAs do not agree with this recommendation. The additional cost and time of pre-metering prescriptive lighting projects would act a potential barrier for customer participation and add costs to both the Customer PAs.							
272	Impact Evaluation of 2010 Prescriptive Lighting Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 14	Electric	2012-14-6	Until a new pre/post lighting controls impact evaluation is done, it is recommended that the lighting controls component of the TRM be updated to reflect these new results.	Statewide	Yes							
273	Impact Evaluation of 2010 Prescriptive Lighting Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 14	Electric	2012-14-7	It is recommended that for all Advanced Lighting Design projects, the PAs try to collect the final lighting as-built, which would be used to adjust the proposed connected kW savings.	Statewide	Yes							
274	Impact Evaluation of 2010 Prescriptive Lighting Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 14	Electric	2012-14-8	It is recommended that the PAs and EEAC consider updating the TRM using these realization rates and savings factors.	Statewide	Yes							
275	Impact Evaluation of 2010 Prescriptive Lighting Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 14	Electric	2012-14-9	This report recommends that the TRM be updated to utilize a refrigeration system efficiency of 1.9 kW/Ton. This value is based on a larger proportion of lower temperature freezer cases than cooler cases found in these applications.	Statewide	Yes							
276	Impact Evaluation of 2010 Prescriptive Lighting Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 14	Electric	2012-14-10	It is recommended that in all future freezer/cooler case LED lighting applications, lighting controls be considered.	Statewide	Yes							
277	Impact Evaluation of 2011 Custom Refrigeration, Motor and Other Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 15	Electric	2012-15-1	Make sure customers and TA vendors understand they need to be prepared to provide assistance if their project is selected for evaluation.	Statewide	Yes							
278	Impact Evaluation of 2011 Custom Refrigeration, Motor and Other Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 15	Electric	2012-15-2	Ensure sufficient time is allowed for logging data for projects with seasonal variability.	Statewide	Yes							
279	Impact Evaluation of 2011 Custom Refrigeration, Motor and Other Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 15	Electric	2012-15-3	All PAs should require more complete pre-retrofit or baseline documentation.	Statewide	Yes							
280	Impact Evaluation of 2011 Custom Refrigeration, Motor and Other Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 15	Electric	2012-15-4	PAs should work together to require consistent methodologies and documentation for similar projects across different PAs.	Statewide	Yes							
281	Impact Evaluation of 2011 Custom Refrigeration, Motor and Other Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 15	Electric	2012-15-5	Consider specifying documentation requirements for compressed air leak repairs.	Statewide	Yes							
282	Impact Evaluation of 2011 Custom Refrigeration, Motor and Other Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 15	Electric	2012-15-6	Consider more of a whole system approach for grouping measures for evaluation.	Statewide	Yes							
283	Impact Evaluation of 2011 Custom Refrigeration, Motor and Other Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 15	Electric	2012-15-7	Require TA vendors to provide metering for retrofit projects.	Statewide	No, the PAs do not agree with this recommendation blanketed across all projects because it has the potential to drive additional cost without additional savings. The PAs do however agree that on a case by case basis metering is warranted.							
284	Impact Evaluation of 2011 Custom Refrigeration, Motor and Other Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 15	Electric	2012-15-8	Consider specifying TA verification of savings via commissioning, and in some cases, pre/post metering for specific measures.	Statewide	Yes							
285	Impact Evaluation of 2011 Custom Refrigeration, Motor and Other Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 15	Electric	2012-15-9	Perform closer review of large savings measures.	PA Specific			Yes.		Yes	Yes	Yes	Yes
286	Impact Evaluation of 2011 Custom Refrigeration, Motor and Other Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 15	Electric	2012-15-10	Include interactive refrigeration savings.	PA Specific			Yes.		Yes	Yes	Yes	Yes

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287	Impact Evaluation of 2011 Custom Refrigeration, Motor and Other Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 15	Electric	2012-15-11	Require adequate savings documentation.	PA Specific		National Grid continually gives feedback to our implementers on what appropriate documentation is for different types of projects.	Yes.		N/A	N/A	N/A	Yes
288	Impact Evaluation of 2011 Custom Refrigeration, Motor and Other Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 15	Electric	2012-15-12	Verify proposed load assumptions as part of the final inspection of new construction projects.	PA Specific		National Grid requires additional commissioning for very large projects. During the commissioning, initial assumptions are verified, and savings entered into our tracking system are updated. Other projects are subject to regular post inspections, where equipment installation and operation is verified.	Yes. Large, custom projects can and often do involve commissioning efforts where the factors detailed are verified upon project completion.		N/A	N/A	N/A	Yes. Large, custom projects can and often do involve commissioning efforts where the factors detailed are verified upon project completion.
289	Impact Evaluation of 2011 Custom Refrigeration, Motor and Other Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 15	Electric	2012-15-13	Verify proposed item count assumptions as part of the final inspection.	PA Specific		National Grid requires additional commissioning for very large projects. During the commissioning, initial assumptions are verified, and savings entered into our tracking system are updated. Other projects are subject to regular post inspections, where equipment installation and operation is verified.	Yes. Large, custom projects can and often do involve commissioning efforts where the factors detailed are verified upon project completion.		N/A	N/A	N/A	Yes. Large, custom projects can and often do involve commissioning efforts where the factors detailed are verified upon project completion.
290	Impact Evaluation of 2011 Custom Refrigeration, Motor and Other Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 15	Electric	2012-15-14	Verify plant operating hours using whole building interval data.	PA Specific		Interval data is not necessarily used to confirm operating hours, but may be used in some cases. National Grid requires additional commissioning for very large projects. During the commissioning, initial assumptions are verified, and savings entered into our tracking system are updated. Other projects are subject to regular post inspections, where	No. Interval data is not a requirement for confirming operating hours may be used in some instances. Large, custom projects can and often do involve commissioning efforts where the factors detailed are verified upon project completion.		N/A	N/A	N/A	No. Interval data is not a requirement for confirming operating hours. Large, custom projects can and often do involve commissioning efforts where the factors detailed are verified upon project completion.
291	Impact Evaluation of 2011 Custom Refrigeration, Motor and Other Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 15	Electric	2012-15-15	Ensure consistent use of data throughout the calculations.	PA Specific		National Grid has various mechanisms in place to ensure quality savings calculations, including technical reviews, peer reviews, and commissioning reports for various custom projects offered through our programs.	Yes. This has been communicated to implementation departments and improvements are anticipated.		N/A	N/A	N/A	Yes.
292	Impact Evaluation of 2011 Custom Refrigeration, Motor and Other Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 15	Electric	2012-15-16	Provide sufficient documentation for understanding the determination of measure savings.	Statewide	Yes. Evaluation departments have provided feedback to implementation departments that documentation is sometimes lacking. This issue is anticipated to improve in the future.							
293	Process Evaluation of the 2012 Bright Opportunities Program	Commercial & Industrial	2012 Annual Report	App. C, Study 16	Electric	2012-16-1	Do more marketing of the program, especially to end users.	Statewide	Yes							
294	Process Evaluation of the 2012 Bright Opportunities Program	Commercial & Industrial	2012 Annual Report	App. C, Study 16	Electric	2012-16-2	Encourage participating trade allies to do more to educate their customers about the source and size of the buydown discounts.	Statewide	Yes							
295	Process Evaluation of the 2012 Bright Opportunities Program	Commercial & Industrial	2012 Annual Report	App. C, Study 16	Electric	2012-16-3	Do more consumer education about the use of LED bulbs with dimmer switches.	Statewide	Yes							
296	Customer Profile Project	Commercial & Industrial	2012 Annual Report	App. C, Study 17	Electric/Gas	2012-17-1	Standardization of tracking database information about end uses and building types would increase the accuracy of any information derived from the records received.	Statewide	Currently Under Consideration							
297	Customer Profile Project	Commercial & Industrial	2012 Annual Report	App. C, Study 17	Electric/Gas	2012-17-2	In order to evaluate overall customer participation, it is necessary to build the capability to link accounts across fuels.	Statewide	Currently Under Consideration							

Rec #	Study Name	Sector	Filing/Docket	Study Location and Number	Fuel	Recommendation ID (Year - Study # - Rec #)	Recommendation	PA Specific / Statewide	Did the Program Administrator implement the recommendation (Yes, No & Explain Why not, Currently Under Consideration, Will Consider for Future Studies, N/A))	National Grid	Eversource	CMA	Liberty	Berkshire	CLC	Unitil
298	Customer Profile Project	Commercial & Industrial	2012 Annual Report	App. C, Study 17	Electric/Gas	2012-17-3	Leverage the baseline information collected here for other market characterization projects and efforts to estimate savings opportunities in each sector.	Statewide	Will Consider for Future Studies							
299	Customer Profile Project	Commercial & Industrial	2012 Annual Report	App. C, Study 17	Electric/Gas	2012-17-4	Incorporate checks to ensure that account numbers entered into tracking systems are accurate, and correspond to those in billing systems.	Statewide	Yes							
300	Customer Profile Project	Commercial & Industrial	2012 Annual Report	App. C, Study 17	Electric/Gas	2012-17-5	If there is a need for more reliable information by business type, explore services and software to use names and addresses to lookup business type rather than relying on PA designations.	Statewide	Currently Under Consideration							
301	Customer Profile Project	Commercial & Industrial	2012 Annual Report	App. C, Study 17	Electric/Gas	2012-17-6	Build on this one year snapshot with additional data going forward to accumulate program participation history.	Statewide	Yes							
302	Mid-Sized Customer Needs Assessment - Interim Results	Commercial & Industrial	2012 Annual Report	App. C, Study 18	Electric/Gas	2012-18-1	Improve processes for linking multiple accounts to customers – The PA's ability to accurately and consistently classify customers depends upon their ability to track multiple account customers within and across PAs. The PAs employ a range of tools to help them link customers; however, these tools did not provide sufficient support to enable the research team to link account representatives to the accounts they manage by account number. Moreover, we found large discrepancies between the segments that the PAs felt they were managing and those we were able to match with account representatives.	Statewide	No. These recommendations pertain to interim findings only. PAs feel it appropriate to await recommendations related to the final report.							
303	Mid-Sized Customer Needs Assessment - Interim Results	Commercial & Industrial	2012 Annual Report	App. C, Study 18	Electric/Gas	2012-18-2	Standardize classification and marketing approaches to multi-account customers – The research found that multiple account customers were treated differently across PAs, and also within a PA, across customers. The lack of standardized approaches for treating multiple account customers limits our ability to isolate segments of customers based on size and complicates the PA's ability to effectively market to those customers.	Statewide	No. These recommendations pertain to interim findings only. PAs feel it appropriate to await recommendations related to the final report.							
304	Mid-Sized Customer Needs Assessment - Interim Results	Commercial & Industrial	2012 Annual Report	App. C, Study 18	Electric/Gas	2012-18-3	Link electric and gas customers – Because much of the identification and marketing to Direct Install customers is handled through the electric PAs, the gas-only PAs lose some autonomy regarding how their customers are marketed. Consequently, some large gas customers are not identified until after they receive Direct Install prescriptive solutions from installation contractors. Improved coordination of tracking systems across PAs would reduce the risk of this occurring. DNV KEMA found that the PA's ability to link accounts across firms is constrained by legal privacy issues that must be addressed before this will be possible.	Statewide	No. These recommendations pertain to interim findings only. PAs feel it appropriate to await recommendations related to the final report.							
305	Impact Evaluation of 2011 Prescriptive Gas Measures	Commercial & Industrial	2012 Annual Report	App. C, Study 19	Gas	2012-19-1	Specific Condensing Boiler Savings (MMBtu) were calculated for different sized boilers from 2010-2012. See study for values.	Statewide	PAs plan to incorporate recommendations							
306	Impact Evaluation of 2011 Prescriptive Gas Measures	Commercial & Industrial	2012 Annual Report	App. C, Study 19	Gas	2012-19-2	Specific condensing furnace savings (MMBtu) were calculated for different furnace efficiencies form 201-2012. See study for values.	Statewide	PAs plan to incorporate recommendations							
307	Impact Evaluation of 2011 Prescriptive Gas Measures	Commercial & Industrial	2012 Annual Report	App. C, Study 19	Gas	2012-19-3	Recommended infrared heater savings (MMBtu) were calculated as 74.4 in 2010, 22.3 in 2011, and 12.0 in 2012.	Statewide	PAs plan to incorporate recommendations							
308	Impact Evaluation of 2011 Prescriptive Gas Measures	Commercial & Industrial	2012 Annual Report	App. C, Study 19	Gas	2012-19-4	Recommended indirect water heater savings (MMBtu) were calculated as 30.4 in 2010, 20.7 in 2011, and 19.0 in 2012.	Statewide	PAs plan to incorporate recommendations							
309	Standard Boiler Research Plan and Interview Results Memo	Commercial & Industrial	2012 Annual Report	App. C, Study 20	Gas	2012-20-1	It is important to note that the initial scoping does not provide conclusive evidence on the absence of standard efficiency boilers in the Massachusetts market, and further research on existing installed stock and recent sales data is warranted.	Statewide	Yes							
310	Impact Evaluation of 2011 Custom Gas Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 21	Gas	2012-21-1	Project documentation should include savings estimates in the native file form and support the claimed baseline.	Statewide	Yes							
311	Impact Evaluation of 2011 Custom Gas Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 21	Gas	2012-21-2	Controls measures, particularly EMS based strategies, must be verified for proper operation, setpoints, and applicability. Savings estimates for these types of measures should include all necessary assumptions and operating characteristics well outlined. Post verification metering should be considered where savings justify the added expense or be included as a requirement of the project.	Statewide	Currently Under Consideration							
312	Impact Evaluation of 2011 Custom Gas Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 21	Gas	2012-21-3	Estimated savings for measures such as combustion controls, which are based on a savings a fixed percentage of total gas used should include not only the percentage savings, but the baseline and projected as-built efficiencies and the billed gas usage. The baseline, if currently installed, should be demonstrated using combustion gas efficiency tests or other measure of the baseline. The resulting parameters can be easily checked against acceptable ranges to validate the measure.	Statewide	Yes							
313	Impact Evaluation of 2011 Custom Gas Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 21	Gas	2012-21-4	The evaluators recommend that PA implementers consider using the results of the savings fraction analysis performed as part of the desk review process as a sanity check of individual application savings estimates and as indicator where a deeper review of an application may be required.	Statewide	Yes. Program administrator implementation departments have considered using the savings fraction as an additional metric to determining estimated savings.							

Rec #	Study Name	Sector	Filing/Docket	Study Location and Number	Fuel	Recommendation ID (Year - Study # - Rec #)	Recommendation	PA Specific / Statewide	Did the Program Administrator implement the recommendation (Yes, No & Explain Why not, Currently Under Consideration, Will Consider for Future Studies, N/A))	National Grid	Eversource	CMA	Liberty	Berkshire	CLC	Unitil
314	Impact Evaluation of 2011 Custom Gas Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 21	Gas	2012-21-5	Consider some summer metering for measures which involve summer gas use such as industrial processes or re-heat operations.	Statewide	No - The PAs took this recommendation into consideration but have not implemented due to 2 factors; 1) small number of impacted projects in the most recent sample and 2) timing we wanted to make sure we could incorporate the most up-to date results in the 2016-2018 planning process.							
315	Impact Evaluation of 2011 Custom Gas Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 21	Gas	2012-21-6	In considering evaluation activities for the PY2012 program, the Evaluation Group may want to consider an additional round of on-site M&V impact evaluations for all the PAs except NSTAR. It is reasonable to conclude that the realization rates may not have stabilized statewide due to the rapid and continued expansion of the programs and the intent of the PAs to improve savings estimate processes.	Statewide	Yes, however the subsequent gas impact evaluation included all gas PAs, including NSTAR.							
316	Impact Evaluation of 2011 Custom Gas Installations	Commercial & Industrial	2012 Annual Report	App. C, Study 21	Gas	2012-21-7	However, before proceeding with the on-site M&Vs, the evaluators recommend repeating the desk-review task to further test the validity of the desk review method for triggering more expensive impact evaluations.	Statewide	Yes. This was completed as part of the subsequent gas impact evaluation.							
317	Massachusetts Cross-Cutting Behavioral Program Evaluation Integrated Report	Special & Cross Sector	2012 Annual Report	App. C, Study 22	Electric/Gas	2012-22-1	There were no recommendations as part of this report.		N/A							
318	2012 Massachusetts Statewide Marketing Campaign Evaluation Report	Special & Cross Sector	2012 Annual Report	App. C, Study 23	Electric/Gas	2012-23-1	There were no recommendations from this report as it was designed to track changes in awareness from the campaign and to measure the campaigns effectiveness.		N/A							
319	2013 Massachusetts Statewide Marketing Campaign: Pre-Campaign Snapshot	Special & Cross Sector	2012 Annual Report	App. C, Study 24	Electric/Gas	2012-24-1	There were no recommendations from this report as it was designed to establish baseline campaign awareness.		N/A							
320	Massachusetts Residential Non-Energy Impacts (NEIs): Deemed NEI Values Addressing Differences in NEIs for Heating and Cooling Equipment that is Early Replacement Compared to Replace on Failure	Special & Cross Sector	2012 Annual Report	App. C, Study 25	Electric/Gas	2012-25-1	The study did not offer any recommendations.		N/A							

8. Provide pre-filed testimony describing the process for identifying and studying new non-energy impacts.

Response:

Please see Pre-Filed Testimony of each Program Administrator (available at Exhibit 2 to each PA's Petition).

9. Provide pre-filed testimony describing all new non-energy impacts that the Program Administrators anticipate studying during the 2016-2018 term.

Response:

Please see Pre-Filed Testimony of each Program Administrator (available at Exhibit 2 to each PA's Petition).

10. Provide a table defining the following budget categories, including descriptions and examples of each component of the budget category (e.g., define market transformation plans and provide an example of costs associated with these plans):

a. program planning and administration ("PP&A");

b. marketing and advertising;

c. participant incentives;

d. sales, technical assistance, and training; and

e. evaluation and market research.

Response:

a. Program Planning and Administration

Program Planning and Administration ("PP&A") - includes costs associated with developing program plans, including market transformation plans, R&D (excluding R&D assigned to Evaluation and Market Research), day-to-day program administration, including labor, benefits, expenses, materials, supplies, overhead costs, any regulatory costs associated with energy efficiency activities, database/data repository development and maintenance, sponsorships and subscriptions, and energy efficiency services contracted to non-affiliated companies, e.g., outside consultants used to prepare plans, screen programs, improve databases and perform legal services. This category also includes internal salaries for administrative employees/ tasks, including program managers who do not have direct sales and technical assistance contact with customers.

Component	Description	Example of Associated Costs
Developing program plans	Administrative costs, including both internal costs, such as salaries, and costs for services contracted to non-affiliated companies for work on developing programs and drafting the three-year plans	Salaries, consultants with expertise in program design, legal counsel, consultants providing cost-effectiveness screening, vendors performing studies of technical potential
Market transformation plans	Market transformation plans are program designs, strategies, and tactics that are focused on efforts that will lead to long-term changes in the marketplace.	Salaries, consultants with expertise in program design and energy markets, vendors performing studies on market transformation
R&D	Research and Design ("R&D") are efforts to design and plan a specific R&D effort.	Salaries, consultants conducting R&D

Component	Description	Example of Associated Costs
Day-to-day program administration, including labor, benefits, expenses, materials, supplies, overhead costs	Administrative costs related to running energy efficiency programs and meeting regulatory requirements	Salaries, employee benefits, employee education, photocopying
Regulatory costs associated with energy efficiency activities	Costs including both internal costs, such as salaries, and costs for services contracted to non-affiliated companies for satisfying regulatory requirements, including Council meetings, workshops, and reporting, and Department filings and proceedings	GCA required payments to EEAC consultants, DOER assessment, costs to pay for AG expert as requested, hiring of expert consultants, legal fees, filing fees, photocopying, salaries
Database/data repository development and maintenance	Development and maintenance of MassSaveData.com and any additional future database reporting	Payment to third-party vendor
Sponsorships and subscriptions	Industry organizations that support energy efficiency, including information sharing, professional networking, new technologies and strategies, skills development, and best practices, all in furtherance of achieving energy savings.	Membership fees, conference sponsorships

b. Marketing and Advertising

Marketing and Advertising - includes costs for the development and implementation of marketing strategies and costs to advertise – through television, radio, billboards, brochures, telemarketing, web-sites and mailings – regarding the existence and availability of energy efficiency programs or technologies, and to induce customers or trade allies to participate in energy efficiency programs. These costs include internal salaries for employee functions related to marketing and advertising.

Component	Description	Example of Associated Costs
Development and implementation of marketing strategies	Costs, both internal and for agencies with expertise in marketing, advertising, and website development	Salaries and payment to third-party vendors
Costs to advertise	Payments for advertising on television, radio, billboards, brochures, telemarketing, websites, and mailings	Radio ads, MBTA billboards, brochures for conferences, www.masssave.com

c. Participant Incentives

Participant Incentives - includes funds paid by the reporting Program Administrator to or on behalf of customers or trade allies as rebates or in other forms. Participant incentives includes costs that directly benefit customers, including permit fees, pre-weatherization expenses, repairs, and interest buy-down.

Component	Description	Example of Associated Costs
Funds paid by the reporting Program Administrator to or on behalf of customers or trade allies as rebates or in other forms	Funds paid to customers or paid to contractors that reduce costs payable by customers	Rebates and incentives, including upstream incentive programs
Costs that directly benefit customers, including permit fees, pre-weatherization expenses, repairs, and interest buy-down	Funds paid to assist customer with installing energy efficiency measures, including financing and costs associated with fees and services that must be done in order to commence or complete energy efficiency installation	Permit fees, pre-weatherization expenses, repairs, interest buy-down

d. Sales, Technical Assistance, and Training

Sales, Technical Assistance & Training ("STAT") **-** includes administration, sales technical assistance and training costs to motivate: (1) customers to install energy efficiency products and services; (2) retailers to stock energy efficiency products; (3) trade professionals to offer energy efficiency services; (4) manufactures to make energy efficiency products; and (5) use of vendor services and suppliers that demonstrate benefits of energy efficiency. This category also includes costs not directly tied to savings, including residential assessments, technical assistance studies, contractor fees and performance bonuses, vendor cost of money; lead vendor fees and internal salaries for employees with direct customer sales and technical assistance contact.

Component	Description	Example of Associated Costs
Sales	Costs to motivate customers to install energy efficiency products and services; motivate retailers to stock energy efficiency products; trade professionals to offer energy efficiency services; manufactures to make energy efficiency products; vendor services and suppliers that demonstrate benefits of energy efficiency	Salaries, vendor costs, performance bonuses
Technical Assistance	Engineering studies, assessments, measure installation, customer support	Salaries, vendor fees, costs of equipment and assessment, contractor fees

Component	Description	Example of Associated Costs
Training	Costs associated with training sales team to encourage installation of energy efficient measures and/or use of services. Costs associated with training contractors to install appropriate measures properly and perform assessments.	Salaries, vendors that perform trainings

e. <u>Evaluation and Market Research</u>

Evaluation and Market Research - includes costs associated with evaluation activities: costs related to cost-effectiveness evaluation, market research (*e.g.*, baseline studies, market assessments and surveys), impact and process evaluation reports, tracking and reporting program inputs and outputs, funding studies, and other costs clearly associated with evaluating the program. This category also includes internal salaries for employee functions related to evaluating the programs.

Component	Description	Example of Associated Costs
Cost-effectiveness evaluation	Costs associated with evaluating the cost-effectiveness of measures	Internal and third-party vendor costs for study implementation and analysis
Market research	Costs associated with baseline studies, market assessments, and surveys	Internal and third-party vendor costs for study implementation and analysis
Impact and process evaluations	Costs associated with determining best practices and attributable or gross energy savings and benefits of measures	Internal and third-party vendor costs for study implementation and analysis
Tracking and reporting program inputs and outputs	Costs associated with accounting for measures, costs, and attributable and gross savings and the monetized value of those savings	Internal and third-party vendor costs for study implementation and analysis

11. Provide an update to the Consistent Cost Categories Report filed on July 31, 2014. Identify whether: (1) the common definitions of the costs assigned to each of the five categories have been finalized; and (2) all Program Administrators categorize costs in the same way. If costs are not categorized in the same way, explain any remaining discrepancies in the definitions and the reasons for the discrepancies.

Response:

The PAs put significant effort into the Consistent Cost Categories Report filed on July 31, 2014, and have finalized the costs assigned to each of the five categories. The only differences in the cost categories in this Plan as compared to July 31, 2014 are the following:

- Costs related to database/data repository development and maintenance, and associated labor have been moved from Evaluation & Marketing to PP&A. This change was made because the PAs determined that the costs associated with the development of the statewide database/data repository administrative costs related to meeting reporting requirements of stakeholders as opposed to costs associated with verifying measure savings and costs.
- Sponsorships & Subscriptions has been added to the definition of PP&A. This is not a change in categorization, just a clarification to make the definition more complete.
- Development and implementation of marketing strategies has been added to the definition of Marketing and Advertising. This is not a change in categorization, just a clarification to make the definition more complete.

In 2016-2018, the PAs will all categorize costs in the same way, including labor costs. Additionally, PAs have worked to harmonize allocations of costs across hard-to-measure categories for this Plan. The PAs recognize that there may be instances in which differences in cost categorization are discovered in the future, but are committed to consistency and continued improvement. The PAs have established consistent budget cost category definitions, determined methods for allocating salaries across cost categories, and harmonized vendor cost categorization, and are committed to continuing to review new costs and to seek and maintain consistency across PAs throughout the Plan term.

12. Refer to the Consistent Cost Categories Report. For program years 2013 through 2018,[4] provide a breakdown (in dollars) of planned and actual PP&A costs using the following administrative cost sub-categories:

a. development of program plans, including market transformation plans and research and development ("R&D") plans (excluding R&D assigned to evaluation and market research);

b. day-to-day program administration, including labor, benefits, expenses, materials, supplies, and overhead costs;

c. regulatory costs associated with energy efficiency;

d. costs for energy efficiency services contracted to non-affiliated companies such as outside consultants used to prepare plans, screen programs, improve databases, and perform legal services; and

e. internal salaries for administrative employees/tasks, including program managers that do not have direct sales and technical assistance contact with customers.

Response:

Parts (a) through (e) above together represent the definition of the PP&A budget category set forth in the PAs' Cost Categories Report. The PAs include significant detail in their definition in order to set forth specific costs and functions that allow PAs capture the possible costs that are and may in the future belong in this category. Providing a breakdown of costs in this manner, however, would not provide meaningful data, and would not add up to a total PP&A budget because the categories above have significant overlap. For example, costs associated with developing program plans include internal labor costs for full-time employees ("FTE"). An FTE may also work on day-to-day program administration or program management. In addition, some costs associated with PP&A would be excluded using the above definitions, for example, sponsorships & subscriptions, which the PAs have now added in this Plan to the PP&A definition to make the definition more complete. In order to provide useful information to the Department that sums to the total PP&A budget, the PAs are submitting PP&A costs in the following three categories:

- Internal Labor Costs (includes labor, benefits, employee expenses, materials, and overhead) – this subcategory encompasses the Department's request in parts a, b, and e.
- External Costs (includes legal fees, external consultants, and contractors) – this subcategory encompasses the Department's request in parts c and d.
- Administrative Costs Associated with Sponsorships & Subscriptions – this subcategory was not included in the Department's original request, and it was not specified in the PAs' definition for PP&A in the Cost Categories Report submitted on July 31, 2014. The definition of PP&A in this Plan now includes this cost. This category encompasses

[4] Provide planned and actual values for plan years 2013-2015, and planned values for plan years 2016-2018.

administrative costs related to conferences and sponsorships of industry organizations that support energy efficiency, including information sharing, professional networking, new technologies and strategies, skills development, and best practices, all in furtherance of achieving energy savings.

These sub-categories are unique and distinct, such that the sum of the three sub-categories will be equal to the total PP&A cost category.

Please note that due to the PAs efforts to have consistent cost category definitions for the 2016-2018 Plan, it may be difficult to compare historical costs with planned budgets across a single cost category.

Please see Table 12-1 on the following pages for each PA.

Table 12-1: CLC

Year	Reporting Period	Internal Labor Costs (Includes labor, benefits, employee expenses, materials & overhead)	External Costs (Includes legal fees, external consultants and contractors)	Administrative Costs Associated with Sponsorships & Subscriptions	Total PP&A
2013	Planned	$ 501,552	$ 778,717	$ 15,000	$ 1,295,269
2013	Evaluated	$ 284,894	$ 842,908	$ 44,094	$ 1,171,896
2014	Planned	$ 526,630	$ 808,417	$ 15,750	$ 1,350,797
2014	Evaluated	$ 714,040	$ 859,324	$ 8,121	$ 1,581,486
2015	Planned	$ 552,962	$ 849,241	$ 16,538	$ 1,418,740
2015	YTD (August)	$ 778,527	$ 708,187	$ 20,595	$ 1,507,309
2016	Planned	$ 1,091,551	$ 1,212,499	$ 63,349	$ 2,367,399
2017	Planned	$ 996,491	$ 1,211,357	$ 68,184	$ 2,276,033
2018	Planned	$ 1,011,945	$ 1,316,074	$ 73,202	$ 2,401,222

Table 12-1: Eversource Electric

Year	Reporting Period	Internal Labor Costs (Includes labor, benefits, employee expenses, materials & overhead)	External Costs (Includes legal fees, external consultants and contractors)	Administrative Costs Associated with Sponsorships & Subscriptions	Total PP&A
2013	Planned	$ 15,514,374	$ 5,459,104	$ 778,981	$ 21,752,459
2013	Evaluated	$ 8,880,507	$ 3,406,947	$ 724,178	$ 13,011,632
2014	Planned	$ 16,239,238	$ 4,733,354	$ 778,981	$ 21,751,573
2014	Evaluated	$ 9,439,868	$ 5,958,292	$ 769,541	$ 16,167,702
2015	Planned	$ 16,964,911	$ 3,536,890	$ 778,981	$ 21,280,782
2015	YTD (August)	$ 6,650,993	$ 2,964,972	$ 707,478	$ 10,323,442
2016	Planned	$ 12,381,923	$ 8,351,144	$ 796,493	$ 21,529,560
2017	Planned	$ 12,713,710	$ 9,108,788	$ 818,392	$ 22,640,890
2018	Planned	$ 13,050,479	$ 8,069,617	$ 826,780	$ 21,946,876

Table 12-1: National Grid Electric

Year	Reporting Period	Internal Labor Costs (Includes labor, benefits, employee expenses, materials & overhead)	External Costs (Includes legal fees, external consultants and contractors)	Administrative Costs Associated with Sponsorships & Subscriptions	Total PP&A
2013	Planned	$ 846,093	$ 3,094,512	$ 638,223	$ 4,578,828
2013	Evaluated	$ 1,481,522	$ 3,308,358	$ 377,281	$ 5,167,161
2014	Planned	$ 870,561	$ 3,120,177	$ 657,369	$ 4,648,108
2014	Evaluated	$ 2,045,910	$ 3,163,146	$ 773,833	$ 5,982,889
2015	Planned	$ 912,410	$ 3,135,797	$ 677,090	$ 4,725,297
2015	YTD (August)	$ 1,879,063	$ 2,490,429	$ 459,304	$ 4,828,795
2016	Planned	$ 3,422,362	$ 5,436,667	$ 789,661	$ 9,648,690
2017	Planned	$ 3,793,983	$ 5,046,446	$ 797,500	$ 9,637,929
2018	Planned	$ 4,176,754	$ 4,775,500	$ 826,875	$ 9,779,129

Notes:
The budgets associated with proposed demand respose efforts are not included Planned Budget amounts in the table above.

Table 12-1: Unitil - Electric

Year	Reporting Period	Internal Labor Costs (Includes labor, benefits, employee expenses, materials & overhead)	External Costs (Includes legal fees, external consultants and contractors)	Administrative Costs Associated with Sponsorships & Subscriptions	Total PP&A
2013	Planned	$ 265,172	$ 77,444	*(Note 1)*	$ 342,617
2013	Evaluated	$ 286,101	$ 29,790	$ 13,966	$ 329,857
2014	Planned	$ 271,207	$ 78,399	*(Note 1)*	$ 349,606
2014	Evaluated	$ 237,721	$ 55,344	$ 7,123	$ 300,188
2015	Planned	$ 275,983	$ 79,475	*(Note 1)*	$ 355,458
2015	YTD (August)	$ 187,938	$ 48,890	$ 8,374	$ 245,201
2016	Planned	$ 610,981	$ 85,501	$ 10,000	$ 706,481
2017	Planned	$ 615,983	$ 94,001	$ 10,000	$ 719,983
2018	Planned	$ 615,532	$ 102,501	$ 10,000	$ 728,033

1) Unitil did not provide separate budgets for Sponsorships & Subscriptions in its 2013-2015 3 Year Energy Efficiency Plan.

Table 12-1: Berkshire

Year	Reporting Period	Internal Labor Costs (Includes labor, benefits, employee expenses, materials & overhead)	External Costs (Includes legal fees, external consultants and contractors)	Administrative Costs Associated with Sponsorships & Subscriptions	Total PP&A
2013	Planned	$ 379,676	$ 119,838	$ 5,000	$ 504,514
2013	Evaluated	$ 339,301	$ 109,455	$ 3,850	$ 452,606
2014	Planned	$ 374,148	$ 138,400	$ 5,000	$ 517,548
2014	Evaluated	$ 231,604	$ 107,325	$ 5,774	$ 344,703
2015	Planned	$ 386,538	$ 143,712	$ 5,000	$ 535,250
2015	YTD (August)	$ 251,576	$ 74,218	$ 5,190	$ 330,984
2016	Planned	$ 382,799	$ 146,200	$ 11,000	$ 539,999
2017	Planned	$ 393,950	$ 148,200	$ 11,000	$ 553,150
2018	Planned	$ 405,436	$ 150,300	$ 11,000	$ 566,736

Table 12-1: CMA

Year	Reporting Period	Internal Labor Costs (Includes labor, benefits, employee expenses, materials & overhead)	External Costs (Includes legal fees, external consultants and contractors)	Administrative Costs Associated with Sponsorships & Subscriptions	Total PP&A
2013	Planned	$ 1,410,625	$ 699,130	$ 7,828	$ 2,117,583
2013	Evaluated	$ 1,153,440	$ 517,573	$ 7,825	$ 1,678,839
2014	Planned	$ 1,476,237	$ 694,264	$ 8,063	$ 2,178,564
2014	Evaluated	$ 1,092,033	$ 1,286,716	$ 8,918	$ 2,387,667
2015	Planned	$ 1,544,981	$ 701,413	$ 8,305	$ 2,254,699
2015	YTD (August)	$ 724,851	$ 438,092	$ 8,915	$ 1,171,858
2016	Planned	$ 731,158	$ 670,881	$ 19,823	$ 1,421,862
2017	Planned	$ 765,953	$ 678,069	$ 21,805	$ 1,465,828
2018	Planned	$ 804,251	$ 702,395	$ 23,986	$ 1,530,632

Table 12-1: Eversource G

Year	Reporting Period	Internal Labor Costs (Includes labor, benefits, employee expenses, materials &	External Costs (Includes legal fees, external consultants and contractors)	Administrative Costs Associated with Sponsorships & Subscriptions	Total PP&A
2013	Planned	$ 1,789,281	$ 981,988	$ -	$ 2,771,269
2013	Evaluated	$ 1,142,838	$ 557,162	$ -	$ 1,700,000
2014	Planned	$ 1,879,088	$ 995,417	$ -	$ 2,874,505
2014	Evaluated	$ 1,226,198	$ 512,705	$ -	$ 1,738,903
2015	Planned	$ 1,973,310	$ 1,017,332	$ -	$ 2,990,642
2015	YTD (August)	$ 899,045	$ 327,597	$ -	$ 1,226,642
2016	Planned	$ 1,553,671	$ 1,431,948	$ 37,000	$ 3,022,619
2017	Planned	$ 1,591,681	$ 1,567,013	$ 37,000	$ 3,195,694
2018	Planned	$ 1,811,075	$ 1,397,498	$ 37,000	$ 3,245,573

Table 12-1: Liberty

Year	Reporting Period	Internal Labor Costs (Includes labor, benefits, employee expenses, materials & overhead)	External Costs (Includes legal fees, external consultants and contractors)	Administrative Costs Associated with Sponsorships & Subscriptions	Total PP&A
2013	Planned	$ 426,822	$ 143,483	$ -	$ 570,305
2013	Evaluated	$ 408,740	$ 226,558	$ 442	$ 635,740
2014	Planned	$ 439,104	$ 128,483	$ -	$ 567,587
2014	Evaluated	$ 433,555	$ 99,905	$ 5,026	$ 538,486
2015	Planned	$ 451,742	$ 141,483	$ -	$ 593,225
2015	YTD (August)	$ 299,641	$ 90,495	$ 5,094	$ 395,230
2016	Planned	$ 241,829	$ 249,981	$ 1,000	$ 492,810
2017	Planned	$ 248,630	$ 167,180	$ 1,000	$ 416,810
2018	Planned	$ 260,938	$ 166,980	$ 1,000	$ 428,918

Table 12-1: National Grid Gas

Year	Reporting Period	Internal Labor Costs (Includes labor, benefits, employee expenses, materials & overhead)	External Costs (Includes legal fees, external consultants and contractors)	Administrative Costs Associated with Sponsorships & Subscriptions	Total PP&A
2013	Planned	$ 752,677	$ 778,115	$ 180,545	$ 1,711,338
2013	Evaluated	$ 1,023,938	$ 1,737,523	$ 116,176	$ 2,877,637
2014	Planned	$ 774,689	$ 792,458	$ 185,961	$ 1,753,109
2014	Evaluated	$ 1,407,426	$ 1,601,757	$ 260,181	$ 3,269,364
2015	Planned	$ 970,364	$ 693,258	$ 132,511	$ 1,796,133
2015	YTD (August)	$ 1,178,151	$ 1,320,295	$ 98,971	$ 2,597,418
2016	Planned	$ 2,066,055	$ 2,742,347	$ 181,830	$ 4,990,232
2017	Planned	$ 2,127,470	$ 2,545,474	$ 190,922	$ 4,863,866
2018	Planned	$ 2,190,727	$ 2,586,489	$ 200,468	$ 4,977,683

Table 12-1: Unitil - Gas

Year	Reporting Period	Internal Labor Costs (Includes labor, benefits, employee expenses, materials & overhead)	External Costs (Includes legal fees, external consultants and contractors)	Administrative Costs Associated with Sponsorships & Subscriptions	Total PP&A
2013	Planned	$ 105,628	$ 25,114	*(Note 1)*	$ 130,742
2013	Evaluated	$ 106,129	$ 15,712	$ 703	$ 122,544
2014	Planned	$ 116,355	$ 25,947	*(Note 1)*	$ 142,302
2014	Evaluated	$ 319,633	$ 13,185	$ 2,092	$ 334,910
2015	Planned	$ 127,041	$ 26,644	*(Note 1)*	$ 153,684
2015	YTD (August)	$ 77,074	$ 15,047	$ 550	$ 92,671
2016	Planned	$ 313,784	$ 31,599	$ 7,160	$ 352,543
2017	Planned	$ 320,119	$ 32,578	$ 7,160	$ 359,858
2018	Planned	$ 327,029	$ 33,128	$ 7,000	$ 367,157

1) Unitil did not provide separate budgets for Sponsorships & Subscriptions in its 2013-2015 3 Year Energy Efficiency Plan.

13. Identify all competitively procured contracts that the Program Administrators have already executed for services to be provided during the 2016-2018 term. For each ontract, state the contract term, whether there is an option to extend, and the conditions for renewal. For each Program Administrator, provide the percentage and total dollar amount of competitively procured services that have already been procured for the 2016-2018 term.

Response:

Please see Table 13-1 on the following pages listing statewide and PA-specific contracts that have already been competitively procured for 2016-2018. In addition to this list, several other contracts are out for bid, or in other intermediate stages of competitive procurement.

Additionally, Table 13-2 below shows the percentage and total dollar amount of competitively procured services that have already been procured for the 2016-2018 term for each PA. For contracts that include customer rebate/incentive dollars (which typically account for a significant portion of contracts), PAs have only included the non-incentive portion of the contract, based on historical spending or other planning values. PAs note that these values are planned estimates of a planned budget; actual expenditures will be available at the time of the Term Report.

Table 13-2

Program Administrator	Dollar Amount Already Competitively Procured	% of Planned Competitive Procurement Already Procured
National Grid Electric	$44,266,606.59	34%
Eversource Electric	$67,670,601.46	42%
Cape Light Compact	$2,752,222.49	10%
Unitil Electric	$425,703.85	20%
National Grid Gas	$31,468,133.67	43%
Eversource Gas	$11,332,271.54	48%
Columbia Gas	$6,041,966.15	27%
Berkshire Gas	$997,587.00	25%
Liberty	$166,140.00	11%
Unitil Gas	$151,297.28	23%

Table 13-1

Vendor Name	Initiative/Topic	Statewide or PA-specific	Term	Option to Extend	Conditions for Renewal
"e" Inc	Residential Education	Eversource - Electric	12/31/2017	Y	Option to extend at same pricing
Advanced Energy Group	Small Business Progam	Eversource - Electric & Gas	1/7/2019	N	
AECOM	Small Business Progam	Eversource - Electric & Gas	1/2/2019	N	
AEG	Work Process Management system, license, support, hosting	CMA	8/30/2018	N	
Andelman & Lelak Engineering	Engineering Services	National Grid - Electric & Gas	12/9/2017	Y	Mutual agreement
Andelman and Lelek Engineering	Engineering Services	Eversource - Electric & Gas	5/31/2018	N	
Antares Group	Engineering Services	National Grid - Electric & Gas	11/12/2017	Y	Mutual agreement
Applied Energy Engineering & Commissioning	Engineering Services	National Grid - Electric & Gas	12/9/2017	Y	Mutual agreement
B2Q Associates, Inc.	Engineering Services	National Grid - Electric & Gas	12/18/2017	Y	Mutual agreement
B2Q Associates, Inc.	Engineering Services	Eversource - Electric & Gas	6/1/2018	N	
BGM Experiential	Residential Education	Eversource - Electric	7/31/2017	Y	Option to extend at the same price for one more year
Boyko Engineering	Engineering Services	National Grid - Electric & Gas	12/9/2017	Y	Mutual agreement
C3	CEP	Eversource - Electric & Gas	2/2/2018	Y	Satisfactory Performance
The Cadmus Group	Residential Evaluation	Statewide - All	6/30/2016	N	
The Cadmus Group	Residential Lighting and Residential Products - Marketing	Statewide - Electric	12/31/2017	Y	Currently in Statewide RFP - scores and pricing will determine renewal status
The Cadmus Group	Engineering Services	Eversource - Electric & Gas	6/2/2018	N	
Center for EcoTechnology	HES- Piggyback program with Berkshire	Eversource - Electric	12/31/2016	Y	Piggyback contract for Berkshire Gas territory. We will extend if Berkshire Gas extends for their Lead Vendor services.
Center for EcoTechnology	Residential Multi-Family	Eversource - Electric	6/30/2016	Y	Option to extend at same pricing
CLEAResult	Codes and Standards	Statewide - All	12/31/2016	N	
CLEAResult	Residential Heating and Cooling	Statewide - Electric	12/31/2016	Y	Mutual agreement
CLEAResult	Marketing	CMA	12/31/2016	Y	Mutual agreement
CLEAResult	HES	Eversource - Electric & Gas	12/31/2016	Y	two year renewal option in one year increments

CLEAResult	Residential Multi-Family	Eversource - Electric & Gas	6/30/2016	Y	Option to extend at same pricing
CLEAResult	HES Lead Vendor	National Grid - Electric & Gas	6/30/2016	N	Program will be bid in Q1 - potential redesign around new SW platform
Competitive Resources, Inc. (CRI)	Residential QA/QC Services	Statewide - All	12/31/2016	N	Re-evaluation
Competitive Resources, Inc. (CRI)	Engineering Services	Eversource - Electric & Gas	6/3/2018	N	
CRI (CMC)	Commercial and Industrial Upstream Lighting and HVAC QA/QC	Statewide - Electric	12/31/2016	N	
DMI Inc	Engineering Services	National Grid - Electric & Gas	11/20/2017	Y	Mutual agreement
DNV-GL	C&I Evaluation	Statewide - All	12/31/2018	Y	Mutual agreement
Ecova	Commercial and Industrial Upstream Lighting	Statewide - Electric	12/31/2017	Y	Mutual agreement
EFI	Home Energy Services - Rebate Processing	Statewide - All	12/31/2018	Y	Mutual agreement
EFI	Upstream HVAC	Statewide - Electric	12/31/2016	N	
EFI	Residential Heating and Cooling - Rebate Processing	Statewide - Electric	12/31/2018	Y	Mutual agreement
EFI	Residential Lighting and Residential Products - Rebate Processing	Statewide - Electric	12/31/2017	Y	Mutual agreement
EFI	Residential Lighting Catalog	Statewide - Electric	12/31/2017	Y	Mutual agreement
EFI	Residential Heating and Hot Water and C&I New Construction - New Equipment/EOUL- Rebate Processing	Statewide - Gas	12/31/2018	Y	Mutual agreement
EFI	HEAT Loan	Statewide	12/31/2016	Y	Contract extension in process
Energy Management Associates, Inc.	Engineering Services	Eversource - Electric & Gas	6/4/2018	N	
Energy Resource Solutions, Inc	Engineering Services	National Grid - Electric & Gas	12/9/2017	Y	Mutual agreement
Energy Solutions	C&I Upstream Water Heaters	Statewide - Gas	12/31/2018	Y	Mutual agreement
Energy Source	Small Business Progam	Eversource - Electric & Gas	1/4/2019	N	
Engineered Solutions, Inc.	Engineering Services	National Grid - Electric & Gas	12/9/2017	Y	Mutual agreement
Engineered Solutions, Inc.	Engineering Services	Eversource - Electric & Gas	6/5/2018	N	
Fuss & O'Neill, Inc.	Engineering Services	Eversource - Electric & Gas	6/6/2018	N	
GDS Associates	Engineering Services	Eversource - Electric & Gas	6/7/2018	N	
The Green Engineer	Engineering Services	Eversource - Electric & Gas	6/8/2018	N	

Horizon	Small Business Progam	Eversource - Electric & Gas	1/6/2019	N	
ICF International	Residential New Construction	Statewide - All	12/31/2016	Y	Mutual agreement
ICF International	Residential Heating and Cooling - Gas	Statewide - Gas	12/31/2018	Y	Mutual agreement
JACO	Residential Products - Recycling	Statewide - Electric	12/31/2016	Y	Mutual agreement
JK Energy	Small Business Progam	Eversource - Electric & Gas	1/8/2019	N	
Kelliher, Samets, and Volk	Statewide Marketing	Statewide - All	12/31/2016	Y	Mutual agreement
Kelliher, Samets, and Volk	National Grid Specific Marketing	National Grid - Electric & Gas	12/31/2016	Y	MSA and strategic partnership with marketing vendor; needs to meet performance targets
L&S Energy Services, Inc	Engineering Services	National Grid - Electric & Gas	11/12/2017	Y	Mutual agreement
Lime Energy	Small Business Progam	Eversource - Electric & Gas	1/1/2019	N	
Lockheed Martin	Residential Lighting and Residential Products - Field Services	Statewide - Electric	12/31/2016	Y	Mutual agreement
Lockheed Martin	Residential Heating and Cooling - Gas	Statewide - Gas	12/31/2017	Y	Mutual agreement
National Theater for Children	Residential Education	Eversource - Electric	12/31/2017	Y	one year renewal option
Navigant	Special/Cross Cutting	Statewide - All	5/31/2017	Y	Mutual agreement
Nexant	Engineering Services	National Grid - Electric & Gas	1/20/2018	Y	Mutual agreement
Northern Energy	Small Business	National Grid - Electric & Gas	12/31/2016	N	
NRM	Small Business - Refrigeration Vendor	National Grid - Electric	12/31/2016	N	
ODC	Special/Cross Cutting	Statewide - All	5/31/2017	Y	Mutual agreement
Opower	Residential Behavior Feedback	Berkshire	12/31/2018	Y	Agreement may be extended by mutual written agreement of the Parties
People Power	Residential Behavior Feedback	CLC	12/31/2016	N	
Peterson Engineering Group, LLC	Engineering Services	Eversource - Electric & Gas	6/9/2018	N	
RISE Engineering	Multi-Family Market Integrator	Statewide - All	12/31/2016	N	
RISE Engineering	Home Energy Services - RCS and Measures	Unitil-gas and electric	8/1/2016	Y	satisfactory performance
RISE Engineering	Small Busines	Unitil-gas and electric	12/31/2016	Y	satisfactory performance
RISE Engineering	Home Energy Services - RCS and Measures	CMA	6/30/2016	Y	Mutual agreement

RISE Engineering	Small Medium Business Retrofit	CMA	12/31/2016	Y	Mutual agreement
RISE Engineering	Resi Multi-family retrofit	CMA	12/31/2016	Y	Mutual agreement
RISE Engineering	Small Business Progam	Eversource - Electric & Gas	12/31/2018	N	
Rise Engineering	Engineering Services	Eversource - Electric & Gas	6/10/2018	N	
RISE Engineering	Small Business CDO	National Grid - Electric & Gas	12/31/2016	N	
RISE Engineering	HES- Piggyback program with gas utilities	Eversource - Electric	12/31/2016	Y	Piggyback contract for Columbia Gas territory. We will extend if Columbia Gas extends for their Lead Vendor services.
Rise Engineering	Home Energy Services - RCS and Measures	Liberty Utilities	11/12/2017	Y	Mutual agreement
River Energy	HES	Statewide	12/31/2016	Y	contract extension in process
River Energy	Heating/Water Heating/Tstats-Admin	Eversource - Electric	12/31/2016	Y	contract extension in process
Second Law Engineers, Inc. dba DMI	Engineering Services	Eversource - Electric & Gas	6/11/2018	N	
Symmes Maini & McKee Associates	Engineering Services	Eversource - Electric & Gas	6/12/2018	N	
Symmes Maini & McKee Associates	Engineering Services	National Grid - Electric & Gas	1/20/2018	Y	Mutual agreement
TetraTech	Special/Cross Cutting	Statewide - All	6/30/2017	Y	Mutual agreement
TNT	Small Busines	Unitil-gas and electric	12/31/2016	Y	satisfactory performance
TNT	Small Business Progam	Eversource - Electric & Gas	1/5/2019	N	
TNT	Small Business	National Grid - Electric & Gas	12/31/2016	N	
TNZ Energy Consulting	Engineering Services	National Grid - Electric & Gas	11/3/2017	Y	Mutual agreement
Weidt Group, The	Engineering Services	Eversource - Electric & Gas	6/13/2018	N	
Work Opportunity Center	Low Income Single & Multi-Family	Eversource - Electric	Open PO	Y	Open purchase order. PO will renew when spending limit is met.
World Energy Solutions	Small Business Progam	Eversource - Electric & Gas	1/3/2019	N	
WSP	Engineering Services	Eversource - Electric & Gas	6/14/2018	N	

14. Refer to the Consistent Cost Categories Report at 4. For each cost category, identify and provide a full description of the functions that are provided as non-competitively procured activities and functions.

Response:

Functions and Activities - Non-Competitively Procured	
Cost Category	**Description of Function or Activity**
Program Planning and Administration	• Low Income Energy Affordability Network that supports Low Income Networks that PA is required to work with per directive of GCA • Specialized contractors with unique knowledge and skills that assist in program design and provide independent verification of the PAs' internal research and conclusions, verify the most current assessments of industry best practices. • Regulatory assessments and costs, such as DOER assessment, non-affiliated contractors that provide unique and specialized services for program administration and regulatory proceedings, including cost-effectiveness screening and legal services
Marketing and Advertising	• Costs associated with newspaper and magazine advertisements and radio advertising
Sales, Technical Assistance & Training	• Lead Vendor services for low-income programs
Evaluation and Market Research	• Retention of evaluation experts with unique experience and qualifications • PA approved electricians that install monitoring equipment in a customer's facility during an impact evaluation

15. Refer to the Consistent Cost Categories Report at 4. For each cost category, identify and provide a full description of the functions that are provided as competitively procured activities and functions.

Response:

Functions and Activities - Competitively Procured	
Cost Category	**Description of Function or Activity**
Program Planning and Administration	• EEAC Consultants • IT/database projects
Marketing and Advertising	• Statewide marketing agency • PA specific marketing done by external firms • Costs associated with promotional items and supplies
Participant Incentive	• Program Administrators bulk procure energy efficiency measures when possible (e.g., bulbs for all residential programs)
Sales, Technical Assistance & Training	• All vendors associated with program implementation • Contractors who conduct Technical Assistance studies for custom projects
Evaluation and Market Research	• All evaluation contractors working on statewide EM&V activities • Contractor selected to perform regional Avoided Energy Supply Cost ("AESC") study

16. Refer to the Historical Budget Table (Table IV.C 2.2). Add planned values for program years from the previous plan (i.e., 2013-2015).

Response:

Please see the Historical Budget Table in the PAs' Energy Efficiency Data Tables, filed individually by PA as Exhibit 4 to each PA's Petition, and aggregated statewide in Appendix C to this Plan.

17. Provide all narrative and supporting D.P.U. 08-50 tables at the core initiative level and the program level.

Response:

Please see the PAs' Energy Efficiency Data Tables, filed individually by PAs as Exhibit 4 to each PA's Petition, and aggregated statewide in Appendix C to this Plan, for all data at the core initiative, program, sector, and portfolio levels.

18. Provide pre-filed testimony describing the process by which the Program Administrator develops bids for the forward capacity market ("FCM") administered by ISO New England, Inc. ("ISO-NE"), including a discussion of the different timelines of the FCM process relative to the planning process for the plans.

Response:

Please see Pre-Filed Testimony of each electric Program Administrator (available at Exhibit 2 to each electric PA's Petition).

19. Provide pre-filed testimony describing the communication that occurs between the Program Administrator and ISO-NE during the FCM process. Include a description of any limits ISO-NE may place on Program Administrator bids (i.e., capacity limits, measure life, etc.).

Response:

Please see Pre-Filed Testimony of each electric Program Administrator (available at Exhibit 2 to each electric PA's Petition).

20. Provide pre-filed testimony describing the Program Administrator's participation in FCM reconfiguration auctions to date (both annual and monthly), including a discussion of any advantages/disadvantages to participating in these auctions.

Response:

Please see Pre-Filed Testimony of each electric Program Administrator (available at Exhibit 2 to each electric PA's Petition).