Massachusetts
Technical Reference Manual

for Estimating Savings from Energy Efficiency Measures

2016-2018 Program Years – Plan Version

October 2015

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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:

$$\Delta kW = (Watts_{BASE} - Watts_{EE})/1000$$

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]

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[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

<u>In-Service Rates</u>

[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]

[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.

$$kWh_{annual} = \frac{\left(\frac{1}{R_{exist}} - \frac{1}{R_{new}}\right) \times CDH \times DUA \times Area}{1{,}000\ Btu/kBtu \times \eta_{cool}} \times 293.1$$

$kW = kWh_{annual} \times kW/kWh_{cooling}$

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.

[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]

[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:

$$\Delta kWh = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left[\left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}} \right) \times Hours_C + \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}} \right) \times Hours_H \right]$$

$$\Delta kW = \max\left(\Delta kW_{COOL}, \Delta kW_{HEAT}\right)$$

$$\Delta kW_{COOL} = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}} \right)$$

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]

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[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:

$$\Delta kWh = Tons \times \frac{12\,kBtu/hr}{Ton} \times \left[\left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}} \right) \times Hours_C + \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}} \right) \times Hours_H \right]$$

$$\Delta kW = \max(\Delta kW_{COOL}, \Delta kW_{HEAT})$$

$$\Delta kW_{COOL} = Tons \times \frac{12\,kBtu/hr}{Ton} \times \left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}} \right)$$

$$\Delta kW_{HEAT} = Tons \times \frac{12\,kBtu/hr}{Ton} \times \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}} \right)$$

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]

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.

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[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.

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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]

[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]

[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.

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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.

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[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:

$$\Delta MMBtu = \Delta MMBtu_{RETIRE} + \Delta MMBtu_{EE}$$
$$\Delta MMBtu_{RETIRE} = \textit{heating load MMBTUs} * (1/AFUE\ base - 1/AFUEee)$$
$$\Delta MMBtu_{EE} = \textit{heating load MMBTUs} * (1/AFUE\ base - 1/AFUEee)$$

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]

[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]

[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].

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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]

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[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].

[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]

[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]

[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]

[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]

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[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]

[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]

[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]

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[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.

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[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]

[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

In-Service Rates
All installations have 100% in service rate since all PA programs include verification of equipment installations.

Realization Rates
Realization rates are based on evaluation results[419].

Coincidence Factors
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.

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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

<u>In-Service Rates</u>
In-services rates are 100% since the program tracks all participating customers.

<u>Realization Rates</u>
Realization rates are based on evaluation results.[430]

<u>Coincidence Factors</u>
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].

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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 Measures*. 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.

[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.

[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:

$$\Delta kWh = \Delta kWh_{Cool} + \Delta kWh_{Heat}$$

$$\Delta kWh_{Cool} = \left(kBtu/h_{COOL}\right)\left(\frac{1}{IEER_{BASE}} - \frac{1}{IEER_{EE}}\right)\left(Hours_{COOL}\right)\left(Cap_{adj}\right)$$

$$\Delta kWh_{Heat} = \frac{\left(kBtu/h_{HEAT}\right)}{3.412}\left(\frac{1}{COP_{BASE}} - \frac{1}{COP_{EE}}\right)\left(EFLH_{HEAT}\right)$$

$$\Delta kW_{Cool} = \left(kBtu/h\right)_{Cool}\left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)$$

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.

[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.

[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.

[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.

[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.

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[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

<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, 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.

<u>Coincidence Factors</u>
- 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^{o}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°F above the store air dew point temperature.[536]

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[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.

[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.

[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

In-Service Rates
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.

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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.

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.

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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.

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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

In-Service Rates
All installations have 100% in service rate since PA programs include verification of equipment installations.

Realization Rates
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]

Coincidence Factors
CFs from the prospective results of the 2015 study of prescriptive compressed air.[626]

[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.

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[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.

[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.

[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]

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.

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[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

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.

[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

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.

[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

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.

[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

<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.

[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]

[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.

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			

Appendix D: Table of Referenced Documents

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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; HVAC HVAC; CMoDr Motors & Drives; DRefr Refrigeration; EHoWa Hot Water; FComA Compressed Air; GProc Process* HEUBe Behavior; Ienvl Insulation & Air Sealing; JGchp Combined Heat & Power; KSdhw Solar Hot Water; LDmdR Demand Response; MPvEl Photovoltaic Panels *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.