Energy Optimization through Fuel Switching Study

Final Report

Prepared for:

The New Hampshire Evaluation, Measurement, and Verification (EM&V) Working Group

Submitted by:
Navigant Consulting, Inc.
255 So. Champlain Street | Suite 10
Burlington, VT 05401

802.526.5113
navigant.com

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GLOSSARY / LIST OF ACRONYMS

This report uses the abbreviations defined below:

A/C: Air Conditioning

ACEEE: American Council for an Energy-Efficient Economy

AESC Study: Avoided Energy Supply Components Study

AFUE: Annual Fuel Utilization Efficiency

ASHP: Air Source Heat Pump

B/C: Benefit Cost

CHP: Combined Heat and Power

CORE Programs: New Hampshire Utilities' Energy Efficiency Programs prior to the EERS

DHP: Ductless Heat Pump

DR: Demand Response

EC4: Executive Climate Change Coordinating Council (RI)

EE: Energy Efficiency

EERS: Energy Efficiency Resource Standard

EF: Energy Factor

EIA: Energy Information Administration

EM&V: Evaluation, Measurement, and Verification

EO: Energy Optimization

EV: Electric Vehicle

GC3: Governor's Council on Climate Change (CT)

GHG: Greenhouse Gas

GSHP: Ground Source Heat Pump

HES: Home Energy Solutions

HP: Heat Pump

HPwES: Home Performance with Energy Star

HPWH: Heat Pump Water Heater

HVAC: Heating, Ventilation and Air Conditioning

ISO-NE: Independent System Operator New England

LRAM: Lost Revenue Adjustment Mechanism

MassCEC: Massachusetts Clean Energy Center

MUCT: Modified Utility Cost Test

NEI: Non-Energy Impact

NG: Natural Gas

NHEC: New Hampshire Electric Cooperative

Northeastern states: MA, CT, RI, VT, ME, NY

NREL: National Renewable Energy Laboratory

NRDC: Natural Resources Defense Council

NYSERDA: New York State Energy Research and Development Authority

PSEG: Public Service Enterprise Group

PSD: Program Savings Document

PUC: Public Utilities Commission

QIV: Quality Installation Verification

RGGI: Regional Greenhouse Gas Initiative

SCT: Societal Cost Test

STEP: Statewide Total Energy Program

TRC: Total Resource Cost Test

TRM: Technical Reference Manual

UCT: Utility Cost Test

VEIC: Vermont Energy Investment Corporation

VFD: Variable Frequency Drive

EXECUTIVE SUMMARY

The New Hampshire Evaluation, Measurement, and Verification (EM&V) Working Group has contracted with Navigant to conduct a study on how energy optimization through fuel switching is commonly treated in cost-effectiveness testing. Throughout this study, Navigant discussed technical issues and received comments and feedback from the New Hampshire Benefit/Cost Working Group. First, we studied how New Hampshire's programs are currently handling energy optimization. Next, we looked at how other states in the Northeast (Connecticut, Massachusetts, Maine, New York, Rhode Island, and Vermont) are handling energy optimization through fuel switching. Finally, we compared the different state policy goals we identified with the activities states are pursuing in order to develop a list of activities by policy goal.

When reviewing both New Hampshire and other states' practices, Navigant gathered data in the same way. We conducted interviews with stakeholders suggested by the EM&V Working Group and found through web research. We then conducted a literature review and secondary research. Through this review, we compiled state policy, strategy, and other documents along with research papers relating to energy optimization measures. After reviewing our findings from other Northeastern states, we identified six policy goals and nine energy efficiency (EE) program changes that are specifically related to energy optimization.

For the purposes of this report, we interpret energy optimization as a strategy to minimize energy use and maximize customer benefits. Energy optimization considers efficiency and the mix of fuels used. Energy optimization measures are a subset of fuel switching measures, but the two are not synonymous because fuel switching does not necessarily account for efficiency. Similarly, energy optimization measures are a subset of EE measures, though EE measures do not necessarily consider the fuel mix. Beneficial or strategic electrification approaches may involve energy optimization, but these terms are not synonymous either. Beneficial or strategic electrification involves powering end uses with electricity instead of fossil fuels in a way that increases EE and reduces pollution, while lowering costs to customers and society, as part of an integrated approach to decarbonization, while energy optimization focuses on any strategy that minimizes energy use and maximizes customer benefits.

Energy Optimization in New Hampshire

Through our review to understand current programs in New Hampshire, Navigant identified the following high-level findings:

- **Priorities:** Utility stakeholders perceive that the New Hampshire Public Utilities Commission's (PUC) priorities to date for EE programs have focused on the reduction of regulated fuel consumption and the protection of low-income participants. Utility stakeholders perceive that the PUC requires consideration of public health and environmental impacts, but the lack of binding targets for greenhouse gas emissions (GHG) is interpreted by the utilities as a signal that emissions reductions are not a priority for NH EE programs marketed under the NHSaves brand. Non-utility stakeholders perceive that there is significant statutory support for consideration of GHG emissions reductions and other environmental and public health benefits.

- **Current Energy Optimization Measures:** NHSaves currently offers energy optimization measures for space heating, water heating, commercial food service, and commercial natural gas cooling. Utility-specific incentives are available for combined heat and power (CHP[1]). Stakeholders agree that most transportation and electric vehicle measures are currently outside the scope of New Hampshire's EE programs, with the exception of certain measures which might

[1] CHP projects displace utility electric consumption by using on-site combustion of natural gas to generate electricity and utilize waste heat from electric generation for space heating and water heating.

be considered in future program years, such as efficient and/or controllable electric vehicle charging stations.

- **Current Fuel-switching Savings Calculation:** Since 2014, New Hampshire utilities have limited their savings calculations to measure only the positive savings of regulated fuel types, from a baseline code-compliant piece of regulated fuel equipment to a high-efficiency program-eligible piece of regulated fuel equipment.

- **Site versus Source:** New Hampshire utilities currently calculate the site savings (energy savings experienced at the customer's premises) associated with energy optimization measures using savings values derived from impact studies. New Hampshire has not yet adopted a framework to compare source savings (energy savings experienced at the source of generation or supply) and site savings that result from energy optimization measures.

- **Winter and Summer Peak Loads:** New Hampshire stakeholders maintain some concern that energy optimization measures could result in winter and summer peak period electricity usage increases, and if not properly managed have the potential to result in peak load growth for regulated fuel types. Stakeholders mostly agreed that peak load growth would be an unintended negative consequence of energy optimization measures, and that peak load growth and increased usage of regulated fuels should be addressed in benefit-cost calculations. Most stakeholders further agreed that potential negative consequences should be mitigated appropriately in program design. Some noted that an increase in electricity usage during off-peak periods has the potential to improve load factor by filling in load gaps, distributing electricity usage over different time periods.

- **Contractor and Workforce Training:** New Hampshire stakeholders agreed that any expansion in the program's energy optimization offerings should be accompanied by customer and contractor education, as well as workforce training.

Energy Optimization in the Northeast

Through our review to understand current programs *outside* New Hampshire, Navigant identified the following high-level findings:

- **Supporting Policies:** All states in the Northeast have robust EE resource standards, with New Hampshire's EE targets lagging somewhat behind the other states. All states in the Northeastern U.S. (CT, MA, ME, NY, RI, VT, NH) have articulated GHG emissions reduction goals[2], with near-term and long-term targets set as some amount of reduction from a past year's consumption (e.g., 40% reduction from 1990 levels by 2030). Several states (NY, RI, ME) set specific targets for heat pump deployment that are defined either in number of installations or in total energy savings. VT has an incentive in its RPS that applies to heat pumps.

- **Unregulated Fuel Savings:** Several states (MA, RI, VT, ME[3], CT[4]) count unregulated fuel savings as a benefit, while other states (NY) do not currently count unregulated fuel savings.[5]

[2] NH has non-binding GHG emission reduction targets.

[3] Maine started officially counting unregulated fuel savings in FY 2020, which began July 2019.

[4] CT counts unregulated fuel savings for weatherization measures and upstream water heating – where customers' existing water heating fuel type cannot be readily identified, CT assumes a blended baseline and counts a portion of savings for each fuel type. They will also count unregulated fuel savings in a heat pump pilot they are conducting this year.

[5] NY has plans to account for unregulated fuel savings in the future. NH currently counts unregulated fuel savings for their weatherization program, but not for measures that involve fuel switching.

- **Total Cost of GHG Emissions as a Non-Energy Impact:** Most Northeastern states (MA, RI, NY, VT) count the total costs of GHG emissions, and the magnitude of this cost varies from state to state, ranging from ~$40/ton to $100/ton of CO_2 reduction.[6]

- **Winter and Summer Peak Loads:** Other Northeastern states (MA, CT, RI, VT, ME, NY) account for peak load impacts using costs recommended by the Avoided Energy Supply Components (AESC) study.[7] A 2018 study in Massachusetts found that energy optimization measures – in particular, heat pumps – have a limited impact on summer peak electric demand in the short term, since the demand growth resulting from new A/C capacity is balanced by the demand reductions from increased efficiency.[8] This finding is confirmed by New York State Energy Research and Development Authority's (NYSERDA) 2018 *New Efficiency: New York* report.[9] The AESC study reports $0 cost for winter electric peak load increases, since there is excess electric capacity during winter peak periods. New York places equal weight on increases to summer and winter peak load, and New York uses a single avoided cost value to account for increases to the electric peak load.

- **Electric Measures versus Natural Gas Measures:** None of the Northeastern states incentivize customers switching from unregulated fuels to natural gas, since conversions to natural gas do not support the states' policy goals or long-term goals for electrification and may be counter-indicated by economics. Additionally, there are concerns about free-ridership.

- **Site Savings versus Source Savings:** All Northeastern states (MA, CT, RI, VT, ME, NY) count site savings. Massachusetts is the only state in the Northeast that has attempted to claim source savings in its benefit/cost calculations, but its methodology for calculating source savings is still in development.

- **Current Energy Optimization Measures:** All Northeastern states offer incentives for heat pumps and water heating. Some Northeastern states (MA, CT, RI, VT, ME) offer additional incentives for customers who displace unregulated fuel usage by installing high efficiency heat pumps or heat pump water heaters.

- **Administration of EE Programs:** In most Northeastern states (CT, MA, NY, RI), energy optimization measures are administered through EE programs administered by the utilities. In Maine and Vermont, measures are administered through statewide organizations (Efficiency Maine and Efficiency Vermont) that operate independently of the utilities. In Massachusetts and New York, third parties (MassCEC and NYSERDA) offer additional efficiency incentives to utility customers.

- **Contractor and Workforce Training:** All of the Northeastern states have some sort of workforce training and outreach to educate contractors about heat pump technologies. Most of these programs have an element of customer training as well, with some programs offering training direct to customers (via marketing literature and social media) and some programs relying on contractors to provide customer education when new systems are installed. Many states have developed a network of contractors to whom they provide training and who help educate customers about energy efficient equipment options.

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[6] MA and RI use $68/ton of CO_2. NY uses $47.25/ton of CO_2. VT uses $100/ton of CO_2.

[7] Synapse Energy Economics (2018). "Avoided Energy Supply Components in New England: 2018 Report." Available at: https://www.synapse-energy.com/sites/default/files/AESC-2018-17-080.pdf

[8] MA EEAC (2018). "RES21 Energy Optimization Study." Available at: http://ma-eeac.org/wordpress/wp-content/uploads/RES21_Energy-Optimization-Study_09OCT2018.pdf

[9] NYSERDA (2019). "New Efficiency: New York. Analysis of Residential Heat Pump Potential and Economics." p.58. Available at: https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/NYSERDA/18-44-HeatPump.pdf

Recommendations

After reviewing our findings from other Northeastern states, we identified six policy goals and nine EE program changes that are specifically related to energy optimization. Navigant's role in this study is not to recommend any particular policy goal, but to recommend actions and activities that would support the various goals that New Hampshire may set. We examined the alignment between the goals and changes we identified and developed a set of potential changes to support each of the six policy goals.

Policy Goals:

1. **Strategic electrification:** Strategic electrification involves powering end uses with electricity instead of fossil fuels in a way that increases EE and reduces pollution, while lowering costs to customers and society, often part of an integrated approach to decarbonization.

2. **Minimize GHG Emissions:** Minimizing GHG emissions involves reducing net GHG emissions as much as possible. To be considered a GHG-minimizing activity, an activity must reduce emissions more than comparable alternatives.

3. **Reduce Fossil Fuel Usage:** Reduction of fossil fuel usage involves directly reducing the net amount of fossil fuel consumed in the economy.

4. **Improve EE Program Cost-Effectiveness:** Improving EE program cost-effectiveness means pursuing activities that create the most savings for the amount of money spent to implement the activity.

5. **Pursue Holistic B/C Accounting:** Pursing holistic benefit/cost (B/C) accounting involves accounting for all relevant impacts, even those that are difficult to quantify. Holistic B/C accounting is symmetrical, where both benefits and costs are included for each relevant type of impact.

6. **Improve Load Factor:** Increasing load factor diminishes the average unit cost of the kWh, both for demand and energy. Load factor can be improved by reducing demand by distributing loads over different time periods or by keeping demand stable and increasing consumption.

The following table lists the nine potential changes Navigant identified, separated into three categories.

Type of Change	Program Changes that Support Energy Optimization-Related Goals
Cost-Effectiveness Practices	1. **Count Unregulated Fuel Savings for Switching to Electric and Count Peak Load Increase for Fuel-to-Electric Measures:** counting the full range of energy savings for customers that shift consumption from unregulated fuels (oil or propane) to electricity and counting electric load increases associated with fuel-to-electric measures. 2. **Count Total Costs of GHG Emissions as a Non-Energy Impact (NEI) in B/C Analysis:** counting reductions in GHG emissions as a non-energy impact with an associated avoided cost. 3. **Count Site & Source Savings in B/C Calculations:** counting the full range of energy savings from both the site and the source.
Measure Offerings	4. **Incentivize Oil-to-Natural Gas Measures:** providing incentives for fuel switching measures that encourage customers to convert from oil-fired equipment to natural gas equipment. 5. **Offer Tailored Air-Source Heat Pump Measure Bundles:** developing specific efficiency measures for air-source heat pumps that that are only available to customers who switch from delivered fuels or electric resistance heating to electric heat pumps. 6. **Incentivize Electric Vehicles Within EE Programs:** incentivizing the purchase of electric vehicles through an EE program. 7. **Incentivize Combined Heat & Power in EE Programs:** incentivizing combined heat & power (CHP) measures through an EE program.
Program Design	8. **Third Party Working in Tandem with Utilities:** establishing a third-party EE promotion agency that works in tandem with the utilities. 9. **Offer EO-Specific Workforce Training Programs:** offering EO-specific workforce training programs to people such as home auditors, contractors, and manufacturers.

The following table maps the six policy goals we identified to the program changes that support them.

Policy Goal	Program Changes that Support Energy Optimization-Related Goals
Strategic Electrification	• Count Unregulated Fuel Savings for Switching to Electric and Count Electric Load Increase for Fuel-to-Electric Measures • Count Total GHG Emissions as an NEI in B/C Analysis • Offer Tailored Air-Source Heat Pump Measure Bundles • Offer EO-specific Workforce Training Programs • Incentivize Vehicles within EE Programs • Third Party Working in Tandem with Utilities
Minimize GHG Emissions	• Count Unregulated Fuel Savings for Switching to Electric and Count Electric Load Increase for Fuel-to-Electric Measures • Count Total GHG Emissions as an NEI in B/C Analysis • Count Site & Source Savings in B/C Calculations • Offer EO-Specific Workforce Training Programs • Offer Tailored Air-Source Heat Pump Measure Bundles • Incentivize Electric Vehicles Within EE Programs • Third Party Working in Tandem with Utilities
Reduce Fossil Fuel Usage	• Count Unregulated Fuel Savings for Switching to Electric and Count Electric Load Increase for Fuel-to-Electric Measures • Count Total GHG Emissions as an NEI in B/C Analysis • Count Site & Source Savings in B/C Calculations • Offer Tailored Air-Source Heat Pump Measure Bundles • Offer EO-Specific Workforce Training Programs • Incentivize Electric Vehicles within EE Programs • Third Party Working in Tandem with Utilities
Improve EE Program Cost-Effectiveness	• Count Total GHG Emissions as an NEI in B/C Analysis • Count Unregulated Fuel Savings for Switching to Electric and Count Electric Load Increase for Fuel-to-Electric Measures • Offer Tailored Air-Source Heat Pump Measure Bundles • Offer EO-Specific Workforce Training Programs • Third Party Working in Tandem with Utilities
Pursue Holistic B/C Accounting	• Count Unregulated Fuel Savings for Switching to Electric and Count Electric Load Increase for Fuel-to-Electric Measures • Count Total GHG Emissions as an NEI in B/C Analysis • Count Site & Source Savings in B/C Calculations
Improve Load Factor	• Count Unregulated Fuel Savings and Count Electric Load Increase for Fuel-to-Electric Measures • Incentivize CHP in EE Programs • Incentivize Electric Vehicles within EE Programs

1. INTRODUCTION

The New Hampshire Evaluation, Measurement, and Verification (EM&V) Working Group has contracted with Navigant to conduct a study on how energy optimization through fuel switching is commonly treated in cost-effectiveness testing. Throughout this study, Navigant discussed technical issues and received comments and feedback from the New Hampshire Benefit/Cost Working Group.

1.1 Definition of Energy Optimization

We interpret energy optimization as a strategy to minimize energy use and maximize customer benefits. Energy optimization considers efficiency and the mix of fuels used. Energy optimization measures are a subset of fuel switching measures, but the two are not synonymous because fuel switching does not necessarily account for efficiency. Similarly, energy optimization measures are a subset of EE measures, though EE measures do not necessarily consider the fuel mix. Beneficial or strategic electrification approaches may involve energy optimization, but these terms are not synonymous either. Beneficial or strategic electrification involves powering end uses with electricity instead of fossil fuels in a way that increases EE and reduces pollution, while lowering costs to customers and society, as part of an integrated approach to decarbonization, while energy optimization focuses on any strategy that minimizes energy use and maximizes customer benefits.

The term “energy optimization” has not been adopted outside of the Northeast. Even within the Northeast, the term does not have a consistent or definitive definition. The definition for energy optimization that is stated above is the definition selected for the purposes of this study.

1.2 Overview of Study

This purpose of this study is to determine how energy optimization through fuel switching is commonly treated in cost-effectiveness testing. This includes the examination of factors or policies that determine such treatment and the customer bill and energy use impacts of such a policy. This study explores how impacts of energy optimization are counted towards energy savings targets and impact evaluation methods and assumptions. The study is based upon internal and external stakeholder interviews, literature review, and secondary research.

New Hampshire has noticed that other states have begun re-examining their B/C assumptions in order to more accurately assess the benefits that result from installing EE measures that include fuel switching.

This study seeks to answer the following questions:

- How is New Hampshire currently handling energy optimization through fuel switching?
- How are other states handling energy optimization through fuel switching in efficiency program cost-effectiveness testing?
- What are the factors or policies that determine such treatment in other states?
- What is the customer bill and energy use impacts associated with energy optimization through fuel switching?

The outcome of the study is a summary of how other states are handling energy optimization and recommendations for ways New Hampshire could handle energy optimization and account for fuel switching. New Hampshire stakeholders and the B/C working group would like to reevaluate the B/C assumptions regarding EE measures that include fuel switching. The findings that come from this study will help to inform New Hampshire’s evaluation of their current practices.

2. METHODOLOGY

For this study, Navigant gathered information in two steps. As a first step, Navigant reviewed the screening practices that are currently used in New Hampshire. The goal of this task was to develop a thorough understanding of how fuel-switching measures are currently handled in the New Hampshire utilities' Total Resource Cost (TRC) test methodology.

For Navigant's second step, we examined how other states treat measures that involve energy optimization and fuel switching and conducted a literature review of energy usage and customer bill impacts resulting from energy optimization measures. Our efforts for this task focused on efficiency programs in the Northeastern U.S., since our interviews with members of the NH Benefit/Cost Working Group indicated that the Northeast is a key area of interest for this study. At the working group's request, we have also profiled a couple jurisdictions outside the Northeast (California and Washington) that actively support fuel switching measures. Information regarding jurisdictions outside of the Northeast can be found in Appendix F section F.7.

In both of these steps, we gathered information using the same tools: interviews, document review, and literature review. The subsections below describe each of these approaches for gathering data, both inside and outside of New Hampshire. Figure 1 summarizes our research efforts.

Figure 1. Summary of Sources

2.1 Stakeholder Interviews

The same methods were applied to internal and external stakeholder interviews. We started by identifying interview candidates based on recommendations from the NH Benefit/Cost Working Group and web searches. Next, we developed an interview guide with input from the NH Benefit/Cost Working Group. Finally, we conducted the interviews. To encourage stakeholders to offer candid responses during our interviews, we informed stakeholders that their responses would be aggregated, that interviews would not be recorded, and that we would seek permission before attributing any quotes to individual respondents. The stakeholder responses documented in this report are presented in aggregate.

2.2 Document Review

The document review was comprised of state policy documents, including statutes, PUC Orders, and the State Energy Strategy relating to energy optimization, with many being policy and strategy documents. The same document review methods were applied to the internal and external reviews. We started by identifying documents based on recommendations from the NH Benefit/Cost Working Group and web searches. We reviewed the documents, looking for energy optimization-related content. Navigant developed a catalog containing all the relevant documents that were reviewed. Appendix A lists the New Hampshire-specific documents that were reviewed.

2.3 Literature Review

Distinct from the document review, Navigant also conducted a literature review for both the internal and external steps. The literature review was different from the document review, because instead of focusing on state policy and strategy, it looked at evaluations and comparisons across jurisdictions. The data sources for the literature review were more academic, such as ACEEE and NREL, instead of state-specific policy documents.

2.4 Develop Recommendations

For the last step of this study, Navigant developed a list of recommended EE program changes to support particular policy goals. This subsection describes the guidelines that Navigant received for developing recommendations and the approach that our team used to develop recommendations for changes related to energy optimization measures.

On May 31, 2019, Navigant hosted a conference call with the New Hampshire EM&V Working Group to discuss our approach to developing recommendations for this study. The EM&V Working Group requested that Navigant take a policy-neutral approach to developing recommendations. New Hampshire's stakeholders may choose to establish one or more policy goals that are related to energy optimization. The goal of this Energy Optimization Study is not to recommend or advocate for any particular policy goal. Instead, the goal of this study is to assess the customer cost impacts and energy usage impacts associated with different screening activities, and to recommend the activities that would support the different policy goals that New Hampshire's stakeholders could define.

Our team took a three-step approach to developing recommendations:

1. Identify common policy goals in other states that relate to energy optimization programs
2. Identify the screening activities that other states use for energy optimization measures, and examine how those activities relate to the policy goals identified in step 1
3. Assess the customer cost impacts and energy usage impacts associated with the activities identified in step 2

Our identification of policy goals and screening activities was informed by the second step of this study, wherein our team reviewed the policies that guide other states' EE programs and the screening activities that other states use. To assess the cost and energy impacts of various screening activities, our team adapted the Massachusetts Residential Energy Optimization Model[10] to estimate the savings associated with different energy optimization measures.

2.4.1 Adaptation of the Massachusetts Residential Energy Optimization Model

To explore how different accounting choices would affect New Hampshire's cost and energy savings calculations, Navigant adapted the Massachusetts Residential Energy Optimization Model created in October of 2018 to compare calculations with different boundaries (e.g., counting savings only for

[10] A memo summarizing the motivation, methodology, and data sources for this model is available from the MA EEAC at: http://ma-eeac.org/wordpress/wp-content/uploads/RES21_Energy-Optimization-Study_09OCT2018.pdf
The spreadsheet model delivered to the MA EEAC in October 2018 is available from the MA EEAC at: http://ma-eeac.org/wordpress/wp-content/uploads/RES21_Task4_Final_Spreadsheet_Model_REVISED_2018-09-25_v4.xlsx

regulated fuels vs. counting savings of regulated and unregulated fuels). For further details on measure characterization, refer to Appendix D.

Our team made the following adaptations to the MA Energy Optimization Model to tailor its calculations to New Hampshire:

- **Annual weather data.** The performance of air-source heat pumps varies depending on the outdoor air temperature. Generally, air-source heat pumps operate less efficiently at low outdoor air temperatures than at high temperatures. The model uses annual weather data to estimate the typical annual performance of air-source heat pumps for a given climate zone. Annual weather data comes from the weather station at Concord Municipal Airport, which is proximate to the population center of New Hampshire.[11]

- **Fuel cost data.** The model uses the cost of different fuel types to calculate the typical operating costs that customers pay to operate different types of equipment as well as the customer cost savings that result from shifting consumption from baseline level equipment to measure level equipment. Fuel cost inputs come from the Energy Information Administration (EIA).[12]

- **Saturation of Baseline A/C Technologies.** The model calculates the energy and demand savings associated with switches from fossil fuel heating to electric heat pumps. The model accounts for changes in electric consumption for space cooling. Assumptions regarding the primary cooling system type in residential properties in New Hampshire are taken from results of the 2018 Claritas Energy Behavior Track annual survey, conducted in partnership with E Source.[13] The results of this survey show that about 80% of NH customers use electric powered air conditioning. For customers with air conditioning systems, the installation of an efficient electric heat pump will likely reduce consumption and demand for space cooling. For customers without air conditioning, the installation of an electric heat pump adds a new space cooling capability, with associated increases in consumption and electric demand.

- **Electric generation mix.** The model uses the average annual electric generation mix for ISO New England to estimate the GHG emissions that would result from the operation of different equipment types. The model focuses on generation sources with significant carbon emissions. These sources and their percent of total electric generation are: natural gas (49.0%), oil (1.1%), and coal (1.0%).[14]

The NH adaptation of the MA Residential Energy Optimization model does not update the following inputs to the MA model: absolute and incremental equipment installation costs; assumptions regarding equipment efficiency at the baseline and measure levels; heat pump performance curves; heat pump performance correction factors. Our team is not aware of any data sources that would provide New

[11] National Renewable Energy Laboratory (NREL). National Solar Radiation Data Base (NSRDB). Typical meteorological year (TMY3) dataset for Concord Municipal Airport. Available at: https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/

[12] EIA 2019 Average New Hampshire Residential Heating Oil Price per gallon (Oct 2018 - Mar 2019) https://www.eia.gov/dnav/pet/PET_PRI_WFR_DCUS_SNH_W.htm

EIA 2019 Electricity Data Browser, New Hampshire Average Residential Retail Price of Electricity (Feb 2018 - Feb 2019) https://www.eia.gov/electricity/data/browser/#/topic/7

EIA 2019 New Hampshire Residential Natural Gas Price per therm (Oct 2018 - Feb 2019) https://www.eia.gov/dnav/ng/ng_pri_sum_dcu_SNH_m.htm where one therm equals 100 cubic ft.

[13] The 2018 Claritas Energy Behavior Track annual survey sampled 32,459 residential customers across the U.S. and asked questions on a variety of energy-related topics. At the state level, the survey reports customers' primary source of cooling, and the results for New Hampshire are based on a sample of 120 residential NH customers. Survey results are behind a paywall, and a description of the survey is available at: https://www.esource.com/about-rcic

[14] ISO New England. "Sources of Electricity Used in 2018." Available at: https://www.iso-ne.com/about/key-stats/resource-mix/

Hampshire-specific data for these inputs, and we assume that the values of these inputs would be similar in New Hampshire and Massachusetts.

Section 5 of this report describes a set of changes that EE programs may undertake to encourage energy optimization measures. Section 5 includes tables of results showing how these different changes would impact the cost and savings calculations for a set of energy optimization measures. The values in these tables are derived from the adapted NH Energy Optimization Model. The energy optimization model has not been thoroughly vetted by NH stakeholders. As such, the model results presented in Section 5 are intended for illustration purposes only, to offer guidance regarding how the energy savings inputs to the B/C model would change depending on what utilities choose to include in the calculation. The cost savings presented in the tables of model results represent customer bill savings and do not include avoided costs calculated in the B/C model. Where these results tables present a comparison to current NH practices, the tables show an “apples-to-apples” comparison of the customer bill savings calculated using current NH practices (only counting efficiency savings of regulated fuels) compared to alternative practices (counting savings of unregulated fuels and negative savings of regulated fuels). The model results presented in Section 5 do not represent finalized inputs to the B/C model.

3. ENERGY OPTIMIZATION IN NEW HAMPSHIRE

3.1 History of Energy Optimization Measures in New Hampshire

New Hampshire's CORE EE programs, branded under the NHSaves banner, were initially rolled out to customers in 2002. The CORE programs are funded by the System Benefits Charge, Regional Greenhouse Gas Initiative (RGGI) funding, and ISO-NE Forward Capacity Market revenue for electric. For natural gas, the programs are funded by a portion of the Local Distribution Adjustment Charge. In June 2009, the NH PUC approved a proposal to conduct a 2009 Home Energy Solutions (HES) Pilot Program on a fuel-blind basis.[15] The HES Pilot Program operated from June 2009 to August 2012. Then, in August 2012, the NH PUC approved the full inclusion of the Home Performance with ENERGY STAR (HPwES) program in the 2013-2014 CORE program.[16]

In 2013, utilities calculated the savings of energy optimization measures as the difference between the consumption of the original fossil fuel equipment and the electric consumption of the new high efficiency equipment. The deemed savings inputs and 2013 planned and actual savings and consumption figures are included as Appendix C. Looking back at this period, stakeholders said that framing the calculation this way yielded positive savings for unregulated fuels, but yielded negative savings (i.e., increased consumption) for electricity and natural gas. Several New Hampshire stakeholders said that including measures with negative savings in their portfolio made it difficult for utilities to achieve their annual EE savings targets for electricity consumption.[17]

Since 2014, utilities have limited their savings calculations for energy optimization measures to count only the savings of regulated fuel types, from a baseline code-compliant piece of regulated fuel equipment to a high-efficiency program-eligible piece of regulated fuel equipment.

In 2016, the NH PUC approved an order establishing the Energy Resource Standard (EERS), a policy that set specific targets/goals for energy savings for utilities to meet. The 2014-2016 CORE programs were extended through 2017 to then be replaced by EERS.

3.2 Current Energy Optimization Measures in New Hampshire

Stakeholders described the following measures that are offered through the EE program and that could involve energy optimization[18]:

- **Space heating and water heating measures.** These include air-source heat pumps, high-efficiency natural gas heating products (such as boilers and furnaces), and heat pump water heaters. These might include "blended baseline" measures like upstream heat pump or heat pump water heater incentives, where the participants' current fuel type is not known, so savings are claimed against a blended baseline of existing fuel types.

[15] *Proposed Fuel Blind Home Energy Solutions Pilot Program - Order Nisi Approving Modified Fuel Blind Program*, Docket No. DE 08-120, Order 24,974 (Jun. 4, 2009).

[16] *Order on Home Performance with Energy Star Program*, Docket No. DE 10-188, Order 25,402 (Aug. 23, 2012).

[17] Utility stakeholders stated that the EERS savings targets only count savings of regulated fuels, although the programs do account for unregulated fuels savings for the purpose of benefit cost testing and the related performance incentive provisions.

[18] Stakeholders described other measures that use electric ratepayer funds to reduce fossil fuel usage, such as weatherization programs for delivered fuel customers. However, these do not fit this study's definition of energy optimization, which requires some amount of fuel switching. NH currently counts unregulated fuel savings for their weatherization program.

- **CHP measures.** CHP measures recover waste heat from electric generation. Stakeholders agreed that CHP has had limited uptake in New Hampshire because New Hampshire's natural gas infrastructure is limited.

- **Commercial food service measures.** These measures may, for example, incentivize customers to switch from natural gas cooking equipment to electric cooking equipment or vice versa.

- **Commercial natural gas cooling measures.** These measures incentivize customers to switch from electric chillers to natural-gas-powered chillers. These measures provide an opportunity to reduce the summer electric peak. Stakeholders noted, though, that these measures may not reduce the strain on natural gas supply during peak periods.

Outside of their regulated EE programs, the New Hampshire Electric Cooperative (NHEC) offers several energy optimization measures. NHEC offers incentives of up to $500 per ton for ENERGY STAR qualified heat pumps. Members who participate in Home Performance with Energy Star (HPwES) program and install all recommended cost-effective shell measures and health and safety measures are eligible to receive an additional $250 per ton installed. In addition, members who install heat pumps to offset 80% of their heating load can receive an additional incentive of $250 per ton. Eligible members can also finance their installation at 2% utilizing the interest rate buy down offering. This entire offering is supported using NHEC funds. Other offerings include a measure for ground-source heat pumps (GSHPs) and a demand response (DR) program that shifts additional demand introduced by electric vehicles.

NHEC and Liberty Utilities are also conducting pilot programs for battery storage. The role of battery storage in energy optimization has yet to be examined by New Hampshire, so these pilot programs may not be relevant for the current discussion.

Transportation measures, such as electric vehicles (EVs) and natural gas vehicles, are not currently covered by New Hampshire's regulated EE program. Most stakeholders agreed that electric vehicle measures are currently outside the purview of the EE programs, with the exception of certain EV load management measures, such as efficient and/or controllable EV charging stations. Some believe that incentivizing EVs is only appropriate at higher EE funding levels and the EE programs should continue to focus on buildings in the near term. Several stakeholders noted that any measures for EVs should be accompanied by a specific rate design that incentivizes load shifting and peak demand reduction.

3.3 New Hampshire's Benefit-Cost Test for Energy Optimization Measures

New Hampshire currently uses the TRC test to evaluate the benefits and costs of EE measures. For energy optimization measures involving fuel switching, the current benefit-cost test assumes that the customer would have switched fuels absent any program intervention. Under this assumption, (1) the program only calculates savings that result from efficiency improvements for the new fuel type, and (2) the installation and connection costs associated with fuel switching are not included in the B/C analysis of individual efficiency measures. New Hampshire does not currently have evaluation data to support or refute the assumption that customers would switch fuels absent any program intervention. Utility stakeholders had differing opinions regarding whether the programs should attempt to measure customer motivation and credit the programs for influencing customers' fuel switching decisions: most stakeholders were in favor of measuring and accounting for customer motivation while some stakeholders were opposed to it. Several stakeholders noted that customer motivation is not factored into savings claims, since New Hampshire evaluates measures based on adjusted gross savings, not net savings.

Several stakeholders said that the current approach to B/C calculation is sensible, since the program's current goal is to reduce the consumption of regulated fuels through cost-effective efficiency measures. There was just one year (2013) that the B/C test accounted for the full spectrum of savings, from the original fuel baseline equipment to the new energy efficient equipment, and this accounting only applied to customers switching from unregulated fuels to electric heat pumps. Stakeholders agreed that this accounting method would reduce the amount of savings that utilities could claim towards their Energy Efficiency Resource Standard (EERS) goals.

Environmental advocates questioned whether a completely fuel-neutral approach is appropriate and suggested that the programs should incentivize customers to switch to the most efficient option available. Environmental advocates also said they would like the B/C analysis to account for the societal benefits that result from GHG reductions,[19] including improved public health.

Several stakeholders suggested that changes made to the program's B/C accounting methods would logically be accompanied by adjusting the program's goals at a high level to align with the new accounting method changes, for example, by setting MMBtu savings goals for the electric programs rather than kWh. Stakeholders suggested that a PUC order would be an appropriate way to approve new B/C calculation methods. There is currently no binding state legislative policy interpreted by the Commission as requiring utilities to count the net energy or emissions savings across different fuel types.

As a point of comparison, NHEC offers heat pump incentives outside of New Hampshire's core suite of EE programs. NHEC's goal for their independent heat pump program extends beyond electric savings, and NHEC calculates the net energy savings across regulated and unregulated fuels with an approach that is similar to the Participant Cost Test. To perform this calculation, NHEC converts the savings for all fuel types to a common unit basis of million Btu (MMBtu), and then sums the energy savings across all fuel types. NHEC compares the heating capacity of the existing fuel-fired equipment to the heating capacity of the electric heat pump equipment that will displace it, and NHEC uses that comparison to determine the amount of fuel consumption that will be displaced by operation of the heat pump. NHEC representatives said that this calculation method is an appropriate way to count the total savings that result from energy optimization measures.

3.4 Gaps in Evaluation Data

Stakeholders mentioned three specific data gaps that hinder the evaluation of energy optimization measures:

- Customer Decision-Making: There is a lack of evidence regarding the extent to which program elements motivate customers to switch fuels. The current benefit-cost test for energy optimization measures assumes that the customer would have switched fuels absent any program intervention. However, New Hampshire does not collect information on customer decision-making with regards to energy optimization measures. Several stakeholders suggested that since New Hampshire is an adjusted gross savings state, it is sufficient for New Hampshire to base resource allocation decisions on other states' findings regarding customer motivation. Others said it may be worthwhile to gather data and probe this assumption. Some stakeholders said anecdotally that their own personal decision to switch fuels was motivated by program incentives.

- Equipment Usage: New Hampshire does not collect information regarding how customers use the equipment that is incentivized by energy optimization measures. Some stakeholders offered anecdotes of customers who have installed heat pump equipment but have used only the cooling function of the heat pump and have continued using fossil fuel equipment to partially or fully meet their heating needs. Savings claims may be overstated if the program assumes that all customers are using their heat pump equipment as intended by the program. Some stakeholders suggested

[19] NH utilities do not count the non-embedded costs of GHG emissions. They do, however, count the embedded costs of GHG emissions for electric consumption as part of energy avoided costs.

that information on customer behavior and equipment usage could help determine the extent to which energy optimization measures are reducing fossil fuel consumption.

- Baselines: New Hampshire lacks information regarding the fossil fuel equipment that gets displaced by energy optimization measures. Stakeholders said that, if the benefit-cost test were adjusted to account for total energy savings, the program would need to quantify the consumption of the baseline fossil fuel equipment. Some stakeholders suggested that a baseline study would be the appropriate method to gather information on the fossil fuel equipment that is being displaced, and that the upcoming statewide potential study is being designed to collect this information.

3.5 Customer Behavior Regarding Dual-Fuel Heating Systems

Stakeholders said that any consideration of energy optimization measures should take customer behavior into account. New Hampshire utilities do not encourage customers to remove a safe and operational piece of fossil fuel heating equipment when they install a new heat pump. Safe and operational fossil fuel heating equipment may be preserved as a backup heating source, in case the heat pump is taken out of service, or in case of extreme outdoor temperatures where the heat pump cannot provide adequate heating capacity. When customers operate both a heat pump and a fossil fuel heating system, it can be described as a “dual-fuel heating system.”

The energy savings realized from a dual-fuel heating system depends on how the customer operates the system. Stakeholders expected that customers’ savings would be maximized if customers primarily use their heat pump and only switch to the fossil fuel heating equipment in extremely cold temperatures where the heat pump is either inefficient or nonoperational. New Hampshire has not studied customer behavior to understand how customers typically manage their dual-fuel systems, although neighboring states such as Maine have more advanced heat pump programs that may be referred to for certain types of information. Information about customer behavior could help inform the development of educational materials targeted at customers.

Stakeholders noted that there is an opportunity to use controls to integrate the electric and fuel systems, so that the switch between the heat pump and fossil fuel heating equipment is automated. The installation of integrated controls for dual-fuel systems may improve customer savings compared to a system with manual controls, although automation may not be practical in every instance.

4. ENERGY OPTIMIZATION FINDINGS IN THE NORTHEAST, BY THEME

After reviewing New Hampshire's practices, our study focused on states in the Northeastern U.S. (Connecticut, Massachusetts, Maine, New York, Rhode Island, and Vermont) since most Northeastern states face challenges similar to New Hampshire. Specifically, Northeastern states all have relatively high proportions of customers that use delivered fuels for heating. Many Northeastern states have programs using energy optimization and fuel switching measures as a means to improve efficiency while also reducing GHG emissions.

Interviewees offered the following high-level comparisons of efforts in different states:

- Massachusetts is a leader in terms of developing energy optimization incentives as part of the EE policies and programs, but Massachusetts is still in the early phases of implementing energy optimization measures. In contrast, Vermont and Maine are further along in terms of implementing fuel switching measures. Vermont has the highest ductless heat pump (DHP) installation rate (as a percentage of total homes) of any state in the Northeast, due in large part to a successful upstream incentive program.[20] Maine has high heat pump adoption which administrators attribute to the large customer cost savings that are available from fuel switching.[21]

- Energy optimization programs in Connecticut and Rhode Island are roughly nine months behind Massachusetts in terms of their program development. Interviewees noted that states are not disadvantaged by this time lag, though, since they benefit from lessons that are learned in early-mover states.

- When states develop benefit-cost tests that are specifically aligned with their policy goals, the efficiency measures that further those goals are more likely to pass through cost-effectiveness screening. For example, the Rhode Island test enables more heat pumps to pass screening because of the state-specific benefits that it counts.

This section presents our findings organized by theme, allowing readers to see how individual issues are handled across different jurisdictions.

4.1 Policies and Optimization Measures in Northeastern States

4.1.1 State Policy

State policies – legislation, strategy, executive order, commission order, etc. – are usually the driving force for EE programs and their goals. The table below identifies the different policies that influence Northeastern states' EE programs and measures.

[20] ACEEE. P.51. https://aceee.org/sites/default/files/publications/researchreports/a1803.pdf

[21] Source: ACEEE (2018). "Energy Savings, Consumer Economics, and Greenhouse Gas Emissions Reductions from Replacing Oil and Propane Furnaces, Boilers, and Water Heaters with Air-Source Heat Pumps." Available at: https://aceee.org/sites/default/files/publications/researchreports/a1803.pdf

Table 1. Key Energy Efficiency and Optimization Policies in the Northeast

State	Key Policies	Focus Areas
NH	RSA 4-E:1 – State Energy Strategy **[2017]**	This legislation directed the Office of Energy and Planning to develop a 10-year Energy Strategy for the state, in consultation with a State Energy Advisory Council. The statute also requires that the plan be updated every 3 years.[22]
	RSA 378:37 – Least Cost Energy Planning, New Hampshire Energy Policy **[2014]**	This statute declared that energy policy in NH must meet the energy needs of the citizens and businesses at the lowest reasonable cost while providing reliability and diversity of energy sources, maximizing cost effective EE resources, protecting health and safety of citizens, and protecting the environment and future supply of resources.[23]
	SB 268 – An Act relative to funding for certain energy efficiency programs **[2014]**	This legislation declared that RGGI funding is to be used for all-fuels.
	HB 1490-FN – An Act relative to NH's RGGI cap and trade program controlling CO2 emissions **[2012]**	House Bill 1490-FN includes the required use of RGGI funds for CORE EE programs funded by SBC. The bill requires a legislative oversight committee on electric utility restructuring to monitor and report on certain CORE EE programs. It also established the EE fund.
	Climate Action Plan **[2009]**	In 2009, the Governor's Climate Change Policy Task Force and the NH Department of Environmental Services published a Climate Action Plan with recommendations to curtail the state's GHG emissions. The action plan recommends that New Hampshire strive for a reduction in GHG emissions of 80 percent below 1990 levels by 2050. In the plan, the task force recommends 67 actions to reduce emissions from buildings, electric generation, and transportation, protect our natural resources, and more. [24]

[22] RSA 4-E:1 is available here: http://www.gencourt.state.nh.us/rsa/html/I/4-E/4-E-1.htm

[23] RSA 378:37 is available here: http://www.gencourt.state.nh.us/rsa/html/xxxiv/378/378-37.htm

[24] The NH Climate Action Plan is available here: https://www.des.nh.gov/organization/divisions/air/tsb/tps/climate/action_plan/nh_climate_action_plan.htm

State	Key Policies	Focus Areas
MA	MA Comprehensive Energy Plan 2018 **[2018]**	The MA 2018 Comprehensive Energy Plan shows that aggressive conservation and fuel switching most significantly reduces 2030 GHG emissions in a modeling scenario.
	The MA Joint Statewide Electric and Gas Three-Year Energy Efficiency Plan for 2019-2021 [**2018]**	The Three-Year Energy Efficiency Plan recognizes the benefits of strategic electrification. It supports energy optimization, including fuel switching.
	An Act to Advance Clean Energy (H.4857, Amendment to the Green Communities Act) [**2018]**	This amendment allows for the inclusion of strategic electrification and renamed the electric utilities' efficiency plan as a broader "energy" efficiency plan, reflecting the expansion of scope.
	The Green Communities Act **[2008]**	The Green Communities Act mandates that there be an EE plan every three years. The plan must align with state policy goals to decrease energy costs and increase reliability through reductions in winter and summer peak demand.
	The Residential Conservation Services statute, G.L. c. 164 App., §§2-1 to 2-10 **[1980]**	This statute is the original MA EE law.

State	Key Policies	Focus Areas
CT	2018 Comprehensive Energy Strategy **[2018]**	The 2018 Comprehensive Energy Strategy calls out the necessity for widespread electrification of building thermal loads and transportation to meet CT's 2050 GHG emission target under the CT Global Warming Solutions Act. It specifically addresses the installation of ASHP for efficient cooling, so it may also displace heating supplied by oil propane, and electric resistance. This strategy also includes the development of an all-electric package for the Residential New Construction program.
	Executive Order 46 – Creating the Governor's Council on Climate Change **[2015]**	This order created the Governor's Council on Climate Change (GC3). The Council's job is to examine the effectiveness of existing policies and regulations designed to reduce GHG emissions and identify new strategies to reach the state's GHG emissions reduction target.
	Gen Stat § 16-245m **[2013]**	This statute orders that a combined electric and gas Conservation and Load Management Plan must be submitted to the Energy Conservation Management Board every three years. The plan needs to "include a detailed budget sufficient to fund all energy efficiency that is cost-effective or lower cost than acquisition of equivalent supply" and "include steps that would be needed to achieve the goal of weatherization of eighty per cent of the state's residential units by 2030."[25]
	The CT Global Warming Solutions Act **[2008]**	This Act set targets for GHG emissions reductions. By 2020, GHG emissions will be reduced to 10% below the level emitted in 1990. By 2050, GHG emissions will be reduced to 80% below the level emitted in 2001.[26]

[25] CT Gen Stat § 16-245m (2013), Paragraph D: https://www.cga.ct.gov/current/pub/chap_283.htm#sec_16-245m

[26] CT Global Warming Solutions Act, Section 2: https://www.cga.ct.gov/2008/ACT/PA/2008PA-00098-R00HB-05600-PA.htm

State	Key Policies	Focus Areas
RI	Annual Energy Efficiency Plan for 2019 **[2018]**	Introduces a heat pump initiative for Fall 2018 with plans to double the number of projects in 2019 to support RI's GHG emissions reduction goals and Power Sector Transformation goals.
	The Least Cost Procurement Standards (under Docket 4684) **[2018]**	The Least Cost Procurement Standards specify that "energy efficiency plans should address new and emerging issues as they relate to Least Cost Procurement (e.g., CHP, strategic electrification, integration of grid modernization, gas service expansion, distributed generation and storage technologies, energy efficiency services for non-regulated fuels, etc.), as appropriate, including how they may meet State policy objectives and provide system, customer, environmental, and societal benefits."[27]
	Settlement Agreement – Docket Nos. 4770 and 4780 **[2018]**	The RI PUC directed the utilities to include heat pump rebates to be funded through the EE programs.
	Resilient Rhode Island Act **[2014]**	The Resilient Rhode Island Act established the Executive Climate Change Coordinating Council (EC4) and set specific GHG emissions reduction targets. These targets are relative to 1990 levels: 10% by 2020; 45% by 2035; and 80% by 2050. The Council was tasked with developing and tracking the implementation of a plan to achieve their GHG emission reduction goals.
	The System Reliability and Least-Cost Procurement Statute, R.I. Gen. Laws § 39-1-27.7 **[2006]**	The System Reliability and Least-Cost Procurement Statute, states that least-cost procurement shall comprise system reliability, EE, conservation procurement. Additionally, least-cost procurement will include distinct activities with the goal of meeting electrical and natural gas needs in Rhode Island, while being optimally cost-effective, reliable, prudent, and environmentally responsible.[28]

[27] As found on page 1 in section 1.2 of the Least Cost Procurement Standards. Available at: http://www.ripuc.org/eventsactions/docket/4684-LCP-Standards-FINAL.pdf

[28] As found in R.I. Gen. Laws § 39-1-27.7. System reliability and least-cost procurement. Available at: http://webserver.rilin.state.ri.us/Statutes/TITLE39/39-1/39-1-27.7.HTM

State	Key Policies	Focus Areas
NY	Order Adopting Accelerated Energy Efficiency Targets (Case 18-M-0084) **[2018]**	The NY Public Utilities Commission responded to the “Ramping Up Heat Pump Adoption in New York State” report with the Order Adopting Accelerated Energy Efficiency Targets. The order adopts a subsidiary target of an annual reduction of 3% in electricity sales by 2025, and a subsidiary target of at least 5 TBtu in reduction through heat pump deployment.
	Ramping Up Heat Pump Adoption in New York State: Targets and Programs to Accelerate Savings **[2018]**	The Natural Resources Defense Council (NRDC) teamed with the Vermont Energy Investment Corporation (VEIC) to develop a report in response to VEIC’s previous report, New Efficiency New York. In this report, they examine the potential of strategic electrification through heat pump technologies to increase energy savings.
	New Efficiency: New York **[2018]**	The VEIC developed a report for NYSERDA, New Efficiency: New York. The report identifies strategies to reduce energy consumption across the state.
	2015 New York State Energy Plan **[2015]**	Set clean energy goals for 2030: • 40% reduction in GHG emissions from 1990 levels • 50% of energy generation from renewable sources
	The Public Service Law (PBS § 65)	The Public Service Law assigned the New York Public Utilities Commission the responsibility and authority to ensure that utilities carry out “their public service responsibilities with economy, efficiency, and care for the public safety, the preservation of environmental values and the conservation of natural resources.” PSL §5(2); see also PSL §66(3).
	The New York Energy Law	The New York Energy Law, including §§ 3-103 and 6-104, orders that the Commission considers actions to effectuate State energy policy and the New York State Energy Plan, which includes increased EE.[29]

[29] Enabling policies as described on page 15 of the Order Adopting Accelerated Energy Efficiency Targets (Case 18-M-0084). Available at: https://drive.google.com/file/d/1jscrJ_1LIloFrwn0dM2dRpqhC1aZHzEY/view

State	Key Policies	Focus Areas
VT	"Tier 3" – Statewide Total Energy Program ("STEP") Beyond Fossil Fuels **[2018]**	Overview, analysis, and projected impacts of Tier III of Act 56. Tier 3 intends to replace fossil fuels with cleaner, renewably-sourced electricity, local wood and biofuels. Additionally, Tier 2 focus on efficiency to reduce net carbon emissions.
	Act 56 / Renewable Energy Standard **[2015]**	Act 56 sets up a strategic electrification program that encourages utilities to electrify heating and transportation. This legislation establishes three Tiers of requirements for the utilities: • Tier I – Total Renewable Electric Requirement – Increase deployment of renewables • Tier II – Distributed Generation – Increase deployment of generation facilities under 5 MW of capacity • Tier III – Energy Transformation – Lower fossil fuel consumption by increasing electrification
	The Least-Cost Integrated Planning statute, 30 V.S.A. § 218c **[2012]**	This statute requires that electric and gas utilities develop a least-cost integrated plan for meeting the public's energy service needs while addressing safety concerns, at the lowest present value life cycle cost, and including environmental and economic costs. Additionally, the statute requires that the plans make process in meeting the state's GHG reduction goals and includes comprehensive EE programs.[30]
	The Jurisdiction statute, 30 V.S.A. § 209 **[2012]**	This statute provides for broad efficiency programs and measures, including CHP. The statute also discusses building efficiency and independent efficiency entities. The statute also calls for a charge to realize all reasonably available, cost-effective EE savings.[31]
	An Act Relating to the Vermont Energy Efficiency and Affordability Act, No. 92 S.209 **[2008]**	In order to meet GHG reduction goals, VT needs to provide effective weatherization services, new funding strategies, green building practices, and installation of renewable energy systems. It is essential VT reduces or eliminates dependency on fossil fuels by significantly improving EE and shifting to non-polluting forms of energy.
	Greenhouse gas reduction goals 10 V.S.A. §578 **[Added in 2005]**	Vermont established GHG reduction goals that call for a 50% reduction in emissions from the 1990 level by 2028 and a 75% reduction by 2050.

[30] As found in the Least-Cost Integrated Planning Statute (30 V.S.A. § 218c). Available at: https://legislature.vermont.gov/statutes/section/30/005/00218c

[31] As found in the Jurisdiction statute (30 V.S.A. § 209). Available at: https://legislature.vermont.gov/statutes/section/30/005/00209

State	Key Policies	Focus Areas
ME	An Act to Transform Maine's Heat Pump Market to Advance Economic Security and Climate Objectives **[2019]**	Requires Forward Capacity Market Payments to support goal of deploying 100,000 heat pumps between fiscal year 2019-20 and fiscal year 2024-25, supplementing funding already allocated under the 2020-2022 Triennial Plan.
	Triennial Plan for Fiscal Year 2020-2022 **[2018]**	Inclusion of an innovation program which will enable ME to focus on fuel-switching measures, converting oil/propane/natural gas heating systems to air source heat pumps.
	Efficiency Maine Trust Act (title 35-A chapter 97) **[2013]**	Established the Efficiency Maine Trust, which administers the EE programs in ME. Set the following goals: reduce energy costs, including heating costs; weatherize all homes by 2030; reduce peak-load demand by 300 MW by 2020; achieve electricity and natural gas program savings of 20% and heat fuel savings of 20% by 2020; create stable private sector jobs providing alternative energy and EE products and services by 2020; reduce GHG emissions from heating and cooling buildings consistent with state's Reduction Goals.
	Reduction Goals 38 MRSA §576 Chapter 3-A: Climate Change **[2003]**	ME set goals to reduce GHG emissions by 2010, 2020, and long-term. In the long-term, reduction of GHG emissions must be enough to eliminate any dangerous threat to the climate. Aggressive reduction targets such as 75% to 80% below 2003 levels may be required.

4.1.2 Optimization Measures in Northeastern States

The focus of Northeastern states' energy optimization measures is electrification using electric heat pumps. Most Northeastern states incentivize CHP projects, which displace utility electric consumption by using on-site combustion of natural gas to generate electricity and utilize waste heat from electric generation for space heating and water heating. Most Northeastern states exclude electric vehicles (EVs) from their EE programs. Typically, EV chargers and infrastructure fall under the EE programs, while the actual vehicles do not.

Table 2. A Selection of Current and Possible Future Residential Energy Optimization Measures in the Northeast

State	Current Residential Energy Optimization Measures		Potential Future Residential Measures, According to Stakeholder Interviews
	Air-Source Heat Pumps	CHP	
NH	Yes[32]	Yes	
MA	Yes	Yes	Wood pellet stoves
CT	Yes	No	Industrial heat pumps
RI	Yes	Yes	
NY	Yes	Yes	Ground source heat pumps, natural gas heat pumps
VT	Yes	Yes	Pellet/wood heat, heat pump hot water heaters
ME	Yes	Yes	

In other Northeastern states, energy optimization measures are typically administered through utilities' EE programs. In MA and NY, third parties offer additional incentives. The rebates offered by third parties are not regulated, and third parties have more freedom than utilities to define metrics and goals.

[32] NH has incentives for HPs and HPHWHs, though currently through the electric utility. This is an under-incented potential fuel-switching measure.

Table 3. Administration of Energy Optimization Measure Incentives in the Northeast

State	Administration of Energy Optimization Measure Incentives
NH	Measures are offered through EE programs administered by the utilities. The PUC offers rebates for solar thermal and wood pellet central boilers and furnaces.
MA	Measures are offered through EE programs administered by the utilities. The Mass Clean Energy Center (MassCEC) offers additional HP incentives on top of utility incentives. MassCEC also rebates ground-source HPs, wood heat, and solar hot water.
CT	Measures are offered through EE programs administered by the utilities.
RI	Measures are offered through EE programs administered by the utilities.
NY	Measures are offered through EE programs administered by the utilities. The utilities offer downstream incentives while NYSERDA, a third party, offers midstream incentives.
VT	Measures are offered through the Tier III program (from Act 56) by the electric utilities. The EE programs are run through Efficiency Vermont, a non-utility program, and do not focus on energy optimization, only EE. Efficiency Vermont does offer heat pump rebates though and counts unregulated fuel savings from the switch. Zero Energy Now, a program run by the Building Performance Professional Association of Vermont and Green Mountain Power, encourages the adoption of cold climate heat pumps and heat pump water heaters.[33]
ME	Measures are offered through Efficiency Maine – a non-utility, statewide agency that promotes EE and helps reduce energy costs for residents. Efficiency Maine provides rebates and incentives for home and business use of efficient lighting, equipment, and heating systems.

4.1.3 Electric Measures versus Natural Gas Measures

None of the Northeastern states we reviewed incentivize customers to switch from unregulated fuels to natural gas, since conversions to natural gas do not support the states' long-term policy goals, as well as concerns over free-ridership. Most Northeast states focus on electrification rather than fuel-neutral energy optimization. Interviewees noted that expanding the natural gas infrastructure and shifting customers to natural gas conflicts with their states' longer-term goals for electrification.

Massachusetts stakeholders offered several reasons for omitting natural gas (NG) fuel-switching measures:

- MA decided there is no need for public intervention to support conversion to natural gas since these conversions are cost effective for customers without incentives. In other words, free ridership would be very high for these measures. However, MA still provides incentives to install high-efficiency gas equipment if a customer makes an independent decision to switch fuels.
- Recent MA legislation allows electric utilities to count total energy savings (i.e., savings of electricity and delivered fuels), but the same legislation limits natural gas utilities to claiming only natural gas savings.

[33] Comparative Energy Use of Residential Gas Furnaces and Electric Heat Pumps: https://aceee.org/sites/default/files/publications/researchreports/a1803.pdf

- MA utilities noted that a subset of NG-to-electric fuel-switching measures does not pass cost screening tests.

California has been encouraging customers to switch from natural gas to electric. One natural gas fuel switching program, the OFF Gas Program, was being develop by East Bay Community Energy in 2018. The program does not appear to be approved yet.[34]

MCE Clean Energy and Sonoma Clean Power, both municipal utilities in California, are piloting $1,500 rebates to customers who switch out their natural gas heaters for heat pump electric models.[35]

4.2 Benefit-Cost Tests for Energy Optimization Measures

Utilities in the Northeast use a variety of cost effectiveness tests to screen energy optimization measures. Rhode Island has developed its own Rhode Island Test based on state-specific priorities such as resiliency. Several states (MA, RI, VT, CT) count unregulated fuel savings as a benefit, while other states (NH, ME, NY) do not count unregulated fuel savings.

Table 4. Benefit-Cost Tests in the Northeast

State	Benefit - Cost Test	Background	Account for Unregulated Fuel Savings?	Total GHG Emission Reduction Counted as NEI?[36]
NH	Total Resource Cost Test (TRC)	NH's goal is to reduce energy usage through cost-effective efficiency measures.	No	No[37]
MA	Total Resource Cost Test (TRC)	The Green Communities Act was broad and gave MA a lot of freedom. The TRC allows them to include many inputs.	Yes, but only for switch to electric	Yes, $68/ton for carbon abatement
CT	Modified Utility Cost Test (MUCT)	CT uses the MUCT for their residential electric programs. CT is currently reviewing its B/C testing methodology.	Yes, but only for residential weatherization program and HPWH	No (being considered for future) [38]

[34] To read more about EBCE's proposed OFF Gas Program, follow this link: https://ebce.org/wp-content/uploads/EBCE_Opportunities-for-Natural-Gas-Fuel-Switching_DRAFT.pdf

[35] As stated on page 23 of the draft of "Opportunities for Natural Gas Fuel Switching" for EBCE: https://ebce.org/wp-content/uploads/EBCE_Opportunities-for-Natural-Gas-Fuel-Switching_DRAFT.pdf

[36] Most Northeastern states include embedded costs of GHG emissions as part of their energy avoided costs. This table describes how states treat total costs of GHG emissions.

[37] NH utilities do not count the non-embedded costs of GHG emissions. They do, however, count the embedded costs of GHG emissions for electric consumption as part of energy avoided costs. Similarly, NH considers GHG emissions from natural gas consumption, and counts these costs separately from the NEI adder.

[38] While CT does not count total costs in its modified utility cost test, its limited heat pump pilot program counts total emissions costs using a value of $100/ton of CO_2 based on the 2018 AESC. Source: CT 2019-2021Conservation & Load Management Plan. p.214. Available at: https://www.ct.gov/deep/lib/deep/energy/conserloadmgmt/final-2019-2021-clm-plan-11-19-18.pdf

State	Benefit - Cost Test	Background	Account for Unregulated Fuel Savings?	Total GHG Emission Reduction Counted as NEI?[36]
RI	Rhode Island Test	The Rhode Island Test allows RI to be state-specific. All data and facts are RI specific.	Yes, but only for switch to electric	Yes, $68/ton for carbon abatement[39]
NY	Societal Cost Test (SCT)	Most of the benefits included in the Benefit Cost Analysis Order can be evaluated under the SCT since their impact can be applied to society as a whole.	No, but there are plans to count unregulated fuel savings in the near future	Yes, $47.25/ton for carbon abatement[40]
VT	Societal Cost Test (SCT)	The SCT looks at how society is impacted, so there are more costs and benefits being considered.	Yes, but only for switch to electric	Yes, estimated at $100/ton for carbon abatement[41]
ME	Total Resource Cost Test (TRC)	The benefit-cost test is required for overall portfolio, total program, customer project, and individual measure level screening, with exceptions for low-income programs, pilots, and new technologies.	Yes	No[42]

4.2.1 Comparing Site Savings and Source Savings

Northeastern states focus on site savings. New Hampshire utilities currently calculate the site savings associated with energy optimization measures using savings values derived from impact studies. Massachusetts utilities are considering methods to account for the fact that electricity used on-site, but generated offsite, contains embedded energy with heat values from a mix of fuels that generate the electricity.[43] New Hampshire stakeholders agreed that New Hampshire does not have a framework to

[39] RI plans to go from $100/ton of CO2 to $68/ton of CO2 in their 2020 Energy Efficiency Plan, available here: http://rieermc.ri.gov/wp-content/uploads/2019/06/2020-energy-efficiency-plan-outline-memorandum_6_10_19-final.pdf

[40] In NY, the primary societal benefit that is quantified in evaluating utility energy efficiency programs is the social cost of carbon, currently valued at $27.41 per MWh. Source: NYSERDA (2018). "New Efficiency: New York" p.43. This value is converted to $/ton CO_2 as follows: ($27.41/MWh) x (2000 lbs/ton) x (1 MWh/1160 lbs CO2) = ~$47.25 /ton CO2

[41] VT uses environmental compliance and externality values from Synapse's 2015 AESC Study, with a value estimated at $100/ton CO_2. Source: ACEEE (2018). "Cost-Effectiveness Tests: Overview of State Approaches to Account for Health and Environmental Benefits of Energy Efficiency." p.10. Available at: https://aceee.org/sites/default/files/he-ce-tests-121318.pdf

[42] Maine does not currently count environmental benefits. Source: National Efficiency Screening Project (NESP). "Database of State Efficiency Screening Practices (DSESP)." Available at: https://nationalefficiencyscreening.org/state-database-dsesp/

[43] In January 2019, the Massachusetts Department of Public Utilities directed the Program Administrators to propose a more refined method to account for the conversion of electric savings to MMBtu savings. See p.156-157 of D.P.U. 18-110 through D.P.U. 18-119, at: https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/10317061

compare source savings and site savings, and they have expressed interest in learning more about the methods that Massachusetts utilities are developing.

New Hampshire stakeholders were wary of the complexity associated with comparing site savings to source savings. Stakeholders said that the boundaries of any comparison should be well-defined, and some suggested that utilities should not attempt a life-cycle fuel analysis. Other stakeholders suggested that New Hampshire should not ignore the source impacts from fuel switching just because these impacts are difficult to measure.

4.2.2 Impacts to Winter and Summer Peak Loads

Other Northeastern states agreed that electrification may increase the winter electric peak load. Northeastern states account for winter electric peak load increases in their B/C models using costs from the Avoided Energy Supply Components (AESC) study. The AESC study reports $0 cost for winter electric peak load increases, since New England is summer peaking and the avoided cost is associated with avoiding new capacity in summer. None of the Northeastern states account for increases to the winter natural gas peak resulting from energy optimization measures, since they do not offer measures to incentivize switching to natural gas. Several areas of New England and New York have constrained natural gas supply in the winter since electric generation competes with heating for natural gas. The use of fuel oil for electricity generation has driven up the cost of electricity during some periods in the winter. A large portion of electric generation is fueled by natural gas and buildings shifting from fuel oil to electric heat will further constrain natural gas supplies until larger quantities of renewables and energy storage enter the winter supply mix.

Assuming that heat pumps are used both for the A/C function in summer as well as the heating function in winter, electrification may affect the summer peak load, but the net effects are expected to be slight. Customers who did not previously use A/C who begin to use the A/C function of heat pumps will see peak demand increase with HP installation, absent other modifications. Customers who previously used window A/C or less efficient central A/C will experience a reduction in peak summer demand resulting from installation of an efficient HP. These effects were explored in the Energy Optimization Study conducted for the MA Energy Efficiency Advisory Council.[44] That study used spreadsheet modeling to examine the energy use impacts of residential fuel switching measures, including measures that incentivize the installation of efficient heat pumps. Residential customers in NH do not face demand charges, so changes in demand will not directly affect individual customers. However, customers may be indirectly affected if system-wide costs go down, and the potential effect of system-wide impacts are discussed in section 4.5 of this report.

At present, New Hampshire's savings claim accounts for decreases in demand resulting from same-fuel efficiency measures, but the calculation does not account for the increase in demand that results from customers switching fuels. For example, when a customer switches from an oil-fired boiler to an electric heat pump, the new kW load of the heat pump is not counted as a cost in the B/C calculation. Similarly, when a customer replaces an electric chiller with a natural gas chiller, the reduction in kW load is not counted as a benefit in the B/C calculation.[45]

4.2.3 Treatment of Increased kWh Usage in Benefit Cost Calculation and Goal Setting

Energy optimization measures that shift customers' energy use from fossil fuels to electricity will result in increased electricity consumption. New Hampshire's EERS policy sets specific targets or goals for energy

[44] MA EEAC (2018). "RES21 Energy Optimization Study." Available at: http://ma-eeac.org/wordpress/wp-content/uploads/RES21_Energy-Optimization-Study_09OCT2018.pdf

[45] Replacing electric chillers with natural gas chillers increases the natural gas load, but these increases occur during the summer when there is excess natural gas supply capacity available in the local distribution system.

savings, which utility companies serving New Hampshire ratepayers must meet. New Hampshire stakeholders expressed concern that energy optimization measures that increase electricity consumption could affect utilities' ability to achieve their energy savings goals. New Hampshire stakeholders asked the team to explore how other states treat the negative electric savings resulting from energy optimization measures in their goal setting and accounting process.

In Massachusetts, utilities report the increased kWh consumption associated with energy optimization measures, and they count increased consumption as a negative benefit in the B/C analysis. However, utilities do not count the negative kWh savings when calculating progress towards achieving their electric program goals.[46] Consolidated Edison (ConEd) in New York uses this same approach for calculating savings from heat pump measures.[47] Massachusetts uses a similar approach for energy optimization measures that increase natural gas consumption. For example, a CHP project incentivized through an electric efficiency program would result in increased natural gas consumption. For such a project, the utility would report the additional natural gas consumption and count it as a negative benefit in the B/C analysis, but the utility would not count the increased consumption against the natural gas program goals.

4.3 Contractor and Workforce Training

All of the Northeastern states have some sort of workforce training and outreach. Many states have developed a network of contractors who they provide training for and who help educate customers about energy efficient equipment options.

Table 5. Contractor and Workforce Training in the Northeast

State	Contractor and Workforce Training
NH	NHSaves currently budgets for contractor training and customer education. New Hampshire utilities spent $250,000 on education programs in 2018. Some New Hampshire stakeholders feel that current training efforts are not sufficient to meet program needs. Any expansion in program energy optimization offerings should be accompanied by additional education and workforce training.
MA	MA requires system integration for fuel switching measures. In this case, system integration is the process of bringing together a fuel-fired system and a heat pump so that they are controlled together and function as one system. MA has done extensive outreach to manufacturers and contractors regarding system integration. Manufacturers have started developing integration controls in response. MA is planning to develop a customer-facing calculator that will help customers make decisions about fuel switching and energy optimization. MA provides trainings for their lead vendors and trade allies to ensure that they are familiar with program offerings and are able to provide appropriate information when conducting energy audits.
CT	CT is in the process of developing customer and contractor training that they will release prior to their heat pump pilot. Energize CT is already providing education and training materials to encourage customers with ductless air source heat pumps to use their heat pumps as the primary heat source and their fuel heating equipment as backup.[48] CT created an Energy Management Systems Trade Ally Network. CT leverages the expertise of their trade allies to better understand particular business applications, industries, and their

[46] Source: Email correspondence on 7/3/2019 with Brandy Chambers, Senior Analyst – Energy Efficiency, Eversource MA.

[47] Source: Email correspondence on 7/8/2019 with Emily Morris, Senior Specialist – Energy Efficiency, Consolidated Edison Co. of NY, Inc.

[48] Comparative Energy Use of Residential Gas Furnaces and Electric Heat Pumps: https://aceee.org/sites/default/files/publications/researchreports/a1803.pdf

State	Contractor and Workforce Training
	customers. Additionally, the trade allies help guide customers through the EE options and provide feedback to CT about what incentives and EE measures are needed. The trade allies receive extra trainings and support to understand the latest EE measures.[49]
RI	RI has a number of workforce development activities available. National Grid supports trainings for trade allies, vendors, and contractors. This includes a code training and in-field technical training for residential new construction, weatherization training, and technical training for HVAC-specific contractors. National Grid also offers certifications for facility managers to learn energy efficient techniques to optimize energy management. The Community-Based Energy Efficiency initiative was developed to educate customers and increase EE program participation. This initiative includes a new website page for community recruitment and workforce trainings. Additionally, there is the HVAC Electric Program's "Quality Installation Verification" training that ensures cold climate mini-split heat pump systems are sized and installed correctly, and that customers are educated on the proper use of the systems.[50]
NY	NY has researched the different types of equipment contractors offer and what barriers exist for them to offer high-efficiency heat pump equipment. NYSERDA offers trainings with respect to the clean energy industry and trainings to teach contractors about high-efficiency technologies.[51] NYSERDA offers mid-stream incentives to participating installers for the installation of air source heat pumps (ASHPs) in order to accelerate the adoption of ASHPs. In order to become a participating installer, the contractor must obtain the ASHP Manufacturer-sponsored Installation Training Certificate, or proof of comparable training.
VT	Efficiency Vermont drove demand for cold-climate heat pumps and heat pump water heaters by engaging across the supply chain, with manufacturers, distributors, and contractors. Vermont's Efficiency Excellence Network provides free technical training, enhanced support, and qualified leads to members who complete EE training with Efficiency VT.
ME	Efficiency Maine provides online and in-store training opportunities, scholarships, and other support for existing programs run by community colleges. Past programs include trainings for: home energy auditors, contractors learning about new mini-split heat pumps, sales staff at large retail chains who promote ENERGY STAR appliances, large commercial contractors for variable frequency drive (VFD) technology, and facility managers to be certified in operation and maintenance for their building's energy systems. Efficiency Maine also plans to use social media and digital advertising to promote energy education and awareness.[52]

[49] The Energy Management Systems Trade Ally Network was established in the 2018 Plan Update of the 2016-2018 Conservation & Load Management Plan: https://www.ct.gov/deep/lib/deep/energy/conserloadmgmt/clm2018planfinal.pdf

[50] Customer awareness and workforce development discussed in the Annual Energy Efficiency Plan for 2019: http://www.ripuc.org/eventsactions/docket/4888-NGrid-EEPP2019(10-15-18).pdf

[51] Training Opportunities available through NYSERDA: https://www.nyserda.ny.gov/Business-and-Industry/Training-Opportunities

[52] From Triennial Plan for Fiscal Year 2020-2022, https://www.efficiencymaine.com/docs/Proposed_Triennial_Plan_for_FY2020_2022_10_22_2018_PUC_Filing.pdf

4.4 Lost Revenue Calculations

Lost revenue calculations are not relevant since other Northeastern states are decoupled. Decoupling removes a disincentive for utilities to promote EE measures, even though these lead to a decrease in revenue. In New Hampshire, all but one of the distribution utilities have not decoupled. Instead, NH utilities collect lost revenues attributable to their investments in EE through a lost revenue adjustment mechanism (LRAM). The LRAM differs from full decoupling since it focuses only on the lost revenues directly attributable to the EE program, and the LRAM does not take into account the possibility that weather, load growth, and other factors might in actuality offset the otherwise lost revenues. Some stakeholders suggested that the negative electric savings attributable to energy optimization measures that build electric load should reduce kWh-based lost revenues.

4.5 Rate Impacts and Inverse Cost Shift Opportunities

Energy optimization and electrification programs will lead to additional electricity sales to customers who convert from fossil fuel heating to electric heating. If programs are deployed effectively, utilities may collect revenue from additional electricity sales that is greater than the sum of the cost of providing the additional electricity plus the cost of promoting the electrification measures. With this additional revenue, utilities have the potential to reduce electric rates by spreading the cost of fixed assets (poles, wires and infrastructure) across a larger volume of sales. Energy Futures Group conducted a high-level analysis in Vermont that estimated up to $7 million in rate savings over the lifetime of Tier 3/STEP measures installed in just 2018 and up to $300 million from measures installed over the 2018-2032 period.[53]

NYSERDA's *New Efficiency: New York* report describes the so-called "inverse cost shift" effect, which can result in heat pump customers paying for more than their fair share of fixed electric grid costs, reducing burdens on other ratepayers.[54] NYSERDA describes the effect as follows: Installations of heat pump technology to replace conventional oil or gas heating lead to increased customer electric bills and increased utility revenues, particularly in the winter heating season. The report continues:

> "Because the system is generally less constrained in the winter heating season, the increase in cost for the utility to provide the additional electricity in the winter is often less than the increase in revenue for the utility.
>
> "For regulated utilities that earn a specified return on invested capital, an increase in utility revenues that exceeds the cost to serve additional load cannot be retained as profit but must be returned to utility ratepayers. As a result of these dynamics, the installation of a heat pump may lead the customer to start paying for a relatively larger fraction of the total systemwide grid infrastructure costs, which in turn, translates to a rate decrease for ratepayers as a whole; an "inverse cost shift" from non-heat pump ratepayers to the heat pump customer occurs."

In summary, customers in decoupled states who replace fossil fuel systems with electric heat pumps may be unduly burdened by bill increases that reduce costs for non-heat pump ratepayers. NYSERDA estimated the amount of inverse cost shift on a per-installation basis. NYSERDA found that, depending on which utility is supplying the electricity, customers who installed air-source heat pumps to replace fuel oil systems could see annual electric bill increases of $534 to $1,187 above the increase in utility costs to

[53] EFG (2018). ""Tier 3" – Statewide Total Energy Program ("STEP") Beyond Fossil Fuels." Available at: http://www.energyfuturesgroup.com/wp-content/uploads/2018/10/Tier-3-White-Paper.pdf

[54] NYSERDA (2019). "New Efficiency: New York. Analysis of Residential Heat Pump Potential and Economics." pp.58-61 Available at: https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/NYSERDA/18-44-HeatPump.pdf

deliver the additional electricity. On a total-bills basis though, those same customers are projected to see a bill savings of between approximately $1,000 and $2,000 annually.[55]

Figure 2 shows how fuel switching to heat pumps leads to increased electric bills and utility revenues, particularly in the winter. In the winter, the increase in utility cost to provide electricity is usually less than the increase in revenue. For regulated utilities, revenues that are greater than costs could be returned to ratepayers.

Figure 2. Inverse Cost Shift – Step 1

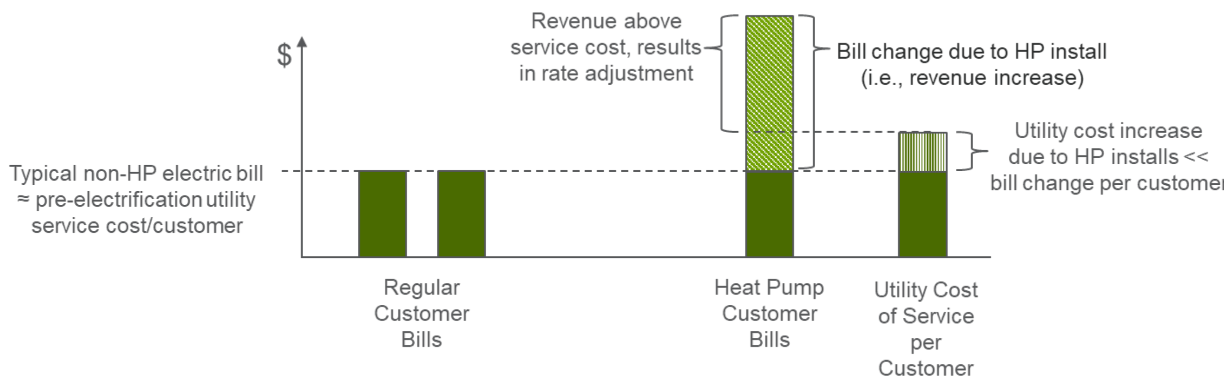
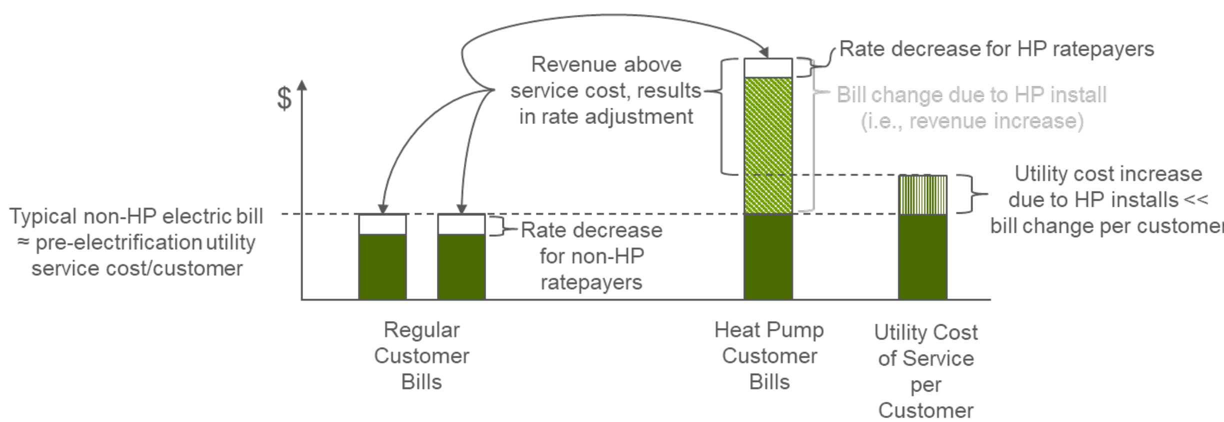


Figure 3 demonstrates that when heat pump customers push revenues above costs, rates decrease for all ratepayers. So, heat pump customers pay a larger share of fixed electricity grid costs than non-heat pump customers. The effects of inverse cost shift may diminish over time, as more customers switch to heat pumps.

Figure 3. Inverse Cost Shift – Step 2



Utilities may take steps to rectify this inverse cost shift effect and improve the payback for heat pump customers. Rate reform and revised rate structures are one means of reducing or eliminating the inverse

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[55] NYSERDA (2019). "New Efficiency: New York. Analysis of Residential Heat Pump Potential and Economics." p.33 Available at: https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/NYSERDA/18-44-HeatPump.pdf

cost shift.[56] However, NYSERDA has noted that: “in the short to medium term, residential customers may not be comfortable choosing such revised rate structures given their typically more complex structure (compared to standard residential rates) and limited visibility for customers as to whether their usage pattern would translate to bill savings. Even customers who would be willing to switch to such rates may discount the additional bill savings under such rate structures heavily given that they occur over time, suggesting that revised rates alone are unlikely to take the place of incentives to stimulate the nascent heap pump market in the short to medium term.”[57]

It is worth noting that the revenue and bill impacts of the inverse cost shift will be more certain to occur in a decoupled state, where any revenues above and beyond the cost of service flow back to ratepayers on an annual basis in between rate cases. Without decoupling, electrification policies stand to benefit utility shareholders more than ratepayers since ratepayers would only receive the benefits of the inverse cost shift once a utility files a rate case (and utilities may not need to do so if electrification policies lead to continued revenue growth). Thus, decoupling should be a prerequisite for electrification policies if such policies are intended to benefit ratepayers rather than utility shareholders.

[56] As an example, NYSERDA notes that PSEG Long Island offers customers with electric heating (including heat pump users) an opt-in rebate of $0.03 per kWh during the winter months, which addresses part of the inverse cost shift for Long Island.

[57] State of New York Public Service Commission (2019). Case 18-M-0084, NYSERDA Comments, 1 July 2019. pp.16-17. Available at: http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7B627EBE62-E9DF-47B5-B088-6CBFFCD00408%7D

5. RECOMMENDATIONS

5.1 Policy Goals Considered in This Study

During this study, our team reviewed policies, orders, and strategy documents, and we identified policy goals and priorities relevant to energy optimization in the Northeastern states. Many states' EE programs have common goals, such as delivering energy savings and reducing customer costs. In this report, we focus on six policy goals, listed in Table 6, that we determined to be specifically related to energy optimization and fuel switching. Some of these policy goals overlap, and some cost-effectiveness screening activities will support more than one goal. For example, activities that support strategic electrification will likely also minimize GHG emissions and reduce fossil fuel usage.

Table 6. Policy Goals Related to Energy Optimization and Fuel Switching

Policy Goal	Description	Northeastern States Pursuing the Goal
Strategic Electrification	Strategic electrification involves powering end uses with electricity instead of fossil fuels in a way that increases EE and reduces pollution, while lowering costs to customers and society, as part of an integrated approach to decarbonization.[58]	CT, MA, NY, RI, VT
Minimize GHG Emissions	Minimizing GHG emissions involves pursuing activities that reduce GHG emissions more than the alternate actions that are available. To be considered a GHG-minimizing activity, an activity must reduce emissions more than any comparable alternatives.	CT, MA, ME, NY, RI, VT
Reduce Fossil Fuel Usage	Reduction of fossil fuel usage involves directly reducing the amount of fossil fuel consumed in the economy.	ME, VT
Improve EE Program Cost-Effectiveness	Improving EE program cost-effectiveness means pursuing activities that increase the amount of energy and demand savings for the amount of money spent to implement the activity.	CT, MA, ME, NY, RI, VT
Pursue Holistic B/C Accounting	Pursing holistic B/C accounting involves accounting for all relevant impacts, even those that are difficult to quantify. Holistic B/C accounting is symmetrical, where both benefits and costs are included for each relevant type of impact.[59]	MA, ME, RI, VT
Improve Load Factor	Load factor can be improved by reducing demand, by distributing loads over different time periods, and/or by keeping demand stable and increasing consumption. Load factor improvements typically reduce the average unit cost per kWh, both for demand and energy.	CT, MA, ME, NY, RI, VT

[58] This definition of strategic electrification is provided by: Northeast Energy Efficiency Partnerships (NEEP) (2017). "Strategic Electrification: An Energy Transformation." Available at: https://neep.org/blog/strategic-electrification-energy-transformation

[59] As stated in Table ES-1. Universal Principles on page viii of the NSPM. Found here: https://nationalefficiencyscreening.org/wp-content/uploads/2017/05/NSPM_Exec_Summary_5-17-17.pdf

5.2 Changes Related to Energy Optimization

In the Task 1 interviews with New Hampshire stakeholders and the Task 2 review of EE programs in other Northeastern states, our team identified changes that EE programs undertake in the course of offering energy optimization measures[60].

This section presents an assessment of the following nine changes related to energy optimization that Northeastern states may or may not pursue, broken out into three categories

Cost-Effectiveness Practices

1. Count Unregulated Fuel Savings for Switching to Electric and Count Electric Load Increase for Fuel-to-Electric Measures
2. Count GHG Emission Reductions as Non-Energy Impacts (NEIs) in B/C Analysis
3. Count Site & Source Savings in B/C Calculations

Measure Offerings

4. Incentivize Oil-to-Natural Gas Measures
5. Offer Tailored Air-Source Heat Pump Measure Bundles
6. Incentivize Electric Vehicles Within EE Programs
7. Incentivize Combined Heat & Power in EE Programs

Program Design

8. Third Party Working in Tandem with Utilities
9. Offer EO-Specific Workforce Training Programs

The following subsections provide detailed information about each of these changes, including the following data:

- A definition of the change
- A list of Northeastern states that have implemented the change
- Policy goals that the change supports
- New Hampshire's current approach to activities affected by the change
- The customer costs, energy usage, and other factors calculated using New Hampshire's current approach compared to an approach that incorporates the change
- The actions required to pursue the change

In section 5.3 of this report, we identify the set of recommended changes that support each of the policy goals identified in section 5.1.

[60] One change that is not discussed here but may be required for a broader EO strategy, is the redesign of performance incentives for utilities. At present, NH utilities are primarily incentivized based on regulated electric/gas savings. These incentive mechanisms could be a significant barrier to the pursuit of EO, since they do not reward efficiency gains associated with fuel switching. There are options available to incentivize utilities' pursuit of EO measures, such as the adoption of an overall "net MMBtu" metric (as in MA) or carving out EO from the rest of the EE programs.

5.2.1 Count Unregulated Fuel Savings and Electric Load Increase for Fuel-to-Electric Measures

Definition of Activity: This activity involves counting the full range of energy and demand savings for customers that shift consumption from unregulated fuels (oil or propane) to electricity. The reduction in unregulated fuel consumption is counted as energy savings and the increase in electric consumption is counted as negative energy savings. In addition to space heating and water heating end uses, this activity could pertain to measures like fossil fuel-to-electric forklifts. This activity also involves counting electric load increases associated with fuel-to-electric measures. Counting electric load increases as a monetized cost lowers the cost-effectiveness of electrification measures and may result in measures having difficulties screening.

Northeastern States That Engage in This Activity: CT[61], MA, ME, RI, and VT all count unregulated fuel savings for certain residential electric measures involving fuel switching. NY has plans to count unregulated fuel savings in the future. CT, MA, ME, NY, RI, and VT account for increased peak load from fuel-to-electric measures.

Relevant Policy Goals:

- Strategic Electrification. This activity improves the cost-effectiveness of measures involving electrification.
- Minimize GHG Emissions. This activity improves the cost-effectiveness of measures that shift consumption from fossil fuels to electricity.[62]
- Pursue Holistic Benefit/Cost Accounting. This activity accounts for the full range of energy savings that are realized by customers who switch their end use consumption from delivered fuels to electricity. Counting unregulated fuel savings for fuel switching customers' accounts for the full range of energy savings that are realized by the customers' fuel switch.
- Reduction of Fossil Fuel Usage. This activity improves the cost-effectiveness of measures that shift consumption from fossil fuels to electricity. Electricity generation uses fossil fuels, but the energy portfolio in the Northeast is partly made up of renewable energy and the efficiency gains associated with a shift to electric heat pumps leads to a net reduction in fossil fuel use.
- Improve Load Factor. Counting load increase for fuel-to-electric measures may encourage states to come up with ways to balance the electricity load in order to continue pursuing electrification goals.
- Improve EE Program Cost-Effectiveness. Counting fuel savings would improve the cost-effectiveness for all electric measures.

Current Practice in NH: For customers who switch fuels, New Hampshire only counts the energy and demand savings associated with the new fuel type (electricity). For example, if a customer switches from an oil-fired boiler to an electric heat pump, the B/C calculation counts the energy and demand savings from a baseline level heat pump to a high-efficiency heat pump but does not count the oil saved by the measure. This does not accurately reflect the fact that the customer's decision to switch fuels will increase electric consumption and will likely increase the winter peak electricity load. Similarly, when a customer replaces an electric chiller with a natural gas chiller, the reduction in kW load is not counted as a benefit in the B/C calculation.

Customer Cost and Energy Usage Impacts: Our team used the NH Energy Optimization spreadsheet model (described in Appendix D) to estimate the customer cost and energy usage impacts associated

[61] CT counts unregulated fuel savings for a 100-unit heat pump pilot. All the other unregulated fuel savings CT claims are for fuel neutral weatherization or upstream HPWHs where they assume a blended market baseline since they do not know existing heating for the homes where upstream units will be installed.

[62] Electricity generation produces GHG emissions, but the efficiency gains associated with a shift to electric heat pumps (typically a shift from 80-90% efficiency for fossil fuel systems to 300% efficiency for electric heat pump systems) leads to a net reduction in GHG emissions when compared to fossil fuel-fired systems.

with different calculation approaches. The values reported here are intended to offer guidance regarding how inputs to the B/C model would change depending on how utilities choose to bound their calculations. The cost savings presented in the tables of model results represent customer bill savings (calculated as fuel savings multiplied by fuel costs) and do not include avoided costs calculated in the B/C model. The table presents an "apples-to-apples" comparison of the customer bill savings calculated using current NH practices (only counting efficiency savings of regulated fuels) compared to alternative practices (counting savings of unregulated fuels and negative savings of regulated fuels). Avoided costs are not included in either calculation. The energy savings values derived from the NH Energy Optimization Model could be used as inputs to the B/C model. Table 7 compares the customer energy cost savings and net energy savings calculated according to the current NH practice (counting only electric efficiency savings) to a calculation that includes savings of unregulated fuels. We used the NH Energy Optimization model (described in Appendix D) to estimate the savings from electric efficiency alone (current NH practice) and to estimate the net savings across all fuel types. Electric savings are converted from kWh/year to a common unit of MMBtu/year using an engineering conversion factor of 1 MMBtu = 293.1 kWh.

The following tables present the energy and demand savings associated with switches from fossil fuel heating to electric heat pumps, and these figures account for changes in electric consumption and demand for space cooling. About 80% of NH customers use electric-powered air conditioning. For customers with air conditioning systems, the installation of an efficient electric heat pump will likely reduce customers' electric consumption and demand from space cooling. For customers without air conditioning, the installation of an electric heat pump adds a new space cooling capability, with associated increases in electric consumption and demand. The savings values in following tables were calculated relative to a weighted baseline blend of A/C technologies in NH that accounts for an estimated saturation of different A/C technologies in NH based on a survey sample of 120 residential New Hampshire customers.[63]

Table 7. Customer Cost and Energy Usage Impacts of Counting Unregulated Fuel Savings for Select Energy Optimization Measures

Energy Optimization Measure	Customer Energy Cost Savings ($/year)				Net Energy Savings (MMBtu/year)			
	Electric EE Savings Only (Current NH Practice)	Counting Unregulated Fuel Savings			Electric EE Savings Only (Current NH Practice)	Counting Unregulated Fuel Savings		
		Fuel Savings	Electric Savings	Net Savings		Fuel Savings	Electric Savings	Net Savings
Residential oil furnace partially displaced by central ASHP (18 SEER)	$183	$1,101	-$649	$451	3.1	49.0	-11.2	37.8
Residential propane furnace partially displaced by central ASHP (18 SEER)	$244	$2,473	-$997	$1,476	4.2	68.8	-17.2	51.6
Residential oil boiler partially displaced by DMSHP (18 SEER)	$444	$1,300	-$678	$622	7.7	57.9	-11.7	46.2
Residential oil-fired coil water heater replaced by HPWH (2.45 UEF)	$547	$404	-$330	$74	9.4	18.0	-5.7	12.3

All impacts in this table were calculated using the adapted Energy Optimization Model described in Appendix D.
Assumes switchover temperature of 25°F from oil to electric heat pump and 15°F from propane to electric heat pump.

[63] The 2018 Claritas Energy Behavior Track annual survey sampled 32,459 residential customers across the U.S. and asked questions on a variety of energy-related topics. At the state level, the survey reports customers' primary source of cooling, and the results for New Hampshire are based on a sample of 120 residential NH customers. Survey results are behind a paywall, and a description of the survey is available at: https://www.esource.com/about-rcic .

This change (i.e., introducing a count of unregulated fuel savings) would affect how savings are calculated by the utilities, but it would not affect the actual customer energy costs or the net energy savings associated with fuel switching measures. In other words, the customer was already saving the unregulated fuel, but the utilities were not counting it. Table 8 presents the summer and winter peak electricity demand impacts for (1) a scenario where the impacts only account for electricity efficiency improvements (current NH practice), and (2) a scenario that counts the demand impacts relative to a baseline of fuel-fired equipment and a baseline blend of A/C technologies in NH.

Table 8. Estimated Electric Demand Savings Impacts for Select Energy Optimization Measures

	Electric Demand Savings (kW)			
	Counting Demand Impacts from Electric Efficiency Only [1]		**Counting Demand Impacts Relative to Fossil Fuel Baseline [2]**	
Energy Optimization Measure	Summer Peak Impact	Winter Peak Impact	Summer Peak Impact [3]	Winter Peak Impact [4]
Residential oil furnace partially displaced by central ASHP (18 SEER)	0.02 kW	1.97 kW	0.61 kW	-1.63 kW
Residential propane furnace partially displaced by central ASHP (18 SEER)	0.02 kW	1.97 kW	0.61 kW	-1.63 kW
Residential oil boiler partially displaced by DMSHP (18 SEER)	0.09 kW	0.16 kW	0.97 kW	-1.09 kW
Residential oil-fired coil water heater replaced by HPWH (2.45 UEF)	0.20 kW	0.19 kW	-0.31 kW	-0.66 kW

[1] The electric capacity savings for the current NH practices were calculated as the product of the maximum load reduction and a seasonal coincidence factor, both of which are reported in the NH B/C models. Demand savings represent the difference in electric demand between a code-level heat pump system and a high-efficiency heat pump system.
[2] The electric capacity savings that would result from counting fuel switching were calculated using the adapted Energy Optimization Model described in Appendix D. Demand savings represent the difference in electric demand between a baseline blend of A/C technologies in NH and a high-efficiency heat pump system.
[3] Fuel switching measures show summer peak demand savings because they compare an efficient electric heat pump to a baseline A/C system. About 80% of NH customers use some type of A/C system (typically central A/C or window/room A/C). The installation of an efficient heat pump would result in demand savings for customers that previously used a baseline A/C system. Calculations of cooling demand savings assume a baseline of 8 EER for window/room A/C and 10 SEER for central A/C systems.
[4] Negative electric demand savings represent an increase in electric demand

Actions Required to Pursue Activity:

- **Utilities must be authorized to count savings outside of regulated fuels when a customer switches from one fuel to another.** New Hampshire's EE program administrators currently have electricity and natural gas savings targets and have limited their savings calculations for energy optimization measures to count only the savings of regulated fuel types, from a baseline code-compliant piece of regulated fuel equipment to a high-efficiency program-eligible piece of regulated fuel equipment. If the Public Utilities Commission seeks to more accurately reflect the value of energy optimization measures by more accurately accounting for unregulated fuel savings and electric load increase for fuel-to-electric measures, it should provide explicit guidance to the program administrators to do so.

- **Must define a baseline level of unregulated fuel consumption.** To prescribe an amount of unregulated fuel savings associated with fuel switching measures, an understanding of the baseline level of unregulated fuel consumption is required. This could involve a baseline study of the oil and propane equipment currently installed in New Hampshire, or New Hampshire could choose to adopt the baseline assumptions used in other states.

- **Develop estimates for electric load impacts of fuel switching measures.** Other Northeastern states already account for increased electric load from fuel-to-electric measures, so New Hampshire could adopt other states' estimates.

- **Update B/C accounting practices to include electric load and kWh increase for fuel-to-electric measures.**

5.2.2 Count Total Costs of GHG Emissions as NEI in B/C Analysis

Definition of Activity: Most Northeastern states already count the embedded costs of power generators' compliance with emissions regulations. This activity involves counting the total costs of GHG emissions as a non-energy impact. Counting total costs of GHG emissions as a monetized benefit increases the calculated cost-effectiveness of measures that reduce GHG emissions, which may result in more measures to better screen or pass B/C screening.

Northeastern states that engage in this activity: MA, RI, NY, and VT all count total costs of GHG emissions. The cost values used in each state are: \$100/ton CO_2 in VT; \$68/ton CO_2 in MA and RI[64]; and \$47.25/ton of CO_2 in NY.[65]

Relevant Policy Goals:

Strategic Electrification. This activity would improve the cost-effectiveness of measures that incentivize switching to efficient electric equipment, since electrification measures reduce GHG emissions. Electrification supports the reduction of GHG emissions as electric systems displace carbon-based fuel systems and increase efficiency. Electricity generation produces GHG emissions, but the efficiency gains associated with a shift to electric heat pumps (typically a shift from 80-90% efficiency for fossil fuel systems to 300% efficiency for electric heat pump systems) leads to a net reduction in GHG emissions when compared to carbon-based fuel systems.

Minimize GHG Emissions. This activity would improve the cost-effectiveness of all measures that reduce GHG emissions, including natural gas efficiency measures.

Pursue Holistic Benefit/Cost Accounting. Holistic B/C accounting involves accounting for all relevant impacts, and the monetization of GHG emissions reductions supports this goal.

Reduction of Fossil Fuel Usage. Monetizing GHG emissions reductions as a benefit would favor measures that reduce fossil fuel consumption since fossil fuel-powered equipment emits larger amounts of GHGs relative to electric-powered equipment.

Improve EE Program Cost-Effectiveness. Counting GHG emission reductions as a benefit would improve the cost-effectiveness of energy optimization measures.

Current Practice in NH: NH utilities do not count the total costs of GHG emissions. They do, however, count the embedded costs of GHG emissions for electric consumption as part of energy avoided costs. This GHG counting activity began with the Statewide Energy Efficiency Plan 2019 Update, and utilities use a value of \$8.98 per ton of CO_2 emissions, based on the AESC forecast of the RGGI price of carbon emissions.[66] This value may change in future plans based on a combination of the RGGI auction price and the AESC emission values.

[64] RI plans to go from \$100/ton of CO2 to \$68/ton of CO2 in their 2020 Energy Efficiency Plan, available here: http://rieermc.ri.gov/wp-content/uploads/2019/06/2020-energy-efficiency-plan-outline-memorandum_6_10_19-final.pdf

[65] This value is calculated from \$27.41/MWh using conversions from the *New Efficiency: New York* report. The calculation is as follows: (\$27.41/MWh) x (2000 lbs/ton) x (1 MWh/1160 lbs CO2) = ~\$47.25 /ton CO2

[66] In response to an inquiry from the NH Office of Consumer Advocate the joint utilities state that the companies referenced the AESC forecast of RGGI price of \$8.98/ton of carbon emissions as depicted in Figure 20 and Appendix D of the 2019 AESC study. Available at: https://drive.google.com/file/d/1WXfihSAAmXLDqP_PsG4RB0Qt25uAn9c7/view

Customer cost and energy usage impacts: Counting the total costs of GHG emissions as an NEI would not impact customer energy costs or net energy savings associated with fuel switching measures. Table 10 presents the estimated GHG emissions reductions for a select set of energy optimization measures. The table compares GHG emissions reductions calculated without counting unregulated fuel savings (current practice in NH) to the GHG emissions reductions when unregulated fuel savings are counted. The GHG reduction values presented in Table 10 are based on energy savings in the NH utilities' 2019 B/C models and on calculations in the adapted Energy Optimization Model (described in Appendix D). To estimate the total costs of these GHG emissions, Table 9 uses an avoided cost of $68 per ton CO_2., consistent with the total cost used in MA and RI.

Table 9. Estimated Amounts of GHG Emissions Reductions and Total Cost Values for Select Energy Optimization Measures

Energy Optimization Measure	GHG Emissions Reduction (tons CO_2/year)				Total Costs of GHG Reductions ($/year), assuming avoided cost of $68/ton CO_2 [1]			
	Electric EE Savings Only (Current NH Practice) [2]	Counting Unregulated Fuel Savings [3]			Electric EE Savings Only (Current NH Practice)	Counting Unregulated Fuel Savings		
		From Fuel Savings	From Electric Savings	Net Savings		From Fuel Savings	From Electric Savings	Net Savings
Residential oil furnace partially displaced by central ASHP (18 SEER)	0.3	4.0	-1.1	2.9	$21	$269	-$73	$196
Residential propane furnace partially displaced by central ASHP (18 SEER)	0.4	4.8	-1.6	3.1	$27	$325	-$112	$213
Residential oil boiler partially displaced by DMSHP (18 SEER)	0.7	4.7	-1.1	3.5	$50	$318	-$76	$241
Residential oil-fired coil water heater replaced by HPWH	0.9	1.5	-0.5	0.9	$61	$99	-$37	$62

[1] This table assumes a total cost of $68/ton CO_2 emissions, which is in line with the total costs used in MA and RI, and is more conservative than the $100/ton CO_2 value used in VT.
[2] GHG emissions reductions for the current NH practice of not counting unregulated fuel savings are calculated by multiplying the energy savings due to electric efficiency by the 2017 ISO-NE average LMU marginal emissions for CO_e: 0.327 tons CO_2/MWh.[67]
[3] The impacts that would result from counting unregulated fuel savings were calculated using the adapted Energy Optimization Model described in Appendix D. For electric consumption, the model calculates GHG emissions using the 2017 ISO-NE average LMU marginal emissions for CO_2. For fossil fuel consumption, the model calculates GHG emissions using carbon emissions factors unique to each fuel type and provided by the U.S. Energy Information Administration (EIA).[68]

Actions Required to Pursue Activity:

- **Select an avoided cost associated with GHG emissions reductions.** As noted above, Northeastern states use different avoided cost values to monetize GHG emissions reductions. To count GHG emissions reductions as an NEI, New Hampshire must associate a cost with these reductions. The 2018 Avoided Energy Supply Cost Study suggests using either a local marginal

[67] ISO NE, 2017 Emissions Report, Table 1-2, 2017 Annual Rate. Available at: https://www.iso-ne.com/static-assets/documents/2019/04/2017_emissions_report.pdf

[68] The model uses GHG emissions factors of 161.3 lb CO2/MMBtu for fuel oil and 117 lb CO2/MMWh for natural gas, and these values are aligned with the OCE 2-006 response cited in footnote 62. For propane, the model uses a GHG emissions factor of 139.0 lb CO_2/MMBtu, which is slightly higher than the value assumed by NH uilities in the OCE 2-006 response.

abatement cost or a global marginal abatement cost, rather than the social cost of carbon. The global marginal abatement cost is $100/ton and based on the cost of carbon capture and sequestration. The local marginal abatement cost is $68/ton and based on the projected cost of offshore wind in New England. These values were chosen due to the uncertainties inherent in selecting a societal cost of carbon value. Some people have argued that because the uncertainties surrounding climate change are large and the potential outcomes could be so significant and long lasting, that larger values associated with GHG emission reduction should be used. There has not been consensus around the higher value though.

- **Update B/C accounting treatment of total GHG emissions to align with AESC 2018 values.**

5.2.3 Incentivize Oil-to-Natural Gas Measures

Definition of Activity: This activity involves providing incentives for fuel switching measures that encourage customers to convert from oil-fired equipment to natural gas equipment.

Northeastern states that engage in this activity: None of the Northeastern states incentivize oil-to-natural gas measures, since incentivizing oil-to-natural gas measures does not support states' goals. MA, CT, and NY specifically call out electrification as a goal. VT's Tier 3 program is intended to replace fossil fuels with cleaner, renewably-sourced electricity. RI's focus on Power Sector Transformation specifically includes efficient heat electrification, and ME has a goal to minimize GHG emissions.

Relevant Policy Goals: Interviewees from other Northeastern states noted that this activity runs counter to strategic electrification, minimizing GHG emissions, and reducing fossil fuel usage.

Current Practice in NH: New Hampshire currently incentivizes natural gas efficiency measures (i.e., measures that upgrade customers from low-efficiency to high-efficiency gas equipment). However, New Hampshire does not currently count delivered fuel savings for customers who switch from other fuels to natural gas.

Customer Cost and Energy Usage Impacts: Table 11 compares the customer energy cost savings and net energy savings calculated with the current NH practice (which counts only natural gas efficiency) to a fuel switching savings calculation that accounts for unregulated fuel savings. The savings under current NH practice are based on values in NH utilities' 2019 B/C Models. The cost savings presented in the tables of model results represent customer bill savings (calculated as fuel savings multiplied by fuel costs) and do not include avoided costs calculated in the B/C model. The table presents an "apples-to-apples" comparison of the customer bill savings calculated using current NH practices (only counting efficiency savings of regulated fuels) compared to alternative practices (counting savings of unregulated fuels and negative savings of regulated fuels). Avoided costs are not included in either calculation.

We used the adapted energy optimization model (described in Appendix D) to estimate savings when unregulated fuels are counted. A full benefit-cost analysis of oil-to-natural gas measures should consider GHG emissions and environmental impacts in addition to the customer cost and energy savings discussed here.

Table 10. Customer Cost and Energy Usage Impacts for Select Oil-to-Natural Gas Measures

Energy Optimization Measure	Customer Energy Cost Savings ($/year)		Net Energy Savings (MMBtu/year)	
	Counting Only Gas Efficiency (Current NH Practice)	Counting Unregulated Fuel Savings [1]	Counting Only Gas Efficiency (Current NH Practice)	Counting Unregulated Fuel Savings [1]
Residential oil furnace (78% AFUE) replaced by natural gas furnace (97% AFUE)	$148 [2]	$800	9.2 [2]	15.6
Residential propane furnace (78% AFUE) replaced by natural gas furnace (97% AFUE)	$148 [2]	$1,970	9.2 [2]	15.6
Residential oil boiler (75% AFUE) replaced by condensing natural gas boiler (95% AFUE)	$227 [3]	$914	14.1 [3]	16.5
Residential oil-fired coil water heater (75% AFUE) replaced by tankless natural gas water heater (EF ≥ 0.94)	$160 [4]	$157	9.9 [4]	2.5

[1] The impacts that would result from counting unregulated fuel savings were calculated using the adapted Energy Optimization Model described in Appendix D.
[2] For the residential ENERGY STAR Products measure “Furnace 97+ AFUE (<150) w/ECM Motor,” NH B/C models show 9.20 MMBtu/year savings.
[3] For the residential ENERGY STAR Products measure “Condensing Boiler >= 95% AFUE (Up to 300 MBH),” NH B/C models show 14.10 MMBtu/year savings.
[4] For the residential ENERGY STAR Products measure “Water Heater - Tankless, On-Demand >=.94,” NH B/C models show 9.90 MMBtu/year savings

Actions Required to Pursue Activity:

- **Authorize EE programs to count total energy savings.** New Hampshire’s EE program is currently authorized to count electricity and natural gas savings. To pursue this activity, natural gas utilities would need to be authorized to include unregulated fuel savings in their B/C calculations. This authorization could come from state legislation or a PUC order.[69]

- **Establish prescriptive savings for common oil-to-natural gas fuel switching measures.** As described in section 5.2.1, any prescriptive measure that counts unregulated fuel savings would need to define the baseline level of unregulated fuel consumption. This could involve a baseline study of the oil and propane equipment currently installed in New Hampshire, or New Hampshire could choose to adopt the baseline assumptions used in other states. Depending on the study scope, Navigant estimates the cost to conduct a baseline study of fossil fuel heating equipment to range from $75,000 to $375,000, depending on whether the study uses data from another jurisdiction(s) or conducts primary data collection in New Hampshire.

- **Conduct additional research, as needed, to determine values for costs and benefits associated with oil-to-natural gas fuel switching measures.**

[69] Note that the NH PUC has rules against the utilities spending ratepayer dollars for promotional activities. Puc 510 prohibits recovery of expenses relating to promotional activity except activities which “Inform gas consumers of or provide gas consumers with information or materials intended to result in economic conservation,”; “Inform natural gas customers how they can improve efficiency in utilizing the utility's service,”; or “[a]re consistent with the utility's approved integrated resource plan.” The rule also requires that “[e]xpenses contained in a utility's IRP shall take into account necessary features for system operation such as diversity, reliability, ability to be readily dispatched, and other factors of risk and shall treat demand and supply to gas consumers on a consistent and integrated basis,” and suggests that “No more than 50% of costs provided for in a utility's IRP shall be borne by ratepayers.”

5.2.4 Count Site & Source Savings in B/C Calculations

Definition of Activity: This activity involves counting the full range of energy savings from both the site and the source. Depending on the scope and scale of the savings calculation, this could involve accounting for the fuel consumed in the generation and distribution of the electricity, or it could involve a larger lifecycle analysis that accounts for consumption associated with extraction and delivery of fuels consumed on-site and at generation facilities. To make a meaningful comparison between electricity and delivered fuels, it is advantageous to apply the same analytical boundaries to all fuel types.

Northeastern states that engage in this activity: None of the Northeastern states currently count both site and source savings in the B/C calculations. Northeastern states only count site savings. MA has plans to count source savings, but their methodology for counting source savings is still in development.

Relevant Policy Goals:

- Minimize GHG Emissions. This activity would capture the complete energy savings of measures and allow measures with the most energy savings to screen more easily. If measures with the most energy savings are screening more easily, in this situation, GHG emissions are minimized.
- Pursue Holistic Benefit/Cost Accounting. Holistic B/C accounting involves accounting for all relevant impacts, and accounting for both site and source savings supports this goal.

States noted that this activity may hinder strategic electrification depending on how electricity is being generated. Also, the generation mix is likely to change significantly over the life of an EO measure—if the site-source calculations are based on current generation mix, they may overstate the emissions increase from electric usage versus a method based on a projection of likely generation sources over the life of a measure.

Current Practice in NH: New Hampshire calculates site savings associated with energy optimization measures using savings values derived from impacts studies. New Hampshire does not currently have a framework to count source savings.

Customer Cost and Energy Usage Impacts: Counting source energy savings would not impact individual customers' energy costs or energy usage. Counting source energy savings may impact the total energy usage savings calculated by the programs, since source savings may include embedded energy from electric generation. The size of this impact would depend on the methodology used to count source savings. A well-developed methodology for counting source savings should account for the environmental impacts of fuel consumption for electricity generation.

Actions Required to Pursue Activity:

- **Develop a method to account for source savings.** In MA, the Department of Public Utilities directed the EE Program Administrators to further develop methodology to count source savings[70]. New Hampshire could wait and adopt the MA method once it is finalized.

- **Update B/C accounting practices to include site and source savings.**

5.2.5 Offer Tailored Air-Source Heat Pump Measure Bundles

Definition of Activity: This activity involves developing specific efficiency measures for air-source heat pumps that that are only available to customers who switch from oil- or propane-fired heating systems or

[70] The MA Department of Public Utilities "direct[ed] the Program Administrators to further study and propose a more refined method to account for the conversion of electric savings to MMBtu savings [and to] report the progress or results of this study as part of their 2019 Annual Reports." (p. 156-157).

electric resistance heating (with or without air conditioning) to electric heat pumps. These EO-specific measures may include eligibility restrictions designed to target fuel switching or electric-resistance heating customers and encourage energy savings in dual-fuel installations.

Northeastern states that engage in this activity: Massachusetts offers air-source heat pump incentives for customers who switch from oil or propane heating systems or from electric resistance heating to an electric heat pump, and these measures are distinct from MA's standard air-source heat pump efficiency measures. MA utilities' benefit-cost models plan to fulfill a larger quantity of standard heat pump measures compared to fuel switching heat pump measures.[71] CT just began (as of July 1) doing this activity as a part of their 100-unit heat pump pilot. The HP fuel switching measure offering includes an additional incentive above the normal HP offering. It is tailored with requirements for configurations and types of existing fossil fuel and new HP systems, integrated controls on ducted units, and weatherization/envelope standards (along with educational materials for customers and contractor training requirements).

Relevant Policy Goals:

- Strategic Electrification. This activity supports strategic electrification goals by developing measures specifically targeted at customers to encourage electrification of their end use consumption.
- Improve EE Program Cost-Effectiveness. This activity involves the development of targeted incentives that could have different incentive values specifically designed for different customer populations.
- Minimize GHG Emissions. This activity would encourage more customers to switch to ASHPs which would minimize GHG emissions.

Current Practice in NH: New Hampshire incentivizes air-source heat pumps within the EE programs, but it does not offer incentives specific to fuel switching customers or to customers with electric resistance heating.

Customer cost and energy usage impacts: This activity has the potential to increase customer cost savings and reduce energy usage. The magnitude of these impacts depends on how measures specific to fuel switching or electric resistance heating are designed. For example, Massachusetts utilities (through the MassSave brand) offer air-source heat pump incentives for customers who switch from oil or propane heating systems to an electric heat pump, and these measures are distinct from MassSave's standard air-source heat pump measures and from MassCEC's whole-home air-source heat pump incentives. Massachusetts' fuel-switching measures only apply to customers who install whole-home systems with an integrated controller. These stipulations guarantee that customers are displacing fossil fuel consumption, and that customers are controlling their heating systems properly. Some NH stakeholders noted that it may be worth integrating controllable load/demand response technologies with heat pumps as a way to ensure minimal peak load impacts. Our team could not identify any evaluations of the customer cost and energy usage impacts from this activity.

[71] For example, the 2019-2021 BCR Model for Eversource Electric forecasts a quantity of about 3,000 for standard heat pump efficiency measures, compared to a quantity of about 2,000 fuel switching heat pump measures in 2021. See tab "EEYr3" of 2019-2021 BCR Model for Eversource Electric, available at: http://ma-eeac.org/wordpress/wp-content/uploads/Exhibit-5-2019-2021-BCR-Model-2-19-19-Eversource-Electric.xlsx

Actions Required to Pursue Activity:

- **Design EE measures specific to fuel-switching customers.** This requires selecting criteria that will be stipulated for fuel-switching rebates, determining the appropriate incentive levels, and revising program websites to promote the targeted measures. Several of these measure updates may be at the discretion of the utilities.
- **Must define a baseline level of unregulated fuel consumption.** To prescribe an amount of unregulated fuel savings associated with fuel switching measures, an understanding of the baseline level of unregulated fuel consumption is required. This could involve a baseline study of the oil and propane equipment currently installed in New Hampshire, or New Hampshire could choose to adopt the baseline assumptions used in other states.

5.2.6 Incentivize Electric Vehicles Within EE Programs

Definition of Activity: This activity involves incentivizing the purchase of electric vehicles through an EE program.

Northeastern states that engage in this activity: VT incentivizes electric vehicles through its EE programs[72]. NY also incentivizes electric vehicles in their EE programs, but to a lesser extent. Most Northeastern states incentivize the installation of efficient EV chargers, but do not incentivize the vehicles themselves.

Relevant Policy Goals:

Strategic Electrification. This activity would encourage electrification of the transportation sector.

Minimize GHG Emissions. This activity would reduce GHG emissions by encouraging customers to switch from gasoline and diesel-powered vehicles to electric vehicles. Because electric vehicles are much more efficient than gasoline and diesel-powered vehicles and Northeast electricity generation is roughly 30% renewables, emissions from electric vehicles are still lower than gasoline and diesel-powered vehicles, even when including source emissions.

Reduction of Fossil Fuel Usage. This activity would encourage customers to power their transportation needs using electricity instead of fossil fuels. Electricity generation uses fossil fuels, but the efficiency gains associated with a shift to EVs lead to a net reduction in fossil fuel use.[73]

Improve Load Factor. Customers may fill in load dips by charging their EVs at off-peak periods. However, default charging patterns may exacerbate winter and summer peaks if not properly managed.

Current Practice in NH: Electric vehicles are not currently covered by New Hampshire's EE program. Several NH stakeholders indicated that electric vehicle incentives are outside the scope of New Hampshire's EE program.

[72] Energy Future's report on VT's Tier 3 program states that the Tier 3 program "requires Vermont's electric utilities to help their customers reduce fossil fuel consumption by adopting… clean energy electrification technologies (such as heat pumps, heat pump water heaters, and electric vehicles)." p.5. Available at: http://www.energyfuturesgroup.com/wp-content/uploads/2018/10/Tier-3-White-Paper.pdf

[73] EVs convert about 59%–62% of the electric energy from the grid to power at the wheels, while conventional gasoline vehicles only convert about 17%–21%. Source: U.S. Dept. of Energy (2017). "Electric-Drive Vehicles." p.3. Available at: https://www.afdc.energy.gov/uploads/publication/electric_vehicles.pdf

Customer cost and energy usage impacts: EVs reduce customers' fuel costs and energy usage for transportation.[74] The amount of annual savings that a given customer will experience depends on the customers' transportation needs. Per the discussion of rate impacts in section 4.5, it is possible that increased vehicle electrification would have the potential to reduce electric rates by spreading utilities' cost of fixed assets (poles, wires and infrastructure) across a larger volume of sales. Some NH stakeholders noted that it may be worth integrating controllable load/demand response technologies with EVs and EV charging infrastructure as a way to ensure minimal peak load impacts.

Actions Required to Pursue Activity:

- **Authorize EE programs to count total energy savings.** New Hampshire's EE program is currently authorized to count electricity and natural gas savings, but the program is not authorized to count gasoline or diesel savings. This authorization could come from state legislation or a PUC order.

- **Adopt a rate scheme with a load management/demand response approach that encourages vehicle charging during off-peak periods.** Under NH's current rate scheme, EV measures could lead to increases in electricity demand at peak periods. NH stakeholders said that if EV measures were to be offered, they should be accompanied by a rate scheme designed to encourage load shifting and peak electricity demand reduction. Considering load management/demand response approaches when designing rate schemes will significantly assist with the management of peak electricity demand.

- **Update EE program scope to include electric vehicles.**

5.2.7 Incentivize Combined Heat & Power in EE Programs

Definition of Activity: This activity involves incentivizing combined heat & power (CHP) measures through an EE program.

Northeastern states that engage in this activity: MA, RI, NY, VT, and ME all incentivize CHP within their EE programs. CT does not.

Relevant Policy Goals:

Improve Load Factor. CHP installations consume natural gas, biofuels, landfill gas, etc., to generate power on-site and make use of waste heat from combustion, which reduces the peak electricity demand through on-site generation.

Current Practice in NH: New Hampshire currently offers CHP as a C&I custom project. CHP projects are rare, though, due to limited commercial and industrial customers capable of implementing CHP.

Customer cost and energy usage impacts: Due to the rarity and variability of CHP projects, impacts should be assessed on a case-by-case basis.

Actions Required to Pursue Activity:

- **None**

[74] The average fuel cost to operate an EV in New Hampshire is $751 per year, while the average for a gasoline-powered vehicle is $1,111, Source: University of Michigan Sustainable Worldwide Transportation (2018). "Relative Costs of Driving Electric and Gasoline Vehicles in the Individual U.S. States." p.4. Available at: http://umich.edu/~umtriswt/PDF/SWT-2018-1.pdf

5.2.8 Third Party Working in Tandem with Utilities

Definition of Activity: This activity involves establishing a third-party EE promotion agency that works in tandem with the utilities. Third-party agencies, such as the Massachusetts Clean Energy Center (MassCEC), have more freedom than utilities to define savings requirements and goals. For example, MassCEC requires that participants receive an energy audit to qualify for rebates. Establishing a third-party agency could allow New Hampshire to target multiple value chain segments sections at once, increasing program awareness and measure adoption. It is possible that a third-party agency could be a group that works on more than just EE.

Northeastern states that engage in this activity: MA, NY, and VT have third party groups that work in tandem with utility programs to offer additional incentives on EE measures. CT's Green Bank provides low-interest financing options and advertising in coordination with Energize CT.

Relevant Policy Goals:

Improve EE Program Cost-Effectiveness. This activity could improve the cost-effectiveness of the EE program through several avenues. A third-party agency could bear some of the costs associated with promoting the program and conducting customer and workforce education. If a third party incentivizes measures that are already offered by the program, then the program could reduce incentive amounts (e.g., NYSERDA offers midstream incentives to heat pump installers that reduce the incremental costs of heat pump adoption). Or, a third party may take on measures that are less cost-effective so that the EE program may focus on more cost-effective measures (e.g., MassCEC offers incentives for whole-home air-source heat pumps in homes with natural gas heat, a measure that was not cost-effective enough to include in MA's EE program).

Current Practice in NH: New Hampshire does not have a statewide third-party EE promotion agency.

Customer cost and energy usage impacts: In several other states, third-party agencies offer incentives that reduce customers' up-front installation costs associated with energy optimization measures. However, this activity does not impact calculations of customer energy costs or energy usage savings.

Actions Required to Pursue Activity:

- **Authorize the development of a third-party EE promotion agency.** Authorization could come from state legislation or the PUC.
- **Establish, maintain, and fund a third-party EE promotion agency.** If a third-party agency is introduced, the agencies' activities and its relationship to the EE program must be thoughtfully designed to result in improved program-wide effectiveness.

5.2.9 Offer EO-Specific Workforce Training Programs

Definition of Activity: This activity includes offering EO-specific workforce training programs. Trainings could include educating home auditors about program offerings, teaching contractors how to properly size and install cold-climate heat pumps, training contractors to provide customer education regarding how to operate their equipment, and informing heating equipment manufacturers about the need for integrated controls.

Northeastern states that engage in this activity: All Northeastern states offer EO-specific workforce training programs. Most of the trainings focus specifically on heat pump installation.

Relevant Policy Goals:

Strategic Electrification. This activity would increase awareness and optimal use of air-source heat pump measures.

Minimize GHG Emissions. This activity may increase the rate of adoption of air-source heat pumps, thus minimizing GHG emissions. Programs with quality installation verification and/or customer education may minimize GHG emissions caused by improper equipment operation.

Reduction of Fossil Fuel Usage. This activity would improve adoption of air-source heat pumps, thus reducing fossil fuel usage. Programs with quality installation verification and/or customer education may reduce the fossil fuel usage caused by improper equipment operation.

Improve EE Program Cost-Effectiveness. This activity would increase awareness of program offerings and measure adoption for a relatively low cost of implementation. Additionally, it would improve customer cost and energy savings, thereby improving cost effectiveness.

Current Practice in NH: New Hampshire currently offers workforce trainings for HVAC contractors, though the 2018-2020 Statewide Energy Efficiency Plan does not explicitly identify energy optimization as a training opportunity for the state. The 2019 Update to the Statewide Energy Efficiency Plan states that NH utilities are reviewing workforce training needs. Several NH stakeholders said there is a need for additional education and workforce training development.

Customer cost and energy usage impacts: A general finding from our interviews is that program administrators believe training programs improve customer cost savings and energy usage savings. One mechanism that interviewees described is as follows: Through trainings, contractors become more familiar with the options, installation, and operation of high-efficiency heat pump products. As a result, contractors are more likely to recommend heat pump products to customers and instruct customers regarding how to operate their heat pumps efficiently. Stakeholders in VT credited the state's contractor training programs and trade ally network with the state's accelerated adoption rate of air-source heat pumps. Several states offer Quality Installation Verification (QIV) measures that require contractors to verify that new heat pump installations use a proper refrigerant charge and airflow. States that offer QIV measures typically require participating contractors to complete a training and certify their understanding of proper installation practices. Specific to energy optimization measures, contractor and customer education can influence the selection of a switchover temperature, which affects system efficiency by governing when a customer's system switches between electric and fossil fuel-fired operation.

Actions Required to Pursue Activity:

- **Develop a trade ally network to facilitate the delivery of training programs.** One example is Vermont's Efficiency Excellence Network, which provides free technical training, enhanced support, and qualified leads to members who complete EE training with Efficiency Vermont.

- **Continue to develop, maintain, and fund EO-specific training.**

5.3 Recommended Activities by Policy Goal

This section organizes the energy optimization-related changes discussed in section 5.2 according to the policy goals that they support. The following tables list the changes we recommend that support each of the policy goals examined in this study. Each change is followed by a number referring to the section of this report that describes the change in detail.

In each table, we have grouped the changes into low-, medium-, and high-priority bins. To develop these priority rankings, our team weighed the expected impacts of each change against the costs and level of effort associated with pursuing the change. For instance, forming a third-party agency could be very impactful if the agency offers incentives that motivate many customers to switch fuels. However, we have designated this change as low-priority because it could be very high cost and our interviews indicated that New Hampshire stakeholders have little appetite for new administrative infrastructure. In comparison, the change “Count GHG Emissions Reduction as an NEI” could have a high impact at a lower cost, since counting GHG emissions improves the screening outcomes of fuel switching measures.

Some of the changes are inter-related and would likely be considered together (*e.g.,* counting GHG emission reductions and accounting for site & source savings). The recommended changes for each goal are limited to the changes that directly help to meet the goal. So, some changes that are not listed under a goal may need to be considered due to the inter-related nature of a change that is listed under that goal.

Table 11. Goal: Strategic Electrification

Associated Activities for Strategic Electrification	
High Priority	Count Unregulated Fuel Savings and Electric Load Increase for Fuel-to-Electric Measures (see section 5.2.1) Count Total Costs of GHG Emissions as NEI in B/C Analysis (5.2.2) Offer Tailored Air-Source Heat Pump Measure Bundles (5.2.5)
Medium Priority	Offer EO-specific Workforce Training Programs (5.2.9)
Low Priority	Incentivize Electric Vehicles Within EE Programs (5.2.6) Third Party Working in Tandem with Utilities (5.2.8)

Table 12. Goal: Minimize GHG Emissions

Associated Activities for Minimizing GHG Emissions	
High Priority	Count Unregulated Fuel Savings and Electric Load Increase for Fuel-to-Electric Measures (see section 5.2.1) Count Total Costs of GHG Emissions as NEI in B/C Analysis (5.2.2)
Medium Priority	Count Site & Source Savings in B/C Calculations (5.2.4) Offer EO-Specific Workforce Training Programs (5.2.9) Offer Tailored Air-Source Heat Pump Measure Bundles (5.2.5)
Low Priority	Incentivize Electric Vehicles Within EE Programs (5.2.6) Third Parties Working in Tandem with Utilities (5.2.8)

Table 13. Goal: Reduce Fossil Fuel Usage

Associated Activities for Reducing Fossil Fuel Usage	
High Priority	Count Unregulated Fuel Savings and Electric Load Increase for Fuel-to-Electric Measures (see section 5.2.1) Count Total Costs of GHG Emissions as NEI in B/C Analysis (5.2.2) Count Site & Source Savings in B/C Calculations (5.2.4)
Medium Priority	Offer Tailored Air-Source Heat Pump Measure Bundles (5.2.5) Offer EO-Specific Workforce Training Programs (5.2.9)
Low Priority	Incentivize Electric Vehicles within EE Programs (5.2.6) Third party Working in Tandem with Utilities (5.2.8)

Table 14. Goal: Improve EE Program Cost-Effectiveness

	Associated Activities for Improving EE Program Cost-Effectiveness
High Priority	Count Total Costs of GHG Emissions as NEI in B/C Analysis (see section 5.2.2) Count Unregulated Fuel Savings and Electric Load Increase for Fuel-to-Electric Measures (5.2.1) Offer Tailored Air-Source Heat Pump Measure Bundles (5.2.5) Offer EO-Specific Workforce Training Programs (5.2.9)
Medium Priority	Third Party Working in Tandem with Utilities (5.2.8)
Low Priority	None

Table 15. Goal: Pursue Holistic B/C Accounting

	Associated Activities for Pursing Holistic B/C Accounting
High Priority	Count Unregulated Fuel Savings and Electric Load Increase for Fuel-to-Electric Measures (see section 5.2.1) Count Total Costs of GHG Emissions as NEI in B/C Analysis (5.2.2)
Medium Priority	Count Site & Source Savings in B/C Calculations (5.2.4)
Low Priority	None

Table 16. Goal: Improve Load Factor

	Associated Activities for Improving Electric Load Factor
High Priority	Count Unregulated Fuel Savings and Electric Load Increase for Fuel-to-Electric Measures (see section 5.2.1) Incentivize CHP in EE Programs (5.2.7)
Medium Priority	None
Low Priority	Incentivize Electric Vehicles within EE Programs (5.2.6)

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APPENDIX A. DOCUMENTS REVIEWED FOR POLICY STUDY

Date	Source	Document	Purpose	Impact on EO	Location	Link
12/31/2018	NH Public Utilities Commission	Order No. 26,207	Approval of implementation of an energy efficiency plan for 2019 for electric and natural gas utilities.	The EM&V Working Group will explore how to treat the benefit and costs associated with fuel switching (energy optimization). Recommendations will be submitted to the Commission by August 2019.	p.8	https://www.puc.nh.gov/Regulatory/Orders/2018orders/26207e.pdf
11/2/2018	NH Office of Consumer Advocate	Docket DE 17-136 Exhibit #12 Testimony of Jeffrey Loiter	Provide recommendations for the 2019 Update to NH's 2018-2020 Three-year EE Plan.	Recommend that the B/C Working Group review how other commissions and program administrators are accounting for the effects of fuel-switching promoted by energy efficiency programs	p.18-21 (Bates 19-22)	https://www.puc.nh.gov/regulatory/Docketbk/2017/17-136/TESTIMONY/17-136_2018-11-02_OCA_DTESTIMONY_LOITER.PDF
11/2/2018	NH Public Utilities Commission	Docket DE 17-136, Direct Testimony of Leszek Stachow	Review the 2019 Update Plan to the 2018-2020 NH Statewide Energy Efficiency Plant (NH Saves Report) to provide recommendations.	* The Performance Incentive Work Group has unresolved issues. Among them, the PI WG is considering replacing their PI formula with an alternative method such as one that measures value in dollars (as in MA) or one with quality performance indicators (QPIs) (as in VT). * The PI WG is discussing the need for and potential design of a metric to promote electrification/energy optimization.	p.16-17	https://www.puc.nh.gov/regulatory/Docketbk/2017/17-136/TESTIMONY/17-136_2018-11-02_STAFF_DTESTIMONY_STACHOW.PDF

Date	Source	Document	Purpose	Impact on EO	Location	Link
10/19/2018	NH Public Utilities Commission	Data responses for Docket DE 17-136	Multiple witnesses provide responses to requests from the OCA regarding water heater rebates and calculation of ASHP savings	* For HPWH measures, utilities calculate savings relative to a baseline of an ENERGY STAR qualified HPWH. * NH incentive programs do not require that thermostats be capable of controlling two heating sources (as may be present in an energy optimization scenario). * Savings calculations in 2013 included oil and propane fuel savings.	all	https://drive.google.com/file/d/16Iol0qrL9yN59X7ckpDa20oSiti69zXU/view
9/21/2018	Regulatory Assistance Project (RAP)	Efficiency & Electrification: Strategic Partners	Panel of Experts on Beneficial Electrification	Presentation on Efficiency & Electrification: Strategic Partners presentation at a panel of experts on beneficial electrification hosted by the NHPUC and EESE Board. Presented by the Regulatory Assistance Project (RAP)	all	https://www.puc.nh.gov/EESE%20Board/EERS_WG/20180921-EERS-WG-PI-Efficiency-and-Electrification.pdf
9/21/2018	Regulatory Assistance Project (RAP)	Beneficial Electrification: Considerations for EE Presentation	Panel of Experts on Beneficial Electrification	Presentation on Beneficial Electrification: Considerations for EE Presentation at a panel of experts on beneficial electrification hosted by the NHPUC and EESE Board. Presented by the Regulatory Assistance Project (RAP)	all	https://www.puc.nh.gov/EESE%20Board/EERS_WG/20180921-EERS-WG-PI-Beneficial-Electrification-Considerations-For-EE.pdf
9/21/2018	Regulatory Assistance Project (RAP)	Heat Pump Primer Presentation	Panel of Experts on Beneficial Electrification	Presentation on Heat Pumps at a panel of experts on beneficial electrification hosted by the NHPUC and EESE Board. Presented by the Regulatory Assistance Project (RAP)	all	https://www.puc.nh.gov/EESE%20Board/EERS_WG/20180921-EERS-WG-PI-Heat-Pump-Technology.pdf

Date	Source	Document	Purpose	Impact on EO	Location	Link
1/2/2018	NH Public Utilities Commission	Order No. 26,095	Approve the implementation of a three-year energy efficiency plan for 2018-2020	* Established the B/C Working Group and other WGs. * Describes program budgets and funding sources * Describes the updates to B/C cost tests in the 2018-2020 three-year plan	pg.3	https://www.puc.nh.gov/Regulatory/Docketbk/2017/17-136/ORDERS/17-136_2018-01-02_ORDER_26095.PDF
7/1/2017	MPRP, EE and Sustainable Energy Board	RSA 125-O:5-a, I(e)	Programs should target more than one fuel resource, including conversion to renewable resources	The board's duties shall include but not be limited to: Explore opportunities to coordinate programs targeted at saving more than one fuel resource, including conversion to renewable resources and coordination between natural gas and other programs which seek to reduce the overall use of nonrenewable fuels.	all	http://www.gencourt.state.nh.us/rsa/html/X/125-O/125-O-5-a.htm
7/1/2017	MPRP, EE and Sustainable Energy Board	RSA 125-O:5-a, I(b)	Develop a plan to achieve the state's energy efficiency potential for all fuels	The board's duties shall include but not be limited to: Develop a plan to achieve the state's energy efficiency potential for all fuels, including setting goals and targets for energy efficiency that are meaningful and achievable.	all	http://www.gencourt.state.nh.us/rsa/html/X/125-O/125-O-5-a.htm
7/1/2017	NH General Court	Chapter 4-E State Energy Strategy, Section 4-E:1	Develop 10-Year energy plan	This legislation directed the Office of Energy and Planning to develop a 10-year Energy Strategy for the state, in consultation with a State Energy Advisory Council. The statute also requires that the plan be updated every 3 years.	All	http://www.gencourt.state.nh.us/rsa/html/I/4-E/4-E-1.htm

Date	Source	Document	Purpose	Impact on EO	Location	Link
8/2/2016	NH Public Utilities Commission	Order No. 25,932	Order approving settlement agreement about Energy Efficiency Resource Standard (EERS)	* Extended 2014-2016 Core program an additional year (through 2017) * Established an Energy Resource Standard (EERS), a policy that sets specific targets or goals for energy savings, which utility companies serving NH ratepayers must meet. * Settlement agreement included the recommendation to implement a lost revenue adjustment mechanism (LRAM). * Staff proposed an adjustment that would reduce revenue recovery by the amount of new natural gas revenue due to fuel-switching from other fuels to natural gas, but this proposal was not incorporated in the Settlement Agreement.	p.1, 24, 30	https://www.puc.nh.gov/Regulatory/Orders/2016orders/25932e.pdf
3/1/2016	NH Public Utilities Commission	Energy Efficiency Resource Standard Docket No. DE15-137, Exhibit #8	Reply Testimony to discuss disagreements between Staff and utilities about lost revenue recovery.	* Explains the current Total Resource Cost (TRC) method for evaluating energy efficiency programs and explains how lost revenue should not be included as a cost. * Argues that savings from fuel switching should not be omitted from the calculation of lost revenue.	p. 5-6,9	http://www.puc.state.nh.us/Regulatory/Docketbk/2015/15-137/TRANSCRIPTS-OFFICIAL%20EXHIBITS-CLERKS%20REPORT/15-137_2016-05-02_EXH_8.PDF

Date	Source	Document	Purpose	Impact on EO	Location	Link
5/8/2015	NH Public Utilities Commission	DE 15-137 Order of Notice	Proceeding to establish an Energy Resource Standard (EERS)	The PUC opens a proceeding to establish an Energy Efficiency Resource Standard (EERS), a policy to establish specific targets or goals for energy savings that utilities must meet in NH. By establishing energy savings goals, there is more of a reason to purse energy optimization.	p.3-4	http://www.puc.state.nh.us/Regulatory/Docketbk/2015/15-137/ORDERS/15-137%202015-05-08%20ORDER%20OF%20NOTICE.PDF
4/3/2015	NH Office of Consumer Advocate	OCA Comments on Investigative Docket, IR 15-072	Comment on the EERS Straw Proposal (Feb 2015)	The OCA supports recommendation that the PUC should establish an EERS for 10 years with interim, short-term goals.	p.1-2	https://www.puc.nh.gov/Regulatory/Docketbk/2015/15-072/LETTERS-MEMOS-TARIFFS/15-072%202015-04-03%20OCA%20COMMENTS.PDF
2/3/2015	NH Public Utilities Commission	Energy Efficiency Resource Standard - A Straw Proposal for NH (developed by NHPUC)	Straw proposal to advance existing discussions about a state-wide EERS.	* Recommends establishing a fuel neutral EERS policy * Recommends establishing mandatory electrical and natural gas equivalent savings targets for the next ten years.	p.4-5	http://www.puc.state.nh.us/Electric/EERS%20Straw%20Proposal.pdf
10/3/2014	NH General Court	RSA 374-F:6, Restructuring, duties of the electric restructuring oversight committee	Electric restructuring committee to review EE programs to determine what barriers exist to providing all-fuels, comprehensive savings	Duties of electric restructuring committee include "reviewing state energy efficiency programs under the administration of the public utilities commission to determine what barriers exist to providing all-fuels, comprehensive energy efficiency savings to New Hampshire consumers"	all	http://www.gencourt.state.nh.us/rsa/html/XXXIV/374-F/374-F-6.htm

Date	Source	Document	Purpose	Impact on EO	Location	Link
10/3/2014	NH General Court	RSA 125-O:23	Establish and energy efficiency fund	Established the rules under which the PUC will administer the energy efficiency fund and auction proceeds received.	all	http://www.gencourt.state.nh.us/rsa/html/X/125-O/125-O-23.htm
9/1/2014	NH Office of Energy and Planning	2014 NH 10-Year State Energy Strategy	Provide guidance on electric and thermal energy to optimize the use of readily-available energy resources while minimizing negative impacts on the economy	Directed the PUC to open a proceeding that directs the utilities, in collaboration with other stakeholders, to develop efficiency savings goals based on the efficiency potential of the state.	p.ii	https://www.nh.gov/osi/energy/programs/documents/energy-strategy.pdf
8/15/2014	NH General Court	Chapter 378 Rates and Charges, Least Cost Energy Planning, Section 378:37 New Hampshire Energy Policy	NH must meet citizens' energy needs at the lowest reasonable cost	This statute declared that energy policy in NH must meet the energy needs of the citizens and businesses at the lowest reasonable cost while providing reliability and diversity of energy sources, maximizing cost effective energy efficiency resources, protecting health and safety of citizens, and protecting the environment and future supply of resources.	all	http://www.gencourt.state.nh.us/rsa/html/xxxiv/378/378-37.htm
1/1/2014	NH General Court	Section 120-O:21	Carbon Dioxide Emissions Budget Trading Program	The department will establish and enforce a CO2 emissions budget trading program consistent with the RGGI program.	all	http://www.gencourt.state.nh.us/rsa/html/x/125-o/125-o-mrg.htm

Date	Source	Document	Purpose	Impact on EO	Location	Link
7/25/2014	NH CleanTech Council	NH Cleantech Council response to Draft State Energy Strategy	Propose ideas for the NH State Energy Strategy	* Recommend that the NH State Energy Strategy goal should be to reduce the export of energy dollars from 66% to 50% by 2023 through reduction of fossil fuel imports. * Proposed three strategies to accomplish the goal: (1) increase EE and conservation; (2) replace imported fossil fuel use with local renewable energy (fuel switching); (3) encourage the private market to finance the infrastructure. * Recommend switching from fuel oil to biomass, bioheat, geothermal, and solar coupled with heat pumps and natural gas.	1-2,4	https://www.nh.gov/osi/energy/programs/documents/sb191pc-2014-7-25-nhctc.pdf
5/22/2014	NH Public Utilities Commission	NH PUC Rule 310- Utility Advertising-Electric: NH PUC Rule 310.01(h), 310.02, 310.03(a)(1)	Limits an electric utility's ability to engage in promotional activity	Limits recovery of promotional activities in certain contexts. The rule would essentially require Energy Optimization to be about providing objective information to customers to customers, so they can compare the installed costs, operating costs, and environmental impact of their primary heating fuels with other available options and encouraging energy efficiency/conservation.	all	https://www.puc.nh.gov/Regulatory/Rules/Puc300.PDF
12/30/2013	NH Public Utilities Commission	Order No. 25,615	Approve Settlement Agreement and 2014 Core Program Changes	PUC approves the Electric Utilities' proposal to modify the savings and incentives for DMSHPs in 2014 to comport with standard practice in other Northeast states. Per the revised savings and incentives for heat pumps, utilities no longer claim fossil savings.	p.3-4	http://www.puc.state.nh.us/Regulatory/Docketbk/2012/12-262/ORDERS/12-262%202013-12-30%20ORDER%20NO%2025-615.PDF

Date	Source	Document	Purpose	Impact on EO	Location	Link
11/1/2013	NH Public Utilities Commission	Docket DE 12-262 Exhibit #13	Provide recommendations for the 2014 Update of EE programs filed 9/13/2013	Staff testimony supports rebate reduction for DMSHPs (from $900 to $500 and from $450 to $300) but does not mention eliminating the MMBtu savings from consideration.	p.5-6	http://www.puc.state.nh.us/Regulatory/Docketbk/2012/12-262/TESTIMONY/12-262%202013-11-01%20STAFF%20DIRECT%20TESTIMONY%20J%20CUNNINGHAM_L%20STACHOW.PDF
9/13/2013	NH Electric and Natural Gas Utilities	2014 CORE New Hampshire Energy Efficiency Programs	NH CORE Utilities provide an update for the 2014 program year	* The NH Electric Utilities modified savings and incentives for DMSHPs in 2014 to bring them in line with standard practice in other northeast states. * The base case assumption has changed from a fossil fuel appliance to a standard efficiency MSHP. (In other words, fuel-to-DMSHP measures no longer count fuel savings.) * By rebating the higher-efficiency MSHP, the utilities are incenting customers to use less electricity than they would with a lower efficiency model.	p.8 (Bates 006)	http://www.puc.state.nh.us/Regulatory/Docketbk/2012/12-262/LETTERS-MEMOS-TARIFFS/12-262%202013-09-13%20NH%20CORE%20UTILITIES%202014%20ENERGY%20EFFICIENCY%20PROGRAM%20UPDATES.PDF
9/6/2013	NH Public Utilities Commission	Order No. 25,569	Approve changes to the performance incentive mechanism	Commission adopted the PI working group's recommended 55% electric threshold for higher performance incentive. The motivation is to prioritize electric savings over unregulated fuels.	p.2-3	http://www.puc.state.nh.us/Regulatory/Docketbk/2012/12-262/ORDERS/12-262%202013-09-06%20ORDER%20NO.%2025,569.PDF

Date	Source	Document	Purpose	Impact on EO	Location	Link
5/10/2013	NH Public Utilities Commission	NH PUC Rule 510 Utility Advertising-Gas: NH PUC Rule 510.01(h), 510.03(a)(1), 510.03(b), 510.03(c), and 510.03(d)	Limits a natural gas utility's ability to engage in promotional activity	Limits recovery of promotional activities in certain contexts. The rule would essentially require Energy Optimization to be about providing objective information to customers to customers, so they can compare the installed costs, operating costs, and environmental impact of their primary heating fuels with other available options and encouraging energy efficiency/conservation.	all	https://www.puc.nh.gov/Regulatory/Rules/Puc500.PDF
2/1/2013	NH Public Utilities Commission	Order No. 25,462	Approved the continuation of HPwES fuel neutral program without changes	* Approved the 2013-2014 Core Electric Energy Efficiency and Natural Gas Energy Efficiency Programs * Recognized that the working group report was expected later in 2013.	p.3-4,7	https://www.puc.nh.gov/regulatory/Orders/2013orders/25462e.pdf

Date	Source	Document	Purpose	Impact on EO	Location	Link
8/23/2012	NH Public Utilities Commission	Order No 25,402	Implement HPwES's fuel-neutral program.	*It has been getting harder to maintain a cost-effective program without broadening the program to include non-electric energy savings. Programs that isolate and target energy efficiency to a single fuel source, such as electricity, have proved less cost-effective, compared to energy efficiency measures delivered as a comprehensive package which are the overall most cost-effective approach to achieving energy efficiency and conservation of all fuel sources. *The Commission finds that allowing the HPwES program to be included in the upcoming CORE energy efficiency program cycle is in the public interest and is consistent with the overall intent of RSA Chapter 374-F. Fuel-neutral measures that save both electric and non-electric should be included in the plans. Non-electric savings such as those realized from weatherization do lead to electric savings. *The Commission supports fuel blind programs.	p.19,22-24,27	https://www.puc.nh.gov/Regulatory/Orders/2012orders/25402e.pdf
3/28/2012	NH General Court	HB 1490-FN	House Bill about NH regional greenhouse gas initiative cap and trade program for controlling carbon dioxide emissions.	House Bill includes the required use of Regional Greenhouse Gas Initiative (RGGI) funds for core energy efficiency programs funded by SBC. Also, requires legislative oversight committee on electric utility restructuring to monitor and report on certain core energy efficiency programs. Established energy efficiency fund.	Amended Analysis	http://www.gencourt.state.nh.us/legislation/2012/HB1490.html

Date	Source	Document	Purpose	Impact on EO	Location	Link
1/9/2012	NH Public Utilities Commission	Order No 25,315	Approve 2012 Energy Efficiency Program Updates	For 2012, PSNH and UES agree to earn a performance incentive on the installation of electric saving measures as has been done since the HPwES Program was first approved.	p.4-5	http://www.puc.state.nh.us/regulatory/CASEFILE/2010/10-188/ORDERS/10-188%202012-01-09%20ORDER%20NO%2025,315%20APPROVING%202012%20ENERGY%20EFFICIENCY%20PROGRAM%20UPDATES.PDF
12/30/2010	NH Public Utilities Commission	Order No 25,189	Commission approved two-year energy efficiency programs	Approved implementation of the HPwES program pilot for the 2011 program year.	p.12,13-18	https://www.puc.nh.gov/Regulatory/Orders/2010orders/25189eg.pdf
6/4/2009	NH Public Utilities Commission	Order No 24,974	Approved modified fuel blind program pilot (HES Pilot)	Commission approved the HES Pilot subject to certain additional modifications: reduce the size of the HES Pilot program, file revised budget, file description of methodology and measures to be used to evaluate the performance of the program.	p.5-7	https://www.puc.nh.gov/Regulatory/CASEFILE/2008/08-120/ORDERS/08-120%202009-06-04%20ORDER%2024,974%20ORDER%20NISI%20APPROVING%20MODIFIED%20FUEL%20BLIND%20PROGRAM.PDF
4/30/2009	NH Public Utilities Commission	Staff Recommendation	Staff provides comments on the modifications to the Home Energy Solutions Program from the Joint Petition	Staff continues to recommend that the commission not approve the PSNH and UES pilots. They believe the system benefits are not adequately captured by the proposed fuel neutral pilots and thus are not in line with the SBC. Staff recommends that if the pilots are approved, the performance incentives should be modified to reflect a calculation that incorporates only the budget for electric-related benefits.	p.2	https://www.puc.nh.gov/Regulatory/CASEFILE/2008/08-120/LETTERS,%20MEMOS/08-120%202009-04-30%20STAFF%20RECOMMENDATION.PDF

Date	Source	Document	Purpose	Impact on EO	Location	Link
4/9/2009	PSNH and Unitil	PSNH's Joint Petition for Approval of Amended Design in the Home Energy Solutions Program	Utilities file further details for the fuel blind program	Utilities file further details for the fuel blind program and request an order from the Commission approving the modifications of the Home Energy Solutions Program as described in the document.	p. 4-16 (Bates 1-12)	https://www.puc.nh.gov/Regulatory/CASEFILE/2008/08-120/LETTERS,%20MEMOS/08-120%202009-04-09%20JOINT%20PETITION%20FOR%20APPROVAL%20OF%20AMENDED%20DESIGN%20IN%20THE%20HOME%20ENERGY%20SOLUTIONS%20PROGRAM.PDF
1/5/2009	NH Public Utilities Commission	Order No. 24,930	Approved Settlement Agreement	Commission approves 2009 CORE programs, with the exception of the proposed fuel-blind Home Energy Solutions pilot program and the use of Renewable Energy and Regional Greenhouse Gas Initiative funds. Directs utilities to file further details on the fuel-blind program.	p.7-8	https://www.puc.nh.gov/Regulatory/CASEFILE/2008/08-120/ORDERS/08-120%202009-01-05%20ORDER%20NO%2024,930%20APPROVING%20SETTLEMENT%20AGREEMENT.PDF
12/9/2008	NH Public Utilities Commission	Docket No. DE 08-120 Settlement Agreement	Settlement to resolve all outstanding issues with fuel neutral program proposal	Determined that electric utilities would continue to meet with natural gas utilities that offer efficiency programs and to develop recommendations that improve energy efficiency services to both natural gas and electric service customers.	p.6	https://www.puc.nh.gov/Regulatory/CASEFILE/2008/08-120/LETTERS,%20MEMOS/08-120%202008-12-10%20SETTLEMENT%20AGREEMENT.PDF

Date	Source	Document	Purpose	Impact on EO	Location	Link
10/7/2008	NH Public Utilities Commission	NHPUC Docket No. DE 08-120	Utilities propose Home Energy Solutions fuel blind component	Utilities note that the proposed Home Energy Solutions program is fuel neutral and thus aligned with the national effort developed by the U.S. EPA. Additionally, there is a fuel blind weatherization component.	p.15	https://www.puc.nh.gov/Regulatory/CASEFILE/2008/08-120/LETTERS,%20MEMOS/08-120%202008-10-07%20PSNH'S%20FILING%20SPECIFIES%20THE%202009%20PROGRAMS%20PERFORMANCE%20TARGETS,%20AND%20BUDGETS%20FOR%20EACH%20UTILITY.PDF
3/19/2008	NH General Court	House Bill 1434	Regional Greenhouse Gas Emissions Reductions Fund	Authorizes the use of Greenhouse Gas Emissions Reduction Fund to support energy efficiency, conservation, and demand response programs to reduce greenhouse gas emissions generated in the state. This will allow for the expansion of energy efficiency programs and eventually the opportunity for energy optimization.	all	http://www.gencourt.state.nh.us/legislation/2008/HB1434.html
9/5/2003	NH Public Utilities Commission	Order No. 24,203	Continue using approved performance incentive mechanism	Utilities will continue to utilize the current approved performance incentive mechanism. The performance incentive encourages utilities to aggressively pursue achievement of performance goals for EE programs. This would likely encourage utilities to pursue energy optimization.	pg. 2	https://www.puc.nh.gov/regulatory/Orders/2003orders/24203G.pdf

APPENDIX B. STAKEHOLDER INTERVIEW PARTICIPANTS AND INTERVIEW GUIDES

B.1 Stakeholders Interviewed for Study of New Hampshire Policies

Interview Group #	Stakeholder Group	Interviewee – Title
1	EESE Board	Raymond Burke – Staff Attorney, New Hampshire Legal Assistance
2	EESE Board	Tonia Chase – Business Industry Affairs (BIA) Designee
3	EESE Board	Rebecca Ohler – Climate and Energy Program Manager, Department of Environmental Services
4	Office of the Consumer Advocate	Brian Buckley – Staff Attorney, Office of the Consumer Advocate Donald Kreis – Consumer Advocate
5	EESE Board	Madeleine Mineau – Executive Director, New Hampshire Sustainable Energy Association PUC Chair Nonprofit Appointment
6	NHPUC Staff	Jim Cunningham – Utility Analyst, Electric Division Jay Dudley – Utility Analyst, Electric Division Elizabeth Nixon – Utility Analyst, Electric Division Leszek Stachow – Assistant Director, Electrical Division
7	Eversource	Miles Ingram – Senior Analyst, Energy Efficiency Kate Peters – Supervisor, Energy Efficiency
8	Liberty Utilities	Tina Poirier – Senior Reporting and Systems Analyst Eric Stanley – Manager, Energy Efficiency & Customer Programs
9	NHEC	Craig Snow – VP of Member Services Carol Woods – PUC Chair Utility Appointment
10	UNITIL Energy Systems	Mary Downes – Manager of Administration and Compliance, Energy Efficiency Programs Deb Jarvis – Energy Efficiency Administration and Compliance Tom Palma – Manager of Distributed Energy Resources
11	Conservation Law Foundation	Melissa Birchard – Conservation Law Foundation Attorney

B.2 Stakeholders Interviewed for Study of Other States' Policies

Interview Group #	Stakeholder Group	Interviewee – Title
1	MA, CT, RI	Ralph Prahl – Consultant, NH Public Utilities Commission, MA Energy Efficiency Advisory Council consultant, CT EEB consultant
2	MA	Caitlin Peale-Sloan – Senior Attorney, Conservation Law Foundation
3	MA, CT, RI, VT, NY	Emily Levin – Managing Consultant, Vermont Energy Investment Corporation
4	NY	Emily Morris – Energy Efficiency Senior Specialist, Con Edison
5	CT MA	Ron Araujo – Energy Efficiency Manager, Eversource Brandy Chambers – Energy Efficiency, Regulatory, Planning, & Regulation Senior Analyst, Eversource
6	MA, CT	Jeff Schlegel, Energy Efficiency Consultant, MA Energy Efficiency Advisory Council
7	MA	Liz Stanton – Clinic Director and Senior Economist, Applied Economics Clinic
8	MA RI	Eric Belliveau – Partner, Optimal Energy, MA Energy Efficiency Advisory Council consultant, RI Energy Efficiency Resource Management Council consultant Mike Guerard – Managing Consultant, Optimal Energy MA Energy Efficiency Advisory Council consultant, RI Energy Efficiency Resource Management Council consultant
9	MA	Steven Menges – Senior Policy Analyst, National Grid
10	NY	Michael Lauchaire – Energy Efficiency Program Manager, Central Hudson Gas & Electric Corp
11	VT	Keith Downes – Associate Director, Navigant. Keith shared findings from Richard Faesy (Energy Futures Group)
12	VT	Sandy Levine – Senior Attorney, Conservation Law Foundation

B.3 Interview Guide for NH Stakeholders

Note: Main bullets (●) indicate key lines of inquiry. Sub-bullets (○) indicate additional prompts or questions for the interviewer to offer.

We understand that energy optimization generally refers to a strategy in which Program Administrators: 1) Encourage participants to minimize energy usage needs by promoting their standard suite of energy efficiency measures; 2) Provide customers with fuel neutral education regarding the installed costs, operating costs, and environmental impact associated with high efficiency heating options including potential conversions to a new primary fuel type (efficient electric or gas); and 3) May provide additional incentives and claim unregulated fuel savings associated with switching to high efficiency renewable or other clean energy technologies.

- In your opinion, why is "energy optimization" of interest to New Hampshire ratepayers?
- In your opinion, is "fuel switching" the same thing or different from energy optimization? Why or why not?
    - We understand that energy optimization measures include measures where customers may reduce consumption of unregulated fuels like oil or propane but increase consumption of electricity or natural gas. Would you agree?
    - We understand that utilities and customers may adopt these measures for cost savings due to relative fuel prices (natural gas is cheaper than oil or propane) or for cost savings due to increased efficiency (in total, heat pumps deliver heat more efficiently than fuel combustion). Would you agree?
    - We understand that energy optimization measures may reduce overall GHG emissions. What level of importance do you place on these emissions reductions, and how should they be prioritized among the other goals of the energy efficiency program?
- What current energy efficiency measures are offered in New Hampshire under the scope of "energy optimization"?
    - We understand NH incentivizes customers who replace existing fuel-fired heating equipment with electric heat pump or high efficiency natural gas equipment (includes both space heating and water heating end uses) but does not currently include savings from the existing fuel-fired heating equipment when determining incentive levels or cost-effectiveness. Would this include customers installing a heat pump alongside fuel-fired equipment, as in a dual-fuel scenario?
- What future measures do you anticipate being offered under the definition of energy optimization?
    - Would this include combined heat and power (CHP) measures?
    - Would this include transportation measures, such as electrification of automobiles?
    - Are you considering other measures, such as biofuels heating?
- Discuss benefit-cost tests for energy optimization measures:
    - NH utilities currently use the Total Resource Cost (TRC) test.

  - We understand that savings are currently calculated only for the new fuel type. For example, when a customer converts from fossil heating to high efficiency electric heat pumps, the program only calculates savings relative to the baseline electric heat pump – not to the original fossil fuel baseline. Can you confirm this understanding?
  - What modifications to the B/C test could be considered to reflect the nature of energy optimization measures? Example: including the valuation of total MMBtu savings or valuation of carbon savings.
  - We understand that neighboring Northeastern states only include the unregulated fuel savings within the cost-benefit calculation for electrification measures, and do not include those fuel savings in the calculation of benefits associated with natural gas conversion. In your opinion, should this also be the case in New Hampshire? Why or why not?

- Discuss other impacts of electrification measures:
  - What is relevance of source vs. site consumption in benefit-cost calculations?
  - Heat pump measures will increase winter peak electric demand and/or electric energy consumption. How would this affect the benefit-cost analysis?
  - Heat pump measures may add new electric consumption for space cooling if customers did not previously use A/C equipment. How would this affect the benefit-cost analysis?
  - What non-energy impacts should be considered when evaluating electrification measures?
  - Some states have supported an embrace of electrification measures with additional contractor training, customer education, and an emphasis on integrated controls systems. Should New Hampshire follow this path?
  - Should the load building associated with electrification measures impact the electric savings claim associated with the energy efficiency programs? How?
  - Should the load building associated with electrification measures impact the lost revenue calculation associated with the energy efficiency programs? How?

- Discuss other impacts of oil-to-natural gas or propane-to-natural gas measures
  - What is relevance of source vs. site consumption in benefit-cost calculations?
  - Conversion from oil or propane to natural gas will increase winter peak natural gas demand in a regional energy system that already faces winter supply constraints and a state that is contemplating major natural gas infrastructure buildouts to meet an already constrained peak day capacity. How will this affect the benefit-cost calculations?
  - We understand that New Hampshire's natural gas utilities offer an installation of up to 100 feet of service line from the main to their residence at no charge to customers who switch from unregulated fuels to natural gas. Should this conversion incentive be considered as a program cost when considering how to count the costs and benefits associated with fuel switching to gas?

- Do you believe that further buildout of natural gas infrastructure with a lifetime of 20-40 years presents a risk of stranded costs that should influence decisions we make relative to avoided costs associated with fuel switching?

- Discuss the characterization of energy optimization measures:
  - If utilities begin calculating benefits relative to the original-fuel baseline, that baseline will need to be defined. How should the fossil fuel baseline equipment be defined?
- What do you know about neighboring states' inclusion of energy optimization measures in their programs?
- What do you know about neighboring states cost effectiveness treatment of energy optimization measures?
- What aspects of neighbor states' programs do you think are relevant to this study? Do you have any specific questions you would like us to investigate when interviewing neighbor states and researching their programs?

B.4 Interview Guide for Study of Other States' Policies

B.4.1 External Review of Energy Optimization Policies

Navigant is working with the New Hampshire Public Utilities Commission to study how energy optimization through fuel switching is commonly treated in New Hampshire and other jurisdictions. Our study includes a review of energy optimization policies in the Northeastern U.S., and we are interviewing energy efficiency experts to learn how states in the Northeast handle energy optimization. This guide describes the topics and questions we would like to discuss so that we may learn more about the programs with which you are familiar.

Note: Main bullets (●) indicate key lines of inquiry; Sub-bullets (○) indicate additional prompts or questions

B.4.2 Discussion Topics and Questions

We understand that "energy optimization" refers to a strategy in which Program Administrators:
1) Encourage participants to minimize energy usage by promoting energy efficiency measures;
2) Provide customers with fuel-neutral education regarding the installed costs, operating costs, and environmental impact associated with high efficiency heating options, including potential conversions to a new primary fuel type (such as electricity or gas); and
3) May provide additional incentives and claim unregulated fuel savings associated with switching to high efficiency technologies.

- In your opinion, is "fuel switching" the same thing or different from energy optimization? Why or why not?
- In your opinion, why is "energy optimization" of interest to ratepayers?
- Are energy optimization measures in your state administered through utilities' energy efficiency programs or through some other vehicle?

- What is the main driver that motivates your state or utility to offer energy optimization measures? (Examples could be state legislation, regulatory commission orders, or other motivators.)
    - We understand that utilities and customers may adopt EO measures for cost savings due to relative fuel prices (natural gas is cheaper than oil or propane) and for cost savings due to increased efficiency (in total, heat pumps deliver heat more efficiently than fuel combustion). What other factors motivate utilities and customers to pursue EO?
    - We understand that energy optimization measures may reduce overall GHG emissions. Compared to energy and cost savings, how do utilities prioritize GHG emissions reductions?
- How does legislation in your state impact the energy optimization measures that are available? What current energy efficiency measures are offered in your state under the scope of "energy optimization"?
- What future measures do you anticipate being offered under the definition of energy optimization?
    - Would this include combined heat and power (CHP) measures?
    - Would this include transportation measures, such as electrification of automobiles?
    - Are you considering other measures, such as biofuels heating?
- Discuss benefit-cost (B/C) tests for energy optimization measures:
    - What B/C test does your state use for energy optimization measures?
    - Does your state's B/C test include savings for the new fuel type only, or does it count savings from the original fuel? What are the benefits and drawbacks of your approach?
    - Does your state's B/C test calculate costs and savings differently if a customer switches to natural gas or to electricity? How are these fuels treated differently and why?
    - Does your state's B/C test calculate costs and savings differently for energy optimization measures in a retrofit scenario compared to a new construction scenario? How are these scenarios treated differently and why?
    - Does your state's B/C test treat savings differently for the "source" savings of delivered fuels consumed on the customers' premises versus the "site" savings of electricity that is generated elsewhere?
- Discuss other impacts of electrification measures:
    - Switching customers from fossil fuel heat to electric heat pumps will increase winter peak electric demand and/or electric energy consumption. Is this accounted for in your state's B/C analyses? If so, how?
    - Heat pump measures may add new electric consumption for space cooling if customers did not previously use A/C equipment. Is this accounted for in your state's B/C analysis? If so, how?

- Does your state calculate utilities' lost revenues associated with energy efficiency programs? If so, how does the lost revenue calculation account for the load increases that result from energy optimization measures?
- What other non-energy impacts are specific to energy optimization measures?

- Discuss other impacts of oil-to-gas or propane-to-gas measures
  - Conversion from oil or propane to natural gas may increase winter peak gas demand in a regional energy system that already faces winter supply constraints. Does your state's B/C calculation account for increases in peak natural gas demand?
  - Do natural gas utilities offer any benefits to new gas customers, such as low- or no-cost installation of a gas service line? If so, how does your state's B/C test account for these offers?
  - How accessible is natural gas supply to potential new customers in your state?
- Discuss support for energy optimization measures:
  - What contractor training and customer education does your state offer to support electrification and energy optimization measures?
  - What are the best practices around retraining a workforce to move away from fossil fuels and towards heat pumps? What assistance does your state provide and how is it administered?
  - Some energy optimization efforts provide customers with information regarding the costs and benefits of switching their primary fuel type. What educational materials are available to customers in your state to help them evaluate their options?
- What have been the customer bill impacts for implementing fuel switching and energy optimization?
- Discuss the characterization of energy optimization measures:
  - If you currently calculate benefits relative to the original-fuel baseline, how do you define the fossil fuel baseline equipment?
  - How do you think the fossil fuel baseline equipment should be defined in the case that benefits are calculated relative to the original-fuel baseline?

Thank you for your time and input.

APPENDIX C. DATA RESPONSE: SAVING INPUTS AND SITE TO SOURCE CONVERSION METHODOLOGY

Public Service of New Hampshire d/b/a Eversource Energy
Docket No. DE 17-136

Date Request Received: 10/05/2018
Request No. OCA 2-027
Request from: Office of Consumer Advocate

Date of Response: **10/19/2018**
Page 1 of 1

Witness: Thomas R. Belair

Request:

Reference 2015-**16 New Hampshire Energy Efficiency Program Plan, at Bates 199, describing 2013** savings claimed for air source heat pumps as negative for electric and positive for MMBtu. Please provide the methodology for calculating such savings, explaining the various inputs, including the baseline from which incremental savings were calculated, and assumptions regarding any alternative heating or cooling sources utilized by a participant.

Response:

The 2013 Air Source Heat Pump energy savings were calculated as follows:

Elec Cooling Savings	= (1/Base SEER - 1/EE SEER) x 1 ton x 12000 BTUs per Ton/ 1000 x 385 cooling hours (per EPA ASHP Calculator) = (1/13-1/19.87) x 1 x 12000/1000 x 385 = 122.9 Annual kWh Savings
Elec Heating Usage	= - (1/EE HSPF) x 1 ton x 16000 BTUs per Ton / 1000 x 50% (% used for heating) x 2641 heating hours = - (1/9.79) x 1 x 16000 / 1000 x 50% x 2641 = - 2,158.1 Annual kWh Usage that will offset the Oil/LP Savings
Fossil Heating Savings	
Oil	= 1/6 x 740 gallons = 123 gallons = 17.14 Annual MMBtu Savings
LP	= 17.14 x 90% (to reflect higher efficiency of LP heating systems) = 15.43 Annual MMBtu Savings

Additional Information re: Calculation:

Cooling (kWh Savings of more efficient unit)
Base SEER=13.0: From EPA's Energy Star ASHP Calculator (SEER = Seasonal Energy Efficiency Ratio rating)
EE SEER=19.87: Estimated Average SEER Rating of incented models.

Heating (kWh Usage of ASHP to displace 50% of fossil fuel heating)
EE HSPF=9.79: Estimated average HSPF of incented ASHP (HSPF=Heating Seasonal Performance Factor rating)

Fossil Heating Savings assumed a typical home served would be 1,800 SF and would use 740 gallons of oil/year. We assumed a 3 ton ASHP would serve the typical home, and then divided the annual fossil fuel usage by 3 to normalize to a 1 ton unit as we did for the electric savings. 740 Gallons of Oil / 3 = 247 gallons of oil/year = 34.3 MMBtus of oil using a 139,000 conversion factor.
Then we assumed that the ASHP would offset 50% of fossil fuel use, or 50% x 247 = 123.33 gallons of oil or 17.14 MMBtus of oil.
Annual Oil Savings = 740 gallons per year / 3 (to normalize to a 1 ton ASHP used for Elec Savings) x 139,000 (BTU content of oil) / 1,000,000 = 34.3 MMBtus x 50% = 17.14 Annual MMBtu Savings.
Annual LP Savings = 34.3 MMBtus x 90% Efficient Boiler/Furnace x 50% = 15.43 Annual MMBtu Savings.

Annual Operating Hours:
Cooling (385) and Heating (2,641) Hours were from the EPA Energy Star ASHP Calculator.

(Joint Utility Response)

2015-2016

New Hampshire Statewide CORE Energy Efficiency Plan

Jointly Submitted by New Hampshire's Electric and Natural Gas Utilities

Granite State Electric Company d/b/a Liberty Utilities
New Hampshire Electric Cooperative, Inc.
Public Service Company of New Hampshire
Unitil Energy Systems, Inc.
EnergyNorth Natural Gas, Inc. d/b/a Liberty Utilities
Northern Utilities, Inc.

NHPUC Docket DE 14-216

September 12, 2014

PSNH ENERGY STAR® Products Program - Appliances

Measure	Quantity				Annual Savings per Unit (kWh)				Measure Life				In-Service / Realization Rate		Total Lifetime Savings (kWh)				Annual Savings Per Unit (MMBTU)				Total Lifetime MMBTU Savings			
	2013 Plan	2013 Actual	2015 Plan	2016 Plan	2013 Plan	2013 Actual	2015 Plan	2016 Plan	2013 Plan	2013 Actual	2015 Plan	2016 Plan	2013	2015 2016	2013 Plan	2013 Actual	2015 Plan	2016 Plan	2013 Plan	2013 Actual	2015 Plan	2016 Plan	2013 Plan	2013 Actual	2015 Plan	2016 Plan
Energy Star Clothes Washer	7,809.0	6,085.0	6,259.5	5,442.1	260.7	260.7	181.8	181.8	11	11	11	11	100.00%	100.00%	22,392,048	17,448,616	12,515,022	10,880,694	0.7	0.7	0.5	0.5	63,359	49,371	31,232	27,154
Energy Star Room A/C	2,552.9	3,869.0	3,698.2	3,215.3	16.2	16.2	16.2	16.2	9	9	9	9	100.00%	100.00%	371,217	562,584	537,752	467,528		0.0	0.0	0.0	0	0	0	0
Smartstrip Power Strip	195.2	419.0	352.2	306.2	75.0	75.0	79.1	79.1	5	5	5	5	100.00%	100.00%	73,252	157,217	139,260	121,075		0.0	0.0	0.0	0	0	0	0
Energy Star Refrigerator	3,904.5	5,608.0	4,754.9	4,133.9	107.0	107.0	107.0	107.0	12	12	12	12	100.00%	100.00%	5,013,355	7,200,672	6,105,245	5,307,965		0.0	0.0	0.0	0	0	0	0
2nd Refrigerator Pickup	300.3	580.0	528.3	459.3	835.0	835.0	835.0	835.0	8	8	8	8	100.00%	100.00%	2,006,303	3,874,400	3,529,164	3,068,294		0.0	0.0	0.0	0	0	0	0
2nd Freezer Pickup	150.2	197.0	176.1	153.1	663.0	663.0	663.0	663.0	8	8	8	8	100.00%	100.00%	796,514	1,044,888	934,066	812,087		0.0	0.0	0.0	0	0	0	0
Energy Star Room Air Purifiers	90.1	97.0	88.1	76.6	390.6	390.6	390.6	390.6	9	9	9	9	100.00%	100.00%	316,772	341,018	309,564	269,138		0.0	0.0	0.0	0	0	0	0
Room AC Pickup/Turn-in	15.0	10.0	17.6	15.3	16.2	16.2	16.2	16.2	5	5	5	5	100.00%	100.00%	1,213	808	1,423	1,237		0.0	0.0	0.0	0	0	0	0
Energy Star Central AC (3 ton)			70.4	61.2			110.3	110.3			14	14		100.00%			108,768	94,565			0.0	0.0	0	0	0	0
Energy Star Ductless Mini Split (Cooling Only)			17.6	15.3			30.6	30.6			14	14		100.00%			7,554	6,567			0.0	0.0	0	0	0	0
Energy Star Air Source Heat Pumps (SEER >=14.5/ EER >=12, Cooling)			52.8	45.9			92.0	92.0			12	12		100.00%			58,316	50,700			0.0	0.0	0	0	0	0
Energy Star Air Source Heat Pumps (HSPF >=8.2, Heating)			52.8	45.9			627.9	627.9			12	12		100.00%			398,089	346,102			0.0	0.0	0	0	0	0
Energy Star Wifi TSTAT for ASHP			38.0	33.1			23.4	23.4			15	15		100.00%			13,348	11,605			0.0	0.0	0	0	0	0
Energy Star DMSHP (Any, SEER >=20, HSPF >=10, Cooling)			792.5	689.0			124.4	124.4			12	12		100.00%			1,182,863	1,028,394			0.0	0.0	0	0	0	0
Energy Star DMSHP (Oil, SEER >=20, HSPF >=10, Heating)			396.2	344.5			536.4	536.4			12	12		100.00%			2,550,662	2,217,571			0.0	0.0	0	0	0	0
Energy Star DMSHP (LP, SEER >=20, HSPF >=10, Heating)			396.2	344.5			536.4	536.4			12	12		100.00%			2,550,662	2,217,571			0.0	0.0	0	0	0	0
Energy Star Wifi TSTAT for DMSHP			570.6	496.1			109.7	109.7			15	15		100.00%			938,858	816,252			0.0	0.0	0	0	0	0
								0.0															0	0		
DHW: Heat Pump Water Heater 50 Gallon Electric, EF>=2.3 (ES=EF>=2.0)			176.1	153.1			1,775.0	1,775.0			10	10		100.00%			3,125,828	2,717,676			0.0	0.0	0	0	0	0
DHW: Heat Pump Water Heater 80 Gallon Electric, EF>=2.3 (ES=EF>=2.0)			17.6	15.3			2,672.0	2,672.0			10	10		100.00%			470,566	409,106			0.0	0.0	0	0	0	0
Energy Star Cental Air Conditioner	43.1	57.0			110.3	110.3	110.3	110.3	14	14	14	14	100.00%	100.00%	66,525	88,013			0.0	0.0			0	0		
Energy Star Mini Split Heat Pump ($900 incentive - total)	77.6	548.0			122.9	122.9	122.9	122.9	12	12	12	12	100.00%	100.00%	114,347	808,015			0.0	0.0			0	0		
Energy Star Mini Split Heat Pump (for homes w/Oil heat)	57.6	423.0			-2,158.1	-2,158.1	-2,158.1	-2,158.1	12	12	12	12	100.00%	100.00%	-1,490,416	-10,954,620			17.1	17.1	17.1	17.1	11,837	87,003		0
Energy Star Mini Split Heat Pump (for homes w/LP heat)	20.0	125.0			-2,158.1	-2,158.1	-2,158.1	-2,158.1	12	12	12	12	100.00%	100.00%	-517,949	-3,237,181			15.4	15.4	15.4	15.4	3,703	23,145		0
Energy Star Mini Split Heat Pump ($450 incentive - total)	0.0	173				79.6				12			100.00%		0	165,174				0.0			0	0		
Energy Star Mini Split Heat Pump (for homes w/Oil heat)	0.0	134.0				-2,158.1				12			100.00%		0	-3,470,258				0.0			0	0		
Energy Star Mini Split Heat Pump (for homes w/LP heat)	0.0	39.0				-2,158.1				12			100.00%		0	-1,010,000				0.0			0	0		
Furn: LP, Furnace, FHA, AFUE >=95% w/ECM	103.4	38.0			168.0	168.0			18	18			100.00%	100.00%	312,684	114,912			4.5	4.5			8,375			
Furn: LP, Furnace, FHA, AFUE >=96% w/ECM	51.7	0.0			168.0	168.0			18	18			100.00%	100.00%	156,342	0			5.6	5.6			5,165			
Furn: LP, Furnace, FHA, AFUE >=97% w/ECM	17.2	24.0			168.0	168.0			18	18			100.00%	100.00%	52,114	72,576			5.9	5.9			1,830			
Furn: Oil, Furnace, FHA, AFUE >=85% w/ECM	51.7	6.0			168.0	168.0			18	18			100.00%	100.00%	156,342	18,144			18.0	18.0			16,751			
Furn: Oil, Furnace, FHA, AFUE >=90 w/ECM	17.2	0.0			168.0	168.0			18	18			100.00%	100.00%	52,114	0			20.7	20.7			6,421			
Boil: LP Boiler, FHW, AFUE >= 90%	103.4	57.0							20	20			100.00%	100.00%	0	0			10.4	10.4			21,507			
Boil: LP Boiler, FHW, AFUE >=96%	34.5	78.0							20	20			100.00%	100.00%	0	0			13.1	13.1			9,030			
Boil: Oil Boiler, FHW, AFUE >=85%	654.9	264.0							20	20			100.00%	100.00%	0	0			5.4	5.4			70,425			
Boil: Oil Boiler, FHW, AFUE >=90%	86.2	3.0							20	20			100.00%	100.00%	0	0			10.8	10.8			18,533			
Boil: LP, Combo condensing boiler w/ On-Demand DWH 90%	8.6	54.0							20	20			100.00%	100.00%	0	0			17.8	17.8			3,068			
Boil: Oil, Combo condensing boiler w/ On-Demand DWH 90%	8.6	0.0							20	20			100.00%	100.00%	0	0			17.8	17.8			3,068			
DHW: LP, Tankless Water Heaters (EF>= 0.82)	206.8	89.0			0.0	0.0			20	20			100.00%	100.00%	0	0			9.7	9.7			40,120			
DHW: LP, Indirect Water Heater (attached to LP Energy Star FHW boiler)	8.6	55.0			0.0	0.0			20	20			100.00%	100.00%	0	0			8.0	8.0			1,379			
DHW: Oil, Indirect Water Heater (attached to oil Energy Star FHW boiler)	8.6	172.0			0.0	0.0			20	20			100.00%	100.00%	0	0			8.0	8.0			1,379			
DHW: LP, Stand Alone Storage Water Heater (EF>=0.67)	8.6	2.0			0.0	0.0			13	13			100.00%	100.00%	0	0			3.7	3.7			414			
DHW: Energy Star Heat Pump 50 Gal Water Heater, EF>=2.3 (ES=EF>=2.0)	8.6	125.0			1,775.0	1,775.0			10	10			100.00%	100.00%	152,947	2,218,750				0.0			0			
DHW: Energy Star Heat Pump 80 Gal Water Heater, EF>=2.3 (ES=EF>=2.0)	8.6	1.0			2,672.0	2,672.0			10	10			100.00%	100.00%	230,239	26,720				0.0			0			
BRC: LP, Boiler Reset Controls	77.6	13.0			0.0	0.0			15	15			100.00%	100.00%	0	0			9.6	9.6			11,167			
BRC: Oil, Boiler Reset Controls	103.4	42.0			0.0	0.0			15	15			100.00%	100.00%	0	0			9.6	9.6			14,890			
TSTAT: LP, 7-Day Programmable Thermostats	8.6	32.0			14.4	14.4			15	15			100.00%	100.00%	1,861	6,911	0	0	7.7	7.7			995			
TSTAT: Oil, 7-Day Programmable Thermostats	8.6	110.0			14.4	14.4			15	15			100.00%	100.00%	1,861	23,757			7.7	7.7			995			
TSTAT: LP, WiFi Enabled 7-Day Programmable Thermostats	8.6	0.0			14.4	14.4			15	15			100.00%	100.00%	1,861	0			6.6	6.6			853			
TSTAT: Oil, WiFi Enabled 7-Day Programmable Thermostats	8.6	0.0			14.4	14.4			15	15			100.00%	100.00%	1,861	0			6.6	6.6			853			
Water Heater: LP Tankless, EF>=0.94	0.0	67.0				0.0				20										39.0			0			

Planning Assumptions

1. Clothes Washer Annual kWH Savings updated based on mix of Water Heating Survey Results (Electric vs LP/Oil/NG water heating) and per EnergyStar.gov Savings Calculator.
2. All Energy Star Appliance savings were updated based on review of the EnergyStar.gov Savings Calculator and/or recent evaluations.
3. Central air conditioner and Mini Split Heat Pump Annual kWh savings were updatd via the EnergyStar.gov calculator, and conservatively assumed 50% of heat provided by heat pump, 50% provided by existing fossil system.
4. As part of the Statewide CORE Energy Efficiency Plan, the plan is to provide Ductless Mini Split incentives only for the more efficient "Low Temperature" models.
5. All furnace-related measures are part of the HPwES program starting in 2015.

PSNH Large Business Energy Solutions Program

PSNH
NHPUC Docket No. DE 14-216
Attachment K (2015-2016 Plan)
Large Business Energy Solutions Program

Measure	Quantity 2013 Plan	Quantity 2013 Actual	Quantity 2015 Plan	Quantity 2016 Plan	Annual Savings per Unit (kWh) 2013 Plan	Annual Savings per Unit (kWh) 2013 Actual	Annual Savings per Unit (kWh) 2015 Plan	Annual Savings per Unit (kWh) 2016 Plan	Measure Life 2013 Plan	Measure Life 2013 Actual	Measure Life 2015 Plan	Measure Life 2016 Plan
NEW EQUIPMENT TRACK												
Cooling	44.2	49.0	28.2	27.4	34,776.7	44,213.2	39,908.4	39,908.4	15	15	15	15
Heating	4.3	10.0	14.3	13.9	53,278.3	225,338.5	94,862.4	94,862.4	15	15	15	15
Lighting	13.0	22.0	17.7	17.2	66,783.4	72,786.9	59,831.5	59,831.5	15	15	15	15
Lighting (LED)	0.0	2.0	0.0	0.0		454,417.5	0.0	0.0	15	15	15	15
Lighting (Occ Sensors Only)	3.8	16.0	0.0	0.0	24,628.0	17,100.5	0.0	0.0	10	10	10	10
Other	8.5	0.0	0.0	0.0	131,370.3	131,370.3	0.0	0.0	15	15	15	15
Process	31.9	36.0	20.5	19.9	54,812.6	124,799.3	117,825.5	117,825.5	15	14	15	15
Lighting - Parking Lot Lights	0.0		43.9	42.6			2,250.0	2,250.0	15	0	15	15
RETROFIT TRACK												
Cooling	18.6	3.0	8.5	8.2	65,103.9	53,784.7	93,521.4	93,521.4	13	13	13	13
Heating	9.4	2.0	5.3	5.1	17,368.5	53,229.0	52,904.1	52,904.1	20	13	13	13
Lighting	83.6	30.0	93.5	90.5	52,212.4	87,626.5	69,199.6	69,199.6	13	13	13	13
Lighting - LED	8.9	16.0	0.0	0.0	88,341.6	36,975.9		0.0	13	13	13	13
Lighting - Occ Sensors only	16.9	9.0	0.0	0.0	30,253.0	24,688.6		0.0	9	9	9	9
Other	6.1	1.0	15.3	14.8	27,788.3	177,033.0	30,062.7	30,062.7	14	13	13	13
Lighting - Parking Lot Lights	8.5	21.0	36.2	35.0	51,129.8	36,125.3	21,950.7	21,950.7	13	13	13	13
Process	50.5	20.0	67.3	65.1	65,379.8	134,197.3	91,880.3	91,880.3	12	13	12	12
Fuel Neutral Heating, Hot Water and Controls												
Air Source Heat Pump Split Systems (Energy Star >= 14.5 SEER)	4.1	0.0			122.9	122.9			12	12		
LP: Air Source Heat Pump Split Systems (Energy Star >= 14.5 SEER)	0.8	0.0			-2,158.1	-2,158.1			12	12		
Oil: Air Source Heat Pump Split Systems (Energy Star >= 14.5 SEER)	3.3	0.0			-2,158.1	-2,158.1			12	12		
Indirect Water Heater (attached to Oil Energy Star FHW boiler)	0.0	3.0				0.0				15		
On Demand Tankless Water Heater >= 95 EF w/Electronic ignition	0.0	4.0				0.0				20		
Boilers, LP >= 90% thermal efficiency (301 to 499 MBH), Condensing	1.0	0.0			0.0	0.0			25	25		
Boilers, LP ≥ 90% thermal efficiency (500 to 999 MBH), Condensing	0.0	5.0			0.0	0.0			25	25		
Boilers, Oil ≥ 85% thermal efficiency (500 to 999 MBH)	2.1	0.0			0.0	0.0			25	25		
Boilers, LP ≥ 90% thermal efficiency (1000 to 1700 MBH), Condensing	0.2	3.0			0.0	0.0			25	25		
Boilers, Oil ≥ 85% thermal efficiency (1000 to 1700 MBH)	12.4	0.0			0.0	0.0			25	25		
Boilers, Oil ≥ 85% thermal efficiency (1701 to 2000 MBH)	20.2	0.0			0.0	0.0			25	25		
7-Day Programmable Thermostats (Oil)	0.0	24.0			0.0	0.0			15	15		
Boiler Reset Controls, LP, After Market, 1 shift operation	0.0	5.0			0.0	0.0			15	15		
Boiler Reset Controls, Oil, After Market, 1 shift operation	1.2	0.0			0.0	0.0			15	15		
Steam Traps, Oil (greater than 10 steam traps requires pre-approval)	0.0	157.0			0.0	0.0			3	3		
Low Intensity Infrared Heaters - LP		2.0				0.0				17		

Measure	In-Service or Realizaton Rate 2013	In-Service or Realizaton Rate 2015 2016	Total Lifetime Savings (kWh) 2013 Plan	Total Lifetime Savings (kWh) 2013 Actual	Total Lifetime Savings (kWh) 2015 Plan	Total Lifetime Savings (kWh) 2016 Plan	Annual Savings Per Unit (MMBTU) 2013 Plan	Annual Savings Per Unit (MMBTU) 2013 Actual	Annual Savings Per Unit (MMBTU) 2015 Plan	Annual Savings Per Unit (MMBTU) 2016 Plan	Total Lifetime MMBTU Savings 2013 Plan	Total Lifetime MMBTU Savings 2013 Actual	Total Lifetime MMBTU Savings 2015 Plan	Total Lifetime MMBTU Savings 2016 Plan
NEW EQUIPMENT TRACK														
Cooling	92.50%	92.50%	21,310,898	29,851,553	15,993,461	15,515,378		0.0	0.0	0.0	0	0	0	0
Heating	92.50%	92.50%	3,210,435	31,265,717	18,680,114	18,121,720		0.0	0.0	0.0	0	0	0	0
Lighting	92.50%	92.50%	12,059,476	22,218,204	14,714,089	14,274,249		0.0	0.0	0.0	0	0	0	0
Lighting (LED)	92.50%	92.50%	0	12,610,086	0	0		0.0	0.0	0.0	0	0	0	0
Lighting (Occ Sensors Only)	92.50%	92.50%	862,163	2,530,874	0	0		0.0	0.0	0.0	0	0	0	0
Other	92.50%	92.50%	15,414,643	0	0	0		0.0	0.0	0.0	0	0	0	0
Process	92.50%	92.50%	24,275,347	58,316,417	32,973,324	31,987,671		0.0	0.0	0.0	0	0	0	0
Lighting - Parking Lot Lights	92.50%	92.50%	0	0	1,371,507	1,330,510				0.0	0	0	0	0
											0	0	0	0
RETROFIT TRACK											0	0	0	0
Cooling	94.00%	94.00%	14,293,887	1,971,746	9,844,960	9,522,725		0.0	0.0	0.0	0	0	0	0
Heating	94.00%	94.00%	3,072,035	1,318,378	3,426,090	3,313,951		0.0	0.0	0.0	0	0	0	0
Lighting	94.00%	94.00%	53,165,257	32,123,861	78,892,908	76,310,672		0.0	0.0	0.0	0	0	0	0
Lighting - LED	94.00%	94.00%	9,636,735	7,229,532	0	0		0.0	0.0	0.0	0	0	0	0
Lighting - Occ Sensors only	94.00%	94.00%	4,512,326	1,879,788	0	0		0.0	0.0	0.0	0	0	0	0
Other	94.00%	94.00%	2,171,361	2,163,343	5,746,144	5,558,068		0.0	0.0	0.0	0	0	0	0
Lighting - Parking Lot Lights	94.00%	94.00%	5,280,733	9,270,471	9,702,149	9,384,588		0.0	0.0	0.0	0	0	0	0
Process	94.00%	94.00%	36,353,093	32,338,842	71,833,817	69,482,631		0.0	0.0	0.0	0	0	0	0
Fuel Neutral Heating, Hot Water and Controls														
Air Source Heat Pump Split Systems (Energy Star >= 14.5 SEER)	100.00%		6,075	0	0	0	0.0	0.0			0	0	0	0
LP: Air Source Heat Pump Split Systems (Energy Star >= 14.5 SEER)	100.00%		-21,339	0	0	0	15.4	15.4			153	0	0	0
Oil: Air Source Heat Pump Split Systems (Energy Star >= 14.5 SEER)	100.00%		-85,354	0	0	0	17.1	17.1			678	0	0	0
Indirect Water Heater (attached to Oil Energy Star FHW boiler)	100.00%		0	0	0	0		20.7			0	932	0	0
On Demand Tankless Water Heater >= 95 EF w/Electronic ignition	100.00%		0	0	0	0		9.6			0	767	0	0
Boilers, LP >= 90% thermal efficiency (301 to 499 MBH), Condensing	100.00%		0	0	0	0	42.3	42.3			1,089	0	0	0
Boilers, LP ≥ 90% thermal efficiency (500 to 999 MBH), Condensing	100.00%		0	0	0	0	77.1	77.1			0	9,638	0	0
Boilers, Oil ≥ 85% thermal efficiency (500 to 999 MBH)	100.00%		0	0	0	0	77.1	77.1			3,970	0	0	0
Boilers, LP ≥ 90% thermal efficiency (1000 to 1700 MBH), Condensing	100.00%		0	0	0	0	142.6	142.6			734	10,695	0	0
Boilers, Oil ≥ 85% thermal efficiency (1000 to 1700 MBH)	100.00%		0	0	0	0	142.6	142.6			44,062	0	0	0
Boilers, Oil ≥ 85% thermal efficiency (1701 to 2000 MBH)	100.00%		0	0	0	0	249.0	249.0			125,665	0	0	0
7-Day Programmable Thermostats (Oil)	100.00%		0	0	0	0	7.7	7.7			0	2,772	0	0
Boiler Reset Controls, LP, After Market, 1 shift operation	100.00%		0	0	0	0	19.3	19.3			0	1,448	0	0
Boiler Reset Controls, Oil, After Market, 1 shift operation	100.00%		0	0	0	0	19.3	19.3			358	0	0	0
Steam Traps, Oil (greater than 10 steam traps requires pre-approval)	100.00%		0	0	0	0	25.7	25.7			0	12,105	0	0
Low Intensity Infrared Heaters - LP	100.00%		0	0	0	0 0		48.3			0	1,642	0	0

Planning Assumptions

1. Annual Savings were updated based on recent trends and reflect expected project sizes.
   - The New Construction Track projects are expected to be generally smaller projects (had we increased the average incentive and annual kwh savings, it would have not reflected trends and it would have reduced the number of projects to be done).
2. Lighting (LED) and Lighting Occupancy Sensor projects are incorporated into Lighting Projects for planning purposes.
3. Fossil Heating System incentives eliminated as a result of SB 268 (no Energy Efficiency Funds (RGGI)).
4. "Heating" projects are mostly efficient snowmaking equipment (we use heating because we don't have a snowmaking load shape yet), and we are expecting smaller projects in 2015-2016 than we've seen in 2013.

PSNH
NHPUC Docket No. DE 14-216
Attachment K (2015-2016 Plan)
Small Business Energy Solutions Program

PSNH Small Business Energy Solutions Program

Measure	Quantity 2013 Plan	Quantity 2013 Actual	Quantity 2015 Plan	Quantity 2016 Plan	Annual Savings per Unit (kWh) 2013 Plan	Annual Savings per Unit (kWh) 2013 Actual	Annual Savings per Unit (kWh) 2015 Plan	Annual Savings per Unit (kWh) 2016 Plan	Measure Life 2013 Plan	Measure Life 2013 Actual	Measure Life 2015 Plan	Measure Life 2016 Plan	In-Service or Installation Rate 2013	In-Service or Installation Rate 2015 2016	Total Lifetime Savings (kWh) 2013 Plan	Total Lifetime Savings (kWh) 2013 Actual	Total Lifetime Savings (kWh) 2015 Plan	Total Lifetime Savings (kWh) 2016 Plan	Annual Savings Per Unit (MMBTU) 2013 Plan	Annual Savings Per Unit (MMBTU) 2013 Actual	Annual Savings Per Unit (MMBTU) 2015 Plan	Annual Savings Per Unit (MMBTU) 2016 Plan	Total Lifetime MMBTU Savings 2013 Plan	Total Lifetime MMBTU Savings 2013 Actual	Total Lifetime MMBTU Savings 2015 Plan	Total Lifetime MMBTU Savings 2015 Plan
Lighting - New Equipment & Construction	143.5	103.0	62.3	60.2	13,787.6	19,780.8	18,194.1	18,194.1	16	16	15	15	100.00%	100.00%	31,432,153	31,681,646	17,025,896	16,459,891	0.0	0.0	0.0		0	0	0	0
Lighting - Retrofit	167.8	285.0	138.4	133.8	19,981.5	22,298.1	23,569.9	23,569.9	13	13	13	13	100.00%	100.00%	42,978,806	81,111,340	42,233,041	40,829,056	0.0	0.0	0.0		0	0	0	0
Lighting - Direct Install	192.1	184.0	187.6	181.3	14,488.5	22,372.0	16,169.2	16,169.2	13	13	13	13	100.00%	100.00%	35,772,621	52,323,322	38,258,064	36,986,222	0.0	0.0	0.0		0	0	0	0
Lighting - Catalog Sales	667.7	3,902.0	120.4	116.4	46.3	46.3	1,618.1	1,618.1	6	6	13	13	100.00%	100.00%	185,501	1,084,093	2,533,108	2,448,898	0.0	0.0	0.0		0	0	0	0
SmartStrips	80.7	13.0	57.8	55.9	75.0	75.0	75.0	75.0	5	5	5	5	100.00%	100.00%	30,280	4,878	21,689	20,968	0.0	0.0	0.0		0	0	0	0
Fuel Neutral Heating, Hot Water and Controls																										
Central Air Conditioner (Energy Star >= 14.5 SEER), 3 ton	32.3	7.0			110.3	110.3			14	14			100.00%		49,810	10,809	0	0	0.0	0.0			0	0	0	0
Central Air Conditioner (Energy Star >= 14.5 SEER), 6 ton	0.0	1.0			220.6	220.6			14	14			100.00%		0	3,088	0	0	0.0	0.0			0	0	0	0
Air Source Heat Pump Split Systems (Energy Star >= 14.5 SEER)	125.4	48.0			122.9	122.9			12	12			100.00%		184,973	70,775	0	0	0.0	0.0			0	0	0	0
Air Source Heat Pump Split Systems (Energy Star >= 14.5 SEER)					-2,158.1	-2,158.1			12	12			100.00%		0	0	0	0	0.0	0.0			0	0	0	0
Gas: Air Source Heat Pump Split Systems (Energy Star >= 14.5 SEER)	0.0	0.0			-2,158.1	-2,158.1			12	12			100.00%		0	0	0	0	15.4	15.4			0	0	0	0
LP: Air Source Heat Pump Split Systems (Energy Star >= 14.5 SEER)	35.8	11.0			-2,158.1	-2,158.1			12	12			100.00%		-928,235	-285,908	0	0	15.4	15.4			6,637	2,044	0	0
Oil: Air Source Heat Pump Split Systems (Energy Star >= 14.5 SEER)	89.6	37.0			-2,158.1	-2,158.1			12	12			100.00%		-2,320,588	-957,170	0	0	17.1	17.1			18,430	7,602	0	0
Indirect Water Heater (attached to LP Energy Star FHW boiler)		4.0				0.0				15			100.00%		0	0	0	0		20.7			0	1,242	0	0
Indirect Water Heater (attached to Oil Energy Star FHW boiler)		3.0				0.0				15			100.00%		0	0	0	0		20.7			0	932	0	0
On Demand Tankless Water Heater, LP, >=.82 EF w/Electronic Ignition	35.8	1.0			0.0	0.0			20	20			100.00%		0	0	0	0	7.1	7.1			5,060	142	0	0
On Demand Tankless Water Heater, LP, >=.95 EF w/Electronic Ignition	21.5	3.0			0.0	0.0			20	20			100.00%		0	0	0	0	9.6	9.6			4,125	575	0	0
Furnace, LP (forced hot air) ≥ 95% AFUE w/ECM (up to 150 MBH)	0.0	6.0			0.0	0.0			18	18			100.00%		0	0	0	0	16.1	16.1			0	1,739	0	0
Furnace, Oil (forced hot air) ≥ 85% AFUE w/ECM (up to 150 MBH)	0.0	2.0			0.0	0.0			18	18			100.00%		0	0	0	0	16.1	16.1			0	580	0	0
Furnace, LP (forced hot air) ≥ 97% AFUE w/ECM (up to 150 MBH)	0.0	6.0			0.0	0.0			18	18			100.00%		0	0	0	0	18.5	18.5			0	1,998	0	0
Boilers, LP ≥ 90% AFUE (up to 300 MBH), Condensing	17.9	3.0			0.0	0.0			25	25			100.00%		0	0	0	0	22.8	22.8			10,215	1,710	0	0
Boilers, Oil ≥ 85% AFUE (up to 300 MBH)	35.8	5.0			0.0	0.0			25	25			100.00%		0	0	0	0	22.8	22.8			20,430	2,850	0	0
Boilers, LP ≥ 96% AFUE (up to 300 MBH), Condensing	0.0	5.0			0.0	0.0			25	25			100.00%		0	0	0	0	25.2	25.2			0	3,150	0	0
Boilers, Oil ≥ 87% AFUE (up to 300 MBH)	0.0	8.0			0.0	0.0			25	25			100.00%		0	0	0	0	25.2	25.2			0	5,040	0	0
Boilers, LP >= 90% thermal efficiency (301 to 499 MBH), Condensing	17.9				0.0	0.0			25	25			100.00%		0	0	0	0	42.3	42.3			18,952	0	0	0
Boilers, Oil >= 85% thermal efficiency (301 to 499 MBH)	35.8				0.0	0.0			25	25			100.00%		0	0	0	0	42.3	42.3			37,904	0	0	0
Boilers, LP ≥ 90% thermal efficiency (500 to 999 MBH), Condensing	0.0	1.0			0.0	0.0			25	25			100.00%		0	0	0	0	77.1	77.1			0	1,928	0	0
Boilers, Oil ≥ 85% thermal efficiency (500 to 999 MBH)	0.0	1.0			0.0	0.0			25	25			100.00%		0	0	0	0	77.1	77.1			0	1,928	0	0
Boilers, Oil ≥ 85% thermal efficiency (1000 to 1700 MBH)	0.0	1.0			0.0	0.0			25	25			100.00%		0	0	0	0	142.6	142.6			0	3,565	0	0
7-Day Programmable Thermostats (LP)	0.0	11.0			0.0	0.0			15	15			100.00%		0	0	0	0	7.7	7.7			0	1,271	0	0
7-Day Programmable Thermostats (Oil)	0.0	21.0			0.0	0.0			15	15			100.00%		0	0	0	0	7.7	7.7			0	2,426	0	0
Boiler Reset Controls, LP, After Market, 1 shift operation	17.9	0.0			0.0	0.0			15	15			100.00%		0	0	0	0	19.3	19.3			5,188	0	0	0
Boiler Reset Controls, Oil, After Market, 1 shift operation	17.9	3.0			0.0	0.0			15	15			100.00%		0	0	0	0	19.3	19.3			5,188	869	0	0
Steam Traps, Oil (greater than 10 steam traps requires pre-approval)	0.0	7.0			0.0	0.0			3	3			100.00%		0	0	0	0	25.7	25.7			0	540	0	0
Unit Heaters (up to 300 MBH), LP, Condensing		5.0				0.0				18			100.00%		0	0	0	0		30.0			0	2,700	0	0
Heat Pump Water Heaters, 50gal		3.0				1,775.0				10			100.00%		0	53,250	0	0		0.0			0	0	0	0

Planning Assumptions

1. Annual kWh Savings updated to reflect the trend in smaller "Lighting - Direct Install" projects.
2. Annual kWh Savings for "Lighting - Catalog Sales" (or online sales) were updated to reflect projects (purchase of more than one bulb) rather than on a per bulb basis, and the measure life updated to reflect the purchase of longer life LEDs.
3. Fossil Heating System incentives eliminated as a result of SB 268 (no Energy Efficiency Funds (RGGI)).

APPENDIX D. ENERGY OPTIMIZATION MODEL – NH ADAPTATION

In October 2018, Navigant created the Massachusetts Residential Energy Optimization Model as part of a study conducted on behalf of the Massachusetts program administrators and the MA Energy Efficiency Advisory Council (EEAC).[75] The Energy Optimization Model is an interactive spreadsheet that enables users to calculate the cost and energy savings associated with residential EE measures that involve fuel switching for space heating and water heating end uses. An unlocked version of the spreadsheet model is publicly available from the MA EEAC.[76]

A key output of the current New Hampshire Energy Optimization Study is an examination of the energy usage and customer cost savings associated with energy optimization measures. Our team developed energy and cost estimates for New Hampshire by adapting the MA Energy Optimization Model using New Hampshire-specific inputs.

The data tables in section 5 of this report present customer cost, energy usage, electricity demand, and GHG emissions outputs from the adapted NH Energy Optimization Model. These section 5 tables compare these outputs to analogous values representing current practices in New Hampshire, which were calculated based on measure data from the benefit-cost models used by New Hampshire utilities. These tables report results for a subset of residential measures representing typical end uses and installation scenarios that New Hampshire may choose to incentivize. The adapted NH Energy Optimization Model is included as an attachment to this report, and it contains the complete results for all of the 29 residential energy optimization measures we have characterized.

Description of the Energy Optimization Model

The October 2018 version of the MA Energy Optimization Model characterizes 29 measures using cost and consumption data gathered from recent EM&V studies conducted in Massachusetts. These measures include oil- and propane-to-electric measures, as well as oil- and propane-to-natural gas measures. The model estimates savings from fuel switching measures by calculating the difference in cost and consumption between a baseline level (oil or propane) and an efficient level (electric or natural gas). In the model, energy and cost savings are calculated for three scenarios: (1) a full/early replacement scenario, where operational baseline equipment is removed from service and fully replaced by efficient equipment; (2) a partial displacement scenario, where the baseline equipment continues operating and is supplemented by new efficient equipment; and (3) a replace on failure scenario, where baseline equipment that has failed is replaced by new efficient equipment.

Table 1 describes the data inputs to the Energy Optimization Model, and the outputs that are available for each measure that is characterized in the model. The model's inputs are set to default values based on publicly-available data sources cited in the model and in Table 1, but the inputs may be adjusted by users of the model to reflect local conditions.

[75] A memo summarizing the motivation, methodology, and data sources for this model is available from the MA EEAC at: http://ma-eeac.org/wordpress/wp-content/uploads/RES21_Energy-Optimization-Study_09OCT2018.pdf

[76] The spreadsheet model delivered to the MA EEAC in October 2018 is available from the MA EEAC at: http://ma-eeac.org/wordpress/wp-content/uploads/RES21_Task4_Final_Spreadsheet_Model_REVISED_2018-09-25_v4.xlsx

Table 1. Energy Optimization Model Inputs and Outputs

Inputs to Energy Optimization Model	Energy Optimization Model Outputs for Each Energy Efficiency Measure
• Average annual temperature profile [1] • Energy costs for all fuel types [2] • Equipment efficiency & consumption [3] [4] • Equipment installation costs [5] • GHG emissions factors for all fuel types [6] • Electric generation mix and heat value [7] • Space heating and water heating loads [5] [8] • Heat pump performance data [5] [9] • Saturation of baseline A/C technologies [10] • User-specified switchover temperatures	• Customer energy cost savings • Energy consumption savings by fuel type • Net energy savings across all fuel types • Summer & winter peak electric demand savings • Net GHG emissions reductions • Incremental installed costs

[1] Outdoor temperatures affect the operating efficiency of air source heat pumps. White Box Technologies, Inc. http://weather.whiteboxtechnologies.com/

[2] Energy Information Administration (EIA) Fuel Price Data. https://www.eia.gov/dnav/pet/PET_PRI_WFR_DCUS_SMA_W.htm

[3] Massachusetts Technical Reference Manual (TRM). http://ma-eeac.org/wordpress/wp-content/uploads/2016-2018-Plan-1.pdf

[4] U.S. Department of Energy (DOE) Appliance Standards Technical Support Documents. https://www.energy.gov/eere/buildings/standards-and-test-procedures

[5] Residential Cost and Evaluation Studies Conducted on Behalf of the Massachusetts EEAC. http://ma-eeac.org/studies/residential-program-studies/

[6] EIA Carbon Dioxide Emissions Factors. https://www.eia.gov/tools/faqs/faq.php?id=73&t=11

[7] EIA Electricity Generation and Heat Value Data for New Hampshire. https://www.eia.gov/electricity/state/newhampshire/index.php

[8] EIA 2015 Residential Energy Consumption Survey (RECS). https://www.eia.gov/consumption/residential/data/2015/index.php

[9] NEEP Cold Climate Air-Source Heat Pump Database. http://www.neep.org/initiatives/high-efficiency-products/emergingtechnologies/ashp/cold-climate-air-source-heat-pump

[10] 2018 Claritas (formerly The Nielsen Company) Energy Behavior Track annual survey. Select results provided by Liberty Utilities. https://www.esource.com/about-rcic

The Energy Optimization Model assumes that (1) residential customers use their heat pump equipment to meet their household’s full cooling load, (2) residential customers use their heat pump equipment to meet all of their household’s heating load above a user-specified switchover temperature, and (3) residential customers with dual-fuel configurations use fossil fuel equipment to meet all of their household’s heating load below a user-specified switchover temperature. In the course of the current study, our team has heard anecdotal evidence that some residential customers who install heat pumps may choose to use only the cooling function of the heat pump. These residential customers may not realize the energy-saving benefits associated with heating by electric heat pumps. A recent customer survey in Massachusetts explored the behavior of customers who received rebates for installing a ductless mini-split heat pump system. The study found that 89% of 2017 program participants that installed DMSHPs rebated through the Mass Save Heating & Cooling Program use their DMSHP systems for heating.[77]

[77] Navigant (2018). “Quick Hit Study: Ductless Mini-Split Heat Pump Survey (RES 29).” Available at: http://ma-eeac.org/wordpress/wp-content/uploads/RES-29_Final-Memo_18.03.30.pdf

However, the Energy Optimization Model assumes that participants make full use of their heat pump's heating function.

The model includes a modest correction factor to account for the possibility that some residential customers operating a dual-fuel configuration (i.e., electric heat pump with fossil fuel backup) will not have an optimized system configuration. In other words, the model's consumption calculations are adjusted upwards on the assumption that some systems will not be properly installed.

Adaptations for New Hampshire

Our team made the following adaptations to the MA Energy Optimization Model to tailor its calculations to New Hampshire:

- **Annual weather data.** The performance of air-source heat pumps varies depending on the outdoor air temperature. Generally, air-source heat pumps operate less efficiently at low outdoor air temperatures than at high temperatures. The model uses annual weather data to estimate the typical annual performance of air-source heat pumps for a given climate zone. Annual weather data comes from the weather station at Concord Municipal Airport, which is proximate to the population center of New Hampshire.[78]

- **Discount Rate.** The model uses a discount rate to calculate the present value of future cost savings due to early replacement measures. The value of the discount rate has been updated to 2.84% to match the real discount rate used in the New Hampshire B/C model.

- **Fuel cost data.** The model uses the cost of different fuel types to calculate the typical operating costs that customers pay to operate different types of equipment as well as the customer cost savings that result from shifting consumption from baseline level equipment to measure level equipment. Fuel cost inputs come from the Energy Information Administration (EIA).[79] The model assumes energy costs of $3.12/gallon fuel oil, $0.20/kWh electricity, $1.61/therm natural gas, and $3.28/gallon propane.

- **Saturation of Baseline A/C Technologies.** The model calculates the energy and demand savings associated with switches from fossil fuel heating to electric heat pumps. The model accounts for changes in electric consumption for space cooling. Assumptions regarding the primary cooling system type in residential properties in New Hampshire are taken from results of the 2018 Claritas Energy Behavior Track annual survey, conducted in partnership with E Source.[80] The results of this survey show that about 80% of NH customers use electric powered air conditioning. For customers with air conditioning systems, the installation of an efficient electric heat pump will likely reduce consumption and demand for space cooling. For customers without air conditioning, the installation of an electric heat pump adds a new space cooling capability, with associated increases in consumption and electric demand. The Energy Behavior Track survey reports eleven primary cooling options for residential customers: central A/C,

[78] National Renewable Energy Laboratory (NREL). National Solar Radiation Data Base (NSRDB). Typical meteorological year (TMY3) dataset for Concord Municipal Airport. Available at: https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/

[79] EIA 2019 Average New Hampshire Residential Heating Oil Price per gallon (Oct 2018 - Mar 2019) https://www.eia.gov/dnav/pet/PET_PRI_WFR_DCUS_SNH_W.htm

EIA 2019 Electricity Data Browser, New Hampshire Average Residential Retail Price of Electricity (Feb 2018 - Feb 2019) https://www.eia.gov/electricity/data/browser/#/topic/7

EIA 2019 New Hampshire Residential Natural Gas Price per therm (Oct 2018 - Feb 2019) https://www.eia.gov/dnav/ng/ng_pri_sum_dcu_SNH_m.htm where one therm equals 100 cubic ft.

[80] The 2018 Claritas Energy Behavior Track annual survey sampled 32,459 residential customers across the U.S. and asked questions on a variety of energy-related topics. At the state level, the survey reports customers' primary source of cooling, and the results for New Hampshire are based on a sample of 120 residential NH customers. Survey results are behind a paywall, and a description of the survey is available at: https://www.esource.com/about-rcic

evaporative cooler, floor (or) ceiling fan, heat pump, split or ductless unit, wall unit, whole-house fan, window unit, other, don't know, no cooling system. The NH Energy Optimization Model groups these technologies into three categories: Central A/C (33.3%, including central A/C and heat pump), Room/Window A/C (46.4%, including split or ductless unit, wall unit, and window unit), and No A/C (20.3%, including all other types). In comparison, the breakdown of primary cooling sources for Massachusetts is 40.6% central A/C, 39.4% room/window A/C, and 20% no A/C.

- **Electric generation mix.** The model uses the average annual electric generation mix for ISO New England to estimate the greenhouse gas emissions that would result from the operation of different equipment types. The model focuses on generation sources with significant carbon emissions. These sources and their percent of total electric generation are: natural gas (49.0%), oil (1.1%), and coal (1.0%).[81]

The NH adaptation of the MA Residential Energy Optimization model does not update the following inputs to the MA model: absolute and incremental equipment installation costs; assumptions regarding equipment efficiency at the baseline and measure levels; heat pump performance curves; heat pump performance correction factors. Our team is not aware of any data sources that would provide New Hampshire-specific data for these inputs, and we assume that the values of these inputs would be similar in New Hampshire and Massachusetts.

[81] ISO New England. "Sources of Electricity Used in 2018." Available at: https://www.iso-ne.com/about/key-stats/resource-mix/

APPENDIX E. NORTHEASTERN STATES' UNREGULATED FUEL SAVINGS ACCOUNTING

Vermont, Massachusetts, Connecticut, and Rhode Island currently claim unregulated fuel savings for certain EE measures in their savings calculations. Maine and New York have plans to count unregulated fuel savings in the future, but do not currently count unregulated fuels in their savings calculations. This appendix reproduces the unregulated fuel savings and calculations for fuel switching from the applicable Northeastern states' Technical Reference Manuals (TRM)[82].

[82] CT does not use a TRM. They have a Program Savings Document (PSD).

E.1 Vermont

Variable Speed Mini-Split Heat Pumps[83]

Measure Number: VII-C-6-a

Version Date & Revision History
Draft date: 8/12/2014
Effective date: 12/1/2014
End date: TBD

Referenced Documents:
1. Energy & Resource Solutions. *Emerging Technology Program Primary Research – Ductless Heat Pumps.* Lexington, MA: NEEP Regional EM&V Forum, 2014.
2. GDS Associates, Inc. *Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures.* Manchester, NH: The New England State Program Working Group (SPWG), 2007.
3. Navigant Consulting Inc. *Incremental Cost Study Phase Two Final Report.* Burlington, MA: NEEP Evaluation, Measurement, and Verification Forum, 2013.
4. NMR Group, Inc. "Vermont Single-Family Existing Homes Onsite Report FINAL." 2013.
5. U.S. Environmental Protection Agency. n.d. http://www.epa.gov/burnwise/woodstoves.html (accessed March 7, 2014).
6. CCHPSavingsAnalysis.xlsx
7. DHP LoadProfileAverager.xlsx

Description
This measure claims savings for the installation of single head variable speed mini-split heat pumps in a residential application. The measure is characterized as a market opportunity claiming electric energy and demand savings for both heating and cooling versus the installation of a baseline heat pump.

Baseline Efficiency
The baseline condition is assumed to be a new heat pump that is capable of providing heat using the heat pump cycle down to 5°F and meets the following minimum efficiency criteria:

Table 5 – Baseline Efficiency Criteria[987]

Equipment	HSPF	EER	SEER
Air-Source Heat Pump	8.2	12	14.5

High Efficiency
To qualify for savings under this measure the installed equipment must be a new mini-split heat pump that has a variable speed inverter-driven compressor, COP at 5°F ≥ 1.75 (at maximum capacity operation), and be capable of providing heat using the heat pump cycle down to -5°F. It must also meet or exceed the following efficiency criteria, per AHRI Standard 210-240-2008 for Unitary Air-Conditioning and Air-Source Heat Pump equipment.

Table 6 – High Efficiency Criteria

Equipment	HSPF	EER	SEER
Air-Source Heat Pump	10.3	12	20

[83] As listed on page 537 of the VT TRM, available here: https://puc.vermont.gov/sites/psbnew/files/doc_library/ev-technical-reference-manual.pdf

Energy Savings
Electric energy savings include reductions in heating and cooling consumption based on improved system efficiency. Seasonal efficiency values have been used to approximate varying system efficiencies due to changes in operating conditions.

Cooling savings are calculated using nominal system capacity and Full Load Cooling Hours for Vermont.

Heating savings are calculated using a weather bin analysis in order to account for the variable heating capacity of CCHPs at different outdoor temperatures. The analysis assumes that both efficient and baseline heating systems operate below 50°F, except in summer months (May to August), and that the heat pump provides heating based on its maximum capacity for each weather bin.[988] Below 5°F the baseline system cuts off and the efficient system continues to provide heating. The operation of the efficient system below 5°F is treated as an electric consumption and demand penalty taken against the previously mentioned savings. While this operation represents a penalty, it also represents a savings of fuel from the home's existing heating system, and the electric penalty is slightly reduced to account for homes with existing electric resistance heat.

$$\Delta kWh = \left[Q_{Cooling} \times FLH_{Cooling} \times \left(\frac{1}{SEER_{Baseline}} - \frac{1}{SEER_{Efficient}}\right) + \sum_{i=1}^{n}\left(Q_{Heating\geq 5°F,i}\right) \times \left(\frac{1}{HSPF_{Baseline}\times 90\%} - \frac{1}{HSPF_{Efficient}\times 90\%}\right) - \sum_{i=1}^{n}\left(Q_{Heating<5°F,i}\right) \times \left(\frac{1}{HSPF_{Efficient}\times 90\%}\right)\right] \times \frac{1\ kWh}{1{,}000\ Wh} + \sum_{i=1}^{n}\left(Q_{Heating<5°F,i}\right) \times \%ElecHeat \times \frac{1\ kWh}{3{,}412\ Btu}$$

Where:

ΔkWh	= total net kWh savings for heating and cooling (deemed assumption for prescriptive savings, based on size category)
$Q_{Cooling}$	= nominal cooling capacity, Btu/hr = See Table 3 (deemed assumption for prescriptive savings, based on size category)
$FLH_{Cooling}$	= full load cooling hours = 375[989] (deemed assumption for prescriptive savings)
$SEER_{Baseline}$	= 14.5[990], Btu/Wh (deemed assumption for prescriptive savings)
$SEER_{Efficient}$	= See

Table **7** (deemed assumption for prescriptive savings, based on size category)

$Q_{Heating\geq 5°F,i}$	= heating capacity in weather bin *i* at or above 5°F, MMBtu = See

Table **7** (deemed assumption for prescriptive savings, based on size category)

$HSPF_{Baseline}$	= 8.2[991], Btu/Wh (deemed assumption for prescriptive savings)
$HSPF_{Efficient}$	= See

Table **7** (deemed assumption for prescriptive savings, based on size category)

90%	= Climatic adjustment to HSPF[992] (deemed assumption for prescriptive savings)
$Q_{Heating<5°F,i}$	= heating capacity in weather bin *i* below 5°F, MMBtu = See

[988] See CCHPSavingsAnalysis.xlsx for detailed analysis
[989] ARI data indicates 500 full load hours for A/C use in Vermont. VEIC experience in other states suggests that ARI estimates for A/C use tend to be overstated. In an effort to compensate for this overstatement, Efficiency Vermont applied a .75 multiplier to the ARI estimate in determining residential A/C hours of use.
[990] See Baseline Efficiency section
[991] See Baseline Efficiency section
[992] Energy & Resource Solutions. (2014). *Emerging Technology Program Primary Research – Ductless Heat Pumps*. Lexington, MA: NEEP Regional EM&V Forum. Table 1-2. Page 5.

Table **7** (deemed assumption for prescriptive savings, based on size category)
%ElecHeat[993] = portion of homes with electric space heat
= 1% (deemed assumption for prescriptive savings)

For prescriptive purposes, electric savings will be assigned using deemed values based on nominal system capacity, SEER, and HSPF as outlined in

Table **7**.

Demand Savings
Demand savings are calculated using a weather bin analysis based on the average demand savings during winter peak demand periods where maximum reductions are anticipated. Reduced power draw for the efficient system compared to the baseline system is treated as a demand savings for heating at or above 5°F. For heating below 5°F the full power draw of the efficient system is treated as a demand penalty.

$$\Delta kW = \frac{\left[\sum_{i=1}^{n}\left[Q_{Heating\geq 5°F,i} \times \left(\frac{1}{HSPF_{Baseline} \times 90\%} - \frac{1}{HSPF_{Efficient} \times 90\%}\right)\right] - \sum_{i=1}^{n}\left[Q_{Heating<5°F,i} \times \left(\frac{1}{HSPF_{Efficient} \times 90\%}\right)\right]\right]}{n} \times \frac{1\ kWh}{1{,}000\ Wh}$$

ΔkW = total average winter coincident peak kW reduction (deemed assumption for prescriptive)

For prescriptive purposes, demand savings will be assigned using deemed values based on nominal system capacity, HSPF, and EER as outlined in

Table **7**.[994]

Fossil Fuel Descriptions
Fossil fuel savings are taken for operation of the efficient system below 5°F for offsetting fuel use from the home's existing heating system.

$$\Delta MMBtu = \sum_{i=1}^{n} Q_{Heating<5°F,i} \times \%HeatSource_j / \eta_{Heat\,j}$$

Where:

$\Delta MMBtu_j$ = MMbtu savings for each fuel type *j* (deemed assumption for prescriptive)
$\%HeatSource_j$[995] = Percent of existing heating systems using fuel type *j*
= 51% for fuel oil
= 15% for propane
= 12% for Wood/Other
= 21% for Natural Gas
$\eta_{Heat\,j}$[996] = Heating system efficiency for fuel type *j* (deemed assumption for prescriptive)
= 84.2% for fuel oil
= 87.4% for propane
= 65% for Wood/Other
= 88% for Natural Gas

[993] Split of primary heating fuels from the VT SF Existing Homes Onsite Report Table 5-1. (NMR Group, Inc. 2013)
[994] See CCHPSavingsAnalysis.xlsx, Demand Savings, for detailed analysis
[995] Split of primary heating fuels from the VT SF Existing Homes Onsite Report Table 5-1. (NMR Group, Inc. 2013).
[996] Weighted efficiencies based on VT SF Existing Homes Onsite Report Table 5-8 and 5-9. (NMR Group, Inc. 2013). Efficiency for homes using wood or pellet stoves based on review of EPA-Certified wood stoves. (U.S. Environmental Protection Agency n.d.)

For prescriptive purposes, fossil fuel savings will be assigned using deemed values based on nominal system capacity, as outlined in Table 8.[997]

Water Descriptions
N/A

Table 7 – Prescriptive Electric Savings Values[998]

Nominal Capacity	$SEER_{Avg}$	EER_{Avg}	$HSPF_{Avg}$	$\Delta kWh_{cooling}$	$Q_{\geq 5F}$	$Q_{<5F}$	$\Delta kWh_{heating}$	ΔkWh_{total}	ΔkW
9,000	26.37	15.7	12.8	105	35.8	1.5	1600	1705	0.22
12,000	23.05	13.1	11.8	115	38.4	1.6	1427	1542	0.24
15,000	21.10	12.9	11.5	121	37.3	1.7	1283	1404	0.27
18,000	20.25	13.5	10.7	132	50.0	1.6	1393	1525	0.33
24,000	20.00	12.5	10.6	171	54.3	1.9	1471	1642	0.37

Table 8 – Prescriptive Fossil Fuel Savings Values

Nominal Capacity	$\Delta MMBtu_{oil}$	$\Delta MMBtu_{propane}$	$\Delta MMBtu_{wood}$	$\Delta MMBtu_{natural\ gas}$
9,000	0.92	0.26	0.28	0.37
12,000	0.98	0.28	0.30	0.39
15,000	1.02	0.29	0.31	0.40
18,000	1.00	0.28	0.30	0.39
24,000	1.16	0.33	0.36	0.46

Loadshape
Loadshape #116, Residential Variable Speed Mini-Split and Multi-Split Heat Pumps

Table 9 – Freeridership/Spillover Factors

Measure Category		**HVAC**	
Product Description		**Efficient ductless mini-split, heat pump baseline**	
Measure Code		**SHRHPCVH**	
Track Name	**Track No.**	**Freerider**	**Spillover**
Efficient Products	6032UPST	0.81	1.07

Persistence
The persistence factor is assumed to be one.

Lifetimes
The expected measure life is assumed to be 18 years.[999]

Measure Cost
Measure cost represents the incremental installed cost of an efficient versus a baseline CCHP.

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997 See CCHPSavingsAnalysis.xlsx, Fuel Offset, for detailed analysis
998 Efficiency values for each bin based on average values from AHRI rated equipment, see AHRI in CCHPSavingsAnalysis.xlsx
999 Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
Table 1 – Residential Measures. https://neep.org/Assets/uploads/files/emv/emv-library/measure_life_GDS%5B1%5D.pdf

Table 10 – Measure Costs[1000]

Nominal Equipment Capacity (Btu/hr)	Incremental Costs
9,000	$493
12,000	$591
15,000	$588
18,000	$611
24,000	$693

O&M Cost Adjustments
There are no operation and maintenance cost adjustments for this measure.

ENERGY STAR Heat Pump Water Heater[84]

Measure Number: IV-I-1-a (Efficient Products Program, DHW End-Use)

Version Date & Revision History
Draft date: 7/9/2014
Effective date: 1/1/2014
End date: TBD

Referenced Documents:
NMR Group, Inc. "Vermont Single-Family Existing Homes Onsite Report FINAL." 2013.
Steven Winter Associates. "Heat Pump Water Heaters Evaluation of Field Installed Performance." Norwalk, CT, 2012.
U.S. Department of Energy. "Residential Heating Products Final Rule Technical Support Document." 2010.
U.S. Environmental Protection Agency. n.d. http://www.epa.gov/burnwise/woodstoves.html (accessed March 7, 2014).

Analysis Documents:
1) HPWH_TRM_Analysis.xlsx

Description
This measure claims savings for the installation of an ENERGY STAR heat pump water heater (HPWH) in place of a baseline water heater in a residential application. The measure is characterized for both market opportunity and retrofit applications. Savings are presented dependent on the existing water heater fuel type and HPWH storage volume. HPWH efficiency has been reduced to account for differences in field performance versus rated efficiency due to ambient conditions, hot water demand, and other factors, and a heating penalty is assessed to account for the impact of the heat pump water heater on the home's heating load.

Homes with existing natural gas water heaters are not eligible for savings under this measure.

Baseline Efficiency
The baseline condition is assumed to be a new water heater that uses the same fuel as the home's existing water heater with efficiency equal to the average energy factor of water heaters in existing Vermont homes for the corresponding fuel type.

High Efficiency
To qualify for this measure the installed equipment must be an ENERGY STAR heat pump water heater.

Algorithms

Energy Savings
For cases where this measure is installed in a home with an existing electric resistance water heater or in a new construction project, electric savings account for the improvement in performance of a HPWH over a baseline electric resistance water heater. For homes with existing fossil fuel water heaters, the installation of a HPWH results in an electric penalty equal to the annual electricity use of the water heater to rerpresent the added electric load. In both caseas a penalty is taken to account for the heating load placed on a home's heating system by the HPWH, apportioned based on the percentage of homes in Vermont with electric heat.

For prescriptive purposes, savings and penalties will be assigned using deemed values, outlined in **Table 4**.

$\Delta kWh = \Delta EF_{Elec} * Q_{DHW} * (1 - PF\_ElecHeat)$

Where:

[84] As found on page 396 of the VT TRM, available here: https://puc.vermont.gov/sites/psbnew/files/doc_library/ev-technical-reference-manual.pdf.

ΔEF_{Elec} = $(1/EF_{ElecBASE} - 1/EF_{HPWH})$ for homes with existing electric water heaters and new homes
= $- 1/EF_{HPWH}$ for homes with existing fossil fuel fired water heaters

Where:

$EF_{ElecBASE}$ = Energy Factor (efficiency) of baseline electric water heater
= 0.91[685]

EF_{HPWH} = Energy Factor of heat pump water heater – prescriptive value based on rated EF and a de-rating factor to account for periods where the HPWH uses its electric resistance element to heat water in response to lower space temperature or increased hot water demand
= Rated EF (prescriptive value from **Table 4**) * De-rating Factor

Table 1 – De-rating Factors[686]

Tank Volume	De-rating Factor
< 60 gallons	26%
≥ 60 gallons	10%

Q_{DHW} = Heat delivered to water in HPWH tank annually
= 2,618 kWh[687]

PF_ElecHeat = Heating penalty factor from conversion of electric heat in home to water heat
= WHHF * %HeatSource / COP * ExistDHWElec

Where:

WHHF = Portion of reduced waste heat that results in increased heating
= 0.558[688]

%Heat Source[689] = portion of homes with electric space heat
= 5%

COP_{HEAT} = Coefficient of Performance of electric space heating system
= 1.5[690]

ExistDHWElec[691] = 1 if the home has an existing electric water heater
= –1 if the home has an existing fossil fuel fired water heater

Demand Savings

The reduction (or increase) in electric demand due to the installation of a HPWH is derived below based on prescriptive energy savings found in **Table 4**.

ΔkW = ΔkWh / Hours

Where:

Hours = Full load hours of water heater

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685 Average efficiency of electric water heaters from VT SF Existing Homes Onsite Report Table 6-9 (NMR Group, Inc. 2013)

686 Based on a 2012 field study conducted by Steven Winter Associates in Massachusetts and Rhode Island, which found field measured COP for HPWHs fell 26% below rated COP for 50 gallons units, 10% below rated COP for 60 gallon units, and 11% below rated COP for 80 gallon units (Steven Winter Associates 2012).

687 Average annual DHW heat input for Vermont homes, derived from metered data for homes on CVPS Rate 3: Off-Peak Water Heating rate. See Q_{DHW} in HPWH_TRM_Analysis.xlsx

688 Based on bin analysis of annual heating hours for Burlington, VT using TMY3 data: 4885 / 8760 = 55.8%. See Heating Penalty in HPWH_TRM_Analysis.xlsx

689 Split of primary heating fuels from the VT SF Existing Homes Onsite Report Table 5-1 after removing homes with natural gas space heat (NMR Group, Inc. 2013).

690 The COP used here is an assumption based upon a 50/50 split between resistance COP 1.0 and average Heat Pump effective COP of 2.0.

691 This factor ensures proper accounting of the heating penalty dependent on the fuel type of the home's existing water heater.

= 2533[692]

Operating Hours
2533 full load hours per year[693]

Loadshape
Loadshape #8 Residential DHW Fuel Switch

Table 2 – Freeridership/Spillover Factors

Measure Category		**Water Heating**	
Product Description		**Heat Pump Water Heater**	
Measure Code		**HWEHWHTP**	
Track Name	**Track No.**	**Freerider**	**Spillover**
Efficient Products	6032EPEP	1.0	1.1

Persistence
The persistence factor is assumed to be one.

Lifetimes
The expected measure life is assumed to be 13 years[694]. For retrofit measures, it is assumed that the existing water heating equipment has five years of remaining life and would be replaced with baseline equipment with the associated installed cost at end of life. Analysis period is the same as the lifetime.

Measure Cost
For measures installed in a market opportunity situation, the measure cost is the incremental cost for the installation of a HPWH versus baseline equipment based on the existing water heater fuel type. For retrofit measures, the measure cost is the full cost for the installation of a HPWH.[695]

Table 3 – Measure Costs

Installation	HPWH EF	Baseline EF	HPWH Installed Cost	Baseline Installed Cost	Incremental Cost
Existing electric DHW	< 2.35	0.91	$1,575	$602	$973
Existing electric DHW	≥ 2.35	0.91	$1,703	$602	$1,101
Existing propane DHW	< 2.35	0.59	$1,575	$1,079	$496
Existing propane DHW	≥ 2.35	0.59	$1,703	$1,079	$624
Existing fuel oil DHW	< 2.35	0.51	$1,575	$1,974	$(399)
Existing fuel oil fired	≥ 2.35	0.51	$1,703	$1,974	$(271)

O&M Cost Adjustments
There are no operation and maintenance cost adjustments for this measure.

Fossil Fuel Descriptions
For homes with existing fossil fuel water heaters, fuel switching results in fuel savings equal to the annual fuel use that would have resulted if a baseline fossil fuel fired water heater had been installed in the home. For upstream measures where fossil fuel type may be unknown, savings are apportioned based on the breakdown of water heating fuels in Vermont homes, excluding natural gas. A fossil fuel penalty is taken to account for the heating load placed

[692] Full load hours assumption based on Efficiency Vermont analysis of Itron eShapes.
[693] Ibid.
[694] Residential Heating Products Final Rule Technical Support Document, Page 8-52, this is the accepted lifetime for standard efficiency electric and gas storage water heaters. Manufacturer warranty and ENERGY STAR criteria for 10-year warranties for heat pump water heaters support assuming baseline lifetime for this measure (U.S. Department of Energy 2010).
[695] Residential Heating Products Final Rule Technical Support Document pages 8-27 to 8-28 (U.S. Department of Energy 2010)

on a home's heating system by the HPWH. For prescriptive purposes, this increased heating usage is allocated by fuel type based on the breakdown of primary heating fuel types in Vermont homes, excluding natural gas.

Savings and penalties will be assigned using deemed values, outlined in **Table 4**.

ΔMMBtu = (SF_FF_DHW – PF_FF_Heating)

Where:

SF_FF_DHW = Savings from fuel switching, accounts for replacement of baseline fossil fuel fired water heater by HPWH
= $1/EF_{FFBASE} * Q_{DHW} * ExistDHWFF * \%DHWFuel$

Where:

EF_{FFBase} = Energy Factor (efficiency) of baseline fossil fuel water heater
= 0.62 for propane water heaters[696]
= 0.65 for fuel oil water heaters[697]
= 0.64 for fossil fuel water heaters with unknown fuel type[698]

Q_{DHW} = Heat delivered to water in HPWH tank annually
= 8.93 MMBtu[699]

ExistDHWFF = 1 if the home has an existing fossil fuel fired water heater
= 0 if the home has an existing electric water heater

%DHWFuel[700] = 1 if the existing water heater fuel type is known, all savings attributed to that fuel type
=76% for fuel oil, if fuel type is unknown
=24% for propane, if fuel type is unknown

PF_FF_Heating = Heating penalty factor from conversion of noneletric heat in home to water heat
= $\Delta EF_{Elec} * Q_{DHW} * WHHF * \%HeatSource / \eta Heat * ExistDHWElec$[701]

Where:

%HeatSource[702] = 61% for fuel oil
= 17% for propane
= 17% for Wood/Other

ηHeat[703] = 84.2% for fuel oil
= 87.4% for propane
= 65% for Wood/Other

Water Descriptions
N/A

[696] Average efficiency of electric water heaters from VT SF Existing Homes Onsite Report Table 6-7 (NMR Group, Inc. 2013)
[697] Ibid.
[698] Weighted average efficiency of propane and fuel oil water heaters from VT SF Existing Homes Onsite Report Tables 6-2 and 6-7 (NMR Group, Inc. 2013), excludes natural gas water heaters
[699] Average annual DHW heat input for Vermont homes, derived from metered data for homes on CVPS Rate 3: Off-Peak Water Heating rate. See Q_{DHW} in HPWH_TRM_Analysis.xlsx
[700] This factor apportions fuel savings for homes with unknown fuel types, a prescreening is conducted to exclude homes with existing natural gas water heaters.
[701] This factor ensures proper accounting of the heating penalty dependent on the fuel type of the home's existing water heater.
[702] Split of primary heating fuels from the VT SF Existing Homes Onsite Report Table 5-1 after removing homes with natural gas space heat. (NMR Group, Inc. 2013).
[703] Weighted efficiencies based on VT SF Existing Homes Onsite Report Table 5-8 and 5-9. (NMR Group, Inc. 2013). Efficiency for homes using wood or pellet stoves based on review of EPA-Certified wood stoves (U.S. Environmental Protection Agency n.d.)

Prescriptive Savings

For prescriptive purposes this measure has been binned based on HPWH energy factor and existing water heater fuel type as follows:

Table 4 – Prescriptive Savings Values[704]

Existing DHW Fuel	Electric			Fuel Oil			Propane			Unknown Fossil Fuel		
Storage Volume	< 60 gallons											
Rated EF	EF<2.35	2.35<EF<2.7	2.7<EF	EF<2.35	2.35<EF<2.7	2.7<EF	EF<2.35	2.35<EF<2.7	2.7<EF	EF<2.35	2.35<EF<2.7	2.7<EF
Average EF	2.31	2.41	2.75	2.31	2.41	2.75	2.31	2.41	2.75	2.31	2.41	2.75
ΔkWh	1321	1384	1561	-1559	-1495	-1311	-1559	-1495	-1311	-1559	-1495	-1311
ΔkW	0.52	0.55	0.62	-0.62	-0.59	-0.52	-0.62	-0.59	-0.52	-0.62	-0.59	-0.52
ΔMMBtu Fuel Oil	-1.86	-1.94	-2.19	12.30	12.39	12.63	-2.11	-2.02	-1.77	8.33	8.42	8.67
ΔMMBtu Propane	-0.50	-0.52	-0.59	-0.57	-0.54	-0.48	13.18	13.20	13.27	2.73	2.76	2.82
ΔMMBtu Wood	-0.67	-0.70	-0.79	-0.76	-0.73	-0.64	-0.76	-0.73	-0.64	-0.76	-0.73	-0.64
Measure life (yrs)	13	13	13	13	13	13	13	13	13	13	13	13
Incremental cost ($)	973	1101	1101	404	532	532	-570	-442	-442	-403	-275	-275
Retrofit cost ($)	1575	1703	1703	1575	1703	1703	1575	1703	1703	1575	1703	1703
Retrofit remaining life (yrs)	5	5	5	5	5	5	5	5	5	5	5	5
Retrofit Baseline Cost ($)	602	602	602	1171	1171	1171	2145	2145	2145	1978	1978	1978
Item Code	EPHPWH1	EPHPWH2	EPHPWH3	EPHPWH4	EPHPWH5	EPHPWH6	EPHPWH7	EPHPWH8	EPHPWH9	EPHPWH10	EPHPWH11	EPHPWH12
Retrofit Item Code	EPHPWH25	EPHPWH26	EPHPWH27	EPHPWH28	EPHPWH29	EPHPWH30	EPHPWH31	EPHPWH32	EPHPWH33	EPHPWH34	EPHPWH35	EPHPWH36

Existing DHW Fuel	Electric			Fuel Oil			Propane			Unknown Fossil Fuel		
Storage Volume	≥ 60 gallons											
Rated EF	EF<2.35	2.35<EF<2.7	2.7<EF	EF<2.35	2.35<EF<2.7	2.7<EF	EF<2.35	2.35<EF<2.7	2.7<EF	EF<2.35	2.35<EF<2.7	2.7<EF
Average EF	2.31	2.41	2.75	2.31	2.41	2.75	2.31	2.41	2.75	2.31	2.41	2.75
ΔkWh	1589	1640	1786	-1282	-1229	-1078	-1282	-1229	-1078	-1282	-1229	-1078
ΔkW	0.63	0.65	0.70	-0.51	-0.48	-0.42	-0.50	-0.48	-0.42	-0.50	-0.48	-0.42
ΔMMBtu Fuel Oil	-2.23	-2.30	-2.51	12.67	12.75	12.95	-1.74	-1.66	-1.46	8.71	8.78	8.99
ΔMMBtu Propane	-0.60	-0.62	-0.67	-0.47	-0.45	-0.39	13.28	13.30	13.35	2.83	2.85	2.91
ΔMMBtu Wood	-0.81	-0.83	-0.91	-0.63	-0.60	-0.53	-0.63	-0.60	-0.53	-0.63	-0.60	-0.53
Measure life (yrs)	13	13	13	13	13	13	13	13	13	13	13	13
Incremental cost ($)	973	1101	1101	404	532	532	-570	-442	-442	-403	-275	-275
Retrofit cost ($)	1575	1703	1703	1575	1703	1703	1575	1703	1703	1575	1703	1703
Retrofit remaining life (yrs)	5	5	5	5	5	5	5	5	5	5	5	5
Retrofit Baseline Cost ($)	602	602	602	1171	1171	1171	2145	2145	2145	1978	1978	1978
Market Opp. Item Code	EPHPWH13	EPHPWH14	EPHPWH15	EPHPWH16	EPHPWH17	EPHPWH18	EPHPWH19	EPHPWH20	EPHPWH21	EPHPWH22	EPHPWH23	EPHPWH24
Retrofit Item Code	EPHPWH37	EPHPWH38	EPHPWH39	EPHPWH40	EPHPWH41	EPHPWH42	EPHPWH43	EPHPWH44	EPHPWH45	EPHPWH46	EPHPWH47	EPHPWH48

E.2 Massachusetts

Central Ducted Heat Pump Fully Displacing Existing Furnace[85]

Measure Code	IE-HVAC-FSHP
Market	Income Eligible
Program Type	Retrofit
Category	Heating Ventilation and Air Conditioning

Description:

Installation of a new high efficiency boiler for space heating.

BCR Measure IDs:

Measure Name	Core Initiative	BCR Measure ID
Central Ducted Heat Pump Fully Displacing Existing Furnace, Propane (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a272
Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a273

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on calculations provided by evaluation consultants using the following assumptions:

Average Home Heating load = 68.4 MMBTUs [1]
Switchover Temperature = 5 Degrees
Tonnage of new Heat Pump = 4 Tons

Measure Name	Saved MMBtu Oil/Propane	ΔkW	ΔkWh
Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil	86.7	-2.64	-6,935
Central Ducted Heat Pump Fully Displacing Existing Furnace, Propane	86.7	-2.64	-7,188

Baseline Efficiency:

For oil the baseline efficiency case is a 78% AFUE furnace. [2] For propane the baseline is a 78% AFUE furnace. [3]

High Efficiency:

The high efficiency case is a new 18 SEER/10 HSPF ducted central heat pump.

[85] As found in the MA eTRM for 2019-2021, available here: https://etrm.anbetrack.com/#/workarea/trm/MADPU/IE-HVAC-FSHP/2019-2021%20Plan%20TRM/version/1?measureName=Central%20Ducted%20Heat%20Pump%20Fully%20Displacing%20Existing%20Furnace,%20Propane%20or%20Oil

Measure Life:

The measure life is 15 years.

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil	IE_CD	All	15	n/a	n/a	15

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Central Ducted Heat Pump Fully Displacing Existing Furnace	IE_CD	All	1.00	1.00	1.00	1.00	1.00	0.34	0.21

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 custom calculated.

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Central Ducted Heat Pump Fully Displacing Existing Furnace	IE_CD	All	0%	0%	0%	100%

Non-Energy Impacts:

There are no non-energy impacts for this measure.

Endnotes:

1: Home Energy Services (HES) Impact Evaluation (RES 34) Engineering Algorithm Workbook Ex Post Furnace Heating Load
2: Federal Standard
3: Federal Standard

Central Ducted Heat Pump Partially Displacing Existing Furnace[86]

Measure Code	IE-HVAC-FSHP-P
Market	Income Eligible
Program Type	Retrofit
Category	Heating Ventilation and Air Conditioning

Description:

Installation of a new high efficiency boiler for space heating.

BCR Measure IDs:

Measure Name	Core Initiative	BCR Measure ID
Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a268
Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a269

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on calculations provided by evaluation consultants using the following assumptions:

Average Home Heating load = 68.4 MMBTUs [1]
Switchover Temperature = 30 Degrees
Tonnage of new Heat Pump = 2.5 Tons

Measure Name	Saved MMBtu Oil	ΔkW	ΔkWh
Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil	56.6	-1.630	-3,637
Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane	76.5	-1.630	-5,409

Baseline Efficiency:

For oil the baseline efficiency case is a 78% AFUE furnace. [2] For propane the baseline is a 78% AFUE furnace. [3]

[86] As found in the MA eTRM for 2019-2021, available here: https://etrm.anbetrack.com/#/workarea/trm/MADPU/RES-HVAC-FSHP-P/2019-2021%20Plan%20TRM/version/1?measureName=Central%20Ducted%20Heat%20Pump%20Partially%20Displacing%20Existing%20Furnace,%20Oil%20or%20Propane

High Efficiency:

The high efficiency case is a new 18 SEER/10 HSPF ducted central heat pump.

Measure Life:

The measure life is 15 years.

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Central Ducted Heat Pump Partially Displacing Existing Furnace	IE_CD	All	15	n/a	n/a	15

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Central Ducted Heat Pump Partially Displacing Existing Furnace	IE_CD	All	1.00	1.00	1.00	1.00	1.00	-0.24	0.21

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 custom calculated.

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Central Ducted Heat Pump Partially Displacing Existing Furnace	IE_CD	All	0%	0%	0%	100%

Non-Energy Impacts:

There are no non-energy impacts for this measure.

E.3 Connecticut

Heat Pump Water Heater[87]

Description of Measure

Installation of a heat pump water heater ("HPWH").

Savings Methodology

Energy and demand savings calculations for a HPWH are shown below. The savings are based on R1614/R1613 HVAC and Water Heater Evaluation (**Ref [1]**). The savings in the study represent a combination of electric saving and fossil fuel savings.

Inputs

Table 4-9: Inputs

Symbol	Description	Units
	Number of Units Installed	
	Size: 55 gallons or less, or greater than 55 gallons	Gallons

Nomenclature

Table 4-10: Nomenclature

Symbol	Description	Units	Comments
$AEDHW_W$	Annual Electric Energy Savings	kWh/yr	**Ref [1]**
$AFDHW_W$	Annual Fossil Fuel Savings	MMBTU/yr	**Ref [1]**
AOG	Annual Oil Savings	Gals	
APG	Annual Propane Savings	Gals	
SKW	Summer Electric Demand Savings	kW	**Ref [1]**
WKW	Winter Electric Demand Savings	kW	**Ref [1]**

[87] As found on page 282-283 of the CT PSD, available here: https://www.energizect.com/sites/default/files/2019%20PSD%20%283-1-19%29.pdf

For an installed HPWH:

Table 4-11: Gross Energy Savings

Existing DHW Type	AkWh Savings (55 gallons or less)	AkWh Savings (>55 gallons)	AOG Savings	APG Savings
Electric Resistance (Retrofit)	1818 kWh	566 kWh		
Unknown (Lost Opportunity)	961 kWh	53 kWh	15.5 Gals	23.54 Gals

Table 4 -12: Gross Seasonal Peak Demand Savings (Electric)

Existing DHW Type	SKW (55 gallons or less)	WKW (55 gallons or less)	SKW (> 55 gallons)	WKW (> 55 gallons)
Electric Resistance (Retrofit)	0.296 kW	0..234 kW	.04 kW	0.036 kW
Unknown (Lost Opportunity)	0.175 kW	0.134 kW	0.014 kW	0.013 kW

Retrofit Gross Energy Savings, Example

An electric resistance water heater is replaced by a 50 Gallon HPWH. What are the annual and peak day savings?

$$AEDHW_W = 1818\ kWh$$

$$SKW = 0.296\ kW$$

$$WKW = 0.234\ kW$$

Lost Opportunity Gross Energy Savings, Example

A 50 Gallon HPWH was sold through an upstream distributor. What are the annual and peak day savings? Since the unit was sold upstream the lost opportunity savings are combination of electric savings and fossil fuel savings.

For electric savings:

$$AEDHW_W = 961\ kWh$$

$$SKW = 0.175\ kW$$

$$WKW = 0.134\ kW$$

For oil savings:

$$AFDHW_W = 15.5Gal$$

For propane savings:

$$AFDHW_W = 23.54Gal$$

Changes from Last Version

- Added in Retrofit electric savings.
- Updated savings based on new HVAC evaluation.

References

[1] R1614/R1613 CT HVAC and Water Heater Process and Impact Evaluation, West Hill Energy and Computing, EMI Consulting & Lexicon Energy Consulting, Jul. 19, 2018. pp. 8.6-8.8.

E.4 Rhode Island

Oil Fuel Switching (Heat Pump Electrification) [88]

Sector: Residential

Fuel: Electric

Program Type: Prescriptive

Measure Category: HVAC

Measure Type: Heating

Measure Sub Type: Heat Pump Electrification

Program: Energy Star HVAC

Measure Description

The purchase and installation of high efficiency mini-split heat pump system rather than the purchase of a standard efficiency oil boiler or to replace a standard efficiency oil boiler.

Baseline Description

The baseline efficiency case for heating is a residential oil boiler with 82 AFUE.

The baseline efficiency case for cooling is a residential window AC unit with EER 9.8.

Savings principle

The high efficiency case is an ENERGY STAR® qualified air-source heat pump.

Savings Method

Deemed

Unit

Installed high-efficiecny air-source heat pump system for heating and cooling.

Savings equation

Cooling Gross kWh = Qty*deltakWh_cooling

Cooling Gross kW = Qty*deltakW_cooling

Heating Gross MMBtu = Qty * deltaMMBtu_oil

Where:

Qty = Total number of units.

deltakWh_cooling = Average annual cooling kWh reduction per unit.

deltakW_cooling = Average annual cooling kW reduction per unit.

deltaMMBTu_oil = Average annual oil reduction per unit.

Hours: N/A

Measure Gross Savings per Unit

Measure	KWh	KW	Gas Heat MMBtu	Gas DHW MMBtu	Gas Other MMBtu	Oil MMBtu	Propane MMBtu
Oil Fuel Switching	126.00	0.50	0.00			17.43	0.00

Electric kWh Source: The Cadmus Group, Inc (2016) Ductless Mini-Split Heat Pump Impact Evaluation

Electric kW Source: The Cadmus Group, Inc (2016) Ductless Mini-Split Heat Pump Impact EvaluationOil MMBtu Source: The Cadmus Group, Inc (2016) Ductless Mini-Split Heat Pump Impact Evaluation

[88] As found on page 108-110 of the RI TRM, available here: http://www.ripuc.org/eventsactions/docket/4755-NGrid-2018-TRM-RI.pdf

Energy Impact Factors

Measure	Measure life	ISR	SPF	RRe Gas	RRe Electric	RR sp	RR wp	CF sp	CF wp
Oil Fuel Switching	18	1.00	1.00		1.00			0.25	0.00

Measure	Winter Peak Energy %	Winter Off-Peak Energy %	Summer Peak Energy %	Summer Off-Peak Energy %
Oil Fuel Switching	0.00	0.00	0.55	0.45

Measure life Source: GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. Prepared for The New England State Program Working Group.

ISR Note: All installations have 100% in-service rate since programs include verification of equipment installations.

SPF Note: Savings persistence is assumed to be 100%.

RRe Note: Realization rate is 100% since gross savings values are based on evaluation results.

CFsp Source: ADM Associated, Inc. (2009). Residential Central AC Regional Evaluation. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating.

CFwp Source: ADM Associated, Inc. (2009). Residential Central AC Regional Evaluation. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating.

Non Energy Impact Factors

Measure	Water: Gallons	Sewer: Gallons	Annual $	One-time $
Oil Fuel Switching	0.00	0.00	0.00	-1960.96

One time $ Note: The one time $ savings represents the net present value of the cost associated with the incremental electric heating load of 1566 kWh from the mini-split heat pump.

Net to Gross Factors

Measure	FR	Sop	Sonp	NTG
Oil Fuel Switching	0.00	0.00	0.00	1.00

Oil Fuel Switching ROF[89]

Sector: Residential

Fuel: Electric

Program Type: Prescriptive

Measure Category: HVAC

Measure Type: Heating

Measure Sub Type: Heat Pump Electrification

Program: Energy Star HVAC

Measure Description

The purchase and installation of high efficiency mini-split heat pump system rather than the purchase of a standard efficiency oil boiler or to replace a standard efficiency oil boiler.

Baseline Description

The baseline efficiency case for heating is a residential oil boiler with 82 AFUE.

The baseline efficiency case for cooling is a residential window AC unit with EER 9.8.

Savings principle

The high efficiency case is an ENERGY STAR® qualified air-source heat pump.

Savings Method

Deemed

Unit

Installed high-efficiecny air-source heat pump system for heating and cooling.

Savings equation

Cooling Gross kWh = Qty*deltakWh_cooling

Cooling Gross kW = Qty*deltakW_cooling

Heating Gross MMBtu = Qty * deltaMMBtu_oil

Where:

Qty = Total number of units.

deltakWh_cooling = Average annual cooling kWh reduction per unit.

deltakW_cooling = Average annual cooling kW reduction per unit.

deltaMMBTu_oil = Average annual oil reduction per unit.

Hours: N/A

Measure Gross Savings per Unit

Measure	KWh	KW	Gas Heat MMBtu	Gas DHW MMBtu	Gas Other MMBtu	Oil MMBtu	Propane MMBtu
Oil Fuel Switching ROF	126.00	0.50	0.00			17.43	0.00

Electric kWh Source: The Cadmus Group, Inc (2016) Ductless Mini-Split Heat Pump Impact Evaluation

Electric kW Source: The Cadmus Group, Inc (2016) Ductless Mini-Split Heat Pump Impact EvaluationOil MMBtu Source: The Cadmus Group, Inc (2016) Ductless Mini-Split Heat Pump Impact Evaluation

[89] As found on page 108-110 of the RI TRM, available here: http://www.ripuc.org/eventsactions/docket/4755-NGrid-2018-TRM-RI.pdf

Energy Impact Factors

Measure	Measure life	ISR	SPF	RRe Gas	RRe Electric	RR sp	RR wp	CF sp	CF wp
Oil Fuel Switching ROF	18	1.00	1.00		1.00			0.25	0.00

Measure	Winter Peak Energy %	Winter Off-Peak Energy %	Summer Peak Energy %	Summer Off-Peak Energy %
Oil Fuel Switching ROF	0.00	0.00	0.55	0.45

Measure life Source: GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. Prepared for The New England State Program Working Group.

ISR Note: All installations have 100% in-service rate since programs include verification of equipment installations.

SPF Note: Savings persistence is assumed to be 100%.

RRe Note: Realization rate is 100% since gross savings values are based on evaluation results.

CFsp Source: ADM Associated, Inc. (2009). Residential Central AC Regional Evaluation. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating.

CFwp Source: ADM Associated, Inc. (2009). Residential Central AC Regional Evaluation. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating.

Non Energy Impact Factors

Measure	Water: Gallons	Sewer: Gallons	Annual $	One-time $
Oil Fuel Switching ROF	0.00	0.00	0.00	-1960.96

One time $ Note: The one time $ savings represents the net present value of the cost associated with the incremental electric heating load of 1566 kWh from the mini-split heat pump.

Net to Gross Factors

Measure	FR	Sop	Sonp	NTG
Oil Fuel Switching ROF	0.00	0.00	0.00	1.00

APPENDIX F. STATE-BY-STATE FINDINGS FROM LITERATURE REVIEW AND EXAMINIATION OF OTHER STATES' SCREENING PRACTICES FOR ENERGY OPTIMIZATION MEASURES (TASK 2 REPORT)

F.1 Connecticut

Enabling Policy	CT Gen Stat § 16-245m (2013) orders that a combined electric and gas Conservation and Load Management Plan must be submitted to the Energy Conservation Management Board every three years. The plan needs to "include a detailed budget sufficient to fund all EE that is cost-effective or lower cost than acquisition of equivalent supply" and "include steps that would be needed to achieve the goal of weatherization of eighty per cent of the state's residential units by 2030."[90]
Supporting Policy	The CT Dept. of Energy and Environmental Protection (DEEP) Order[91] approving the 2019-2021 Conservation and Load Management Plan also approved the heat pump pilot, though it required additional information to be provided by the utilities prior to implementation. CT's DEEP updated its Comprehensive Energy Strategy in 2017. The 2017 CES update states that CT should: "Pursue strategic electrification, including encouraging the utility companies to promote the installation of efficient heat pumps, initially focusing on buildings currently heated by electric-resistance heating systems and on new construction, then eventually replacing combustion heating systems as the electric power sector becomes cleaner."[92] The CT Global Warming Solutions Act (2008) set targets for GHG emissions reductions. By 2020, GHG emissions will be reduced to 10% below the level emitted in 1990. By 2050, GHG emissions will be reduced to 80% below 2001 levels.[93]
Current Measures	The Energize CT program promotes heat pumps for EE but has not incentivized energy optimization or fuel switching measures. CT is conducting a heat pump pilot in the 2019-2021 program cycle to explore the financial, market and technical challenges associated with displacing or replacing fuel oil or propane-supplied heat with heat supplied via a cost-effective, high-efficiency heat pump.[94] The heat pump pilot is limited to 100 sites. For ducted HP systems, the HP must have controls integrated with the existing fossil fuel heating system. For ductless HP systems, integrated controls are recommended but not required.

[90] CT Gen Stat § 16-245m (2013), Paragraph D: https://www.cga.ct.gov/current/pub/chap_283.htm#sec_16-245m

[91] CT DEEP Order approving 2019-2021 Conservation and Load Management Plan: https://www.ct.gov/deep/lib/deep/energy/conserloadmgmt/ct-deep-approval-with-conditions-of-2019-2021-c-lm-plan-12-20-18.pdf

[92] Department of Energy & Environmental Protection (DEEP). 2017 Comprehensive Energy Strategy. Draft: July 2017. p.xvii Available at: http://www.ct.gov/deep/lib/deep/energy/ces/2017_draft_comprehensiveenergystrategy.pdf.

[93] CT Global Warming Solutions Act, Section 2: https://www.cga.ct.gov/2008/ACT/PA/2008PA-00098-R00HB-05600-PA.htm

[94] A detailed description of the heat pump pilot program is available in the DEEP Condition of Approval for the program, at: https://app.box.com/s/kz880yd9icmxrvcxibsd9uaryzq89dog/file/420145660471

	CT's Electric Efficiency Partners Program also offers incentives for gas-powered chillers.[95]
Benefit/Cost Approach	CT uses the Utility Cost Test (UCT) and Modified Utility Cost Test (MUCT) to evaluate EE measures. CT uses the MUCT for residential electric programs/measures, including weatherization and an upstream HPWH incentive program that uses a blended baseline of electric/oil/propane water heaters. CT uses the TRC as a secondary test to provide a broader perspective of program performance. CT is currently reviewing its benefit-cost testing methodology. Stakeholders have completed several working sessions in support of a resource value framework (RVF) study.[96] CT's current EE program does not count savings for unregulated fuels for heat pump incentives. The heat pump pilot program will count unregulated fuel savings using each customer's currently-installed system as the customer-specific baseline. CT currently counts unregulated fuel savings for the residential electric funded weatherization programs and upstream heat pump water heaters. CT does not count total GHG costs in their B/C model, though the state is considering counting total GHG costs in the future.
Education & Training	CT is developing customer and contractor training that it will release prior to the heat pump pilot. EnergizeCT already provides education and training materials to encourage customers with ductless air source heat pumps to use heat pumps as the primary heat source and fuel heating equipment as backup. CT created an Energy Management Systems Trade Ally Network to leverage the expertise of trade allies to better understand particular business applications, industries, and their customers. Through this network, trade allies help guide customers through the EE options and provide feedback to CT about what incentives and EE measures are needed. The trade allies receive extra trainings and support to understand the latest EE measures.
Key Findings	CT has seen extensive debate over energy optimization measures. Some key stakeholders believe that ratepayer funds should not be used to incentivize fuel switching. A new heat pump pilot program will provide the state's first foray into fuel switching incentives. The HES Fuel Oil/Propane Heating Displacement Rebate for the heat pump pilot will be $700/unit for each qualifying heat pump. Vendors in the HES program that recommend a heat pump installation to replace fuel oil or propane will receive $100 once the heat pump is successfully installed.

[95] More information on the Electric Efficiency Partners Program is available from DEEP at: https://www.ct.gov/pura/cwp/view.asp?a=3355&q=417158

[96] The 2019-2021 Conservation & Load Management Plan describes the planned efforts for revising CT's benefit-cost methodology. See pp.18-19 & 216 of the plan, available at: https://www.ct.gov/deep/lib/deep/energy/conserloadmgmt/final-2019-2021-clm-plan-11-19-18.pdf

F.2 Maine

Enabling Policy	In 2013, the Efficiency Maine Trust Act (title 35-A chapter 97) established Efficiency Maine to run the state's EE programs, with the following goals for Efficiency Maine: reduce energy costs, including heating costs; weatherize all homes by 2030; reduce peak electric demand by 300 MW by 2020; achieve electricity and natural gas program savings of 20% and heat fuel savings of 20% by 2020; create stable private sector jobs providing alternative energy and EE products and services by 2020; reduce GHG emissions from heating and cooling buildings consistent with the state's reduction goals.[97] In 2019, ME legislature set specific targets for heat pump deployment under An Act to Transform Maine's Heat Pump Market To Advance Economic Security and Climate Objectives. The Act requires Efficiency Maine Trust's Forward Capacity Market Payments to support the goal of deploying 100,000 heat pumps between fiscal year 2019-20 and fiscal year 2024-25, supplementing funding already allocated under the 2020-2022 Triennial Plan.
Supporting Policy	The Triennial Plan for Fiscal year 2020-2022 includes an innovation program that will enable ME to focus on fuel switching measures if it chooses to pursue the conversion of oil/propane/natural gas heating systems to air source heat pumps.[98] In 2003, the ME legislature set the following GHG reduction goals: Reduction to 1990 levels by 2010; reduction to 10% below 1990 levels by 2020; and long-term reduction that is sufficient to eliminate any dangerous threat to the climate. The statute notes that aggressive long-term reduction targets, such as 75% to 80% below 2003 levels, may be required.[99]
Current Measures	ME offers EE measures through Efficiency Maine – a non-utility, statewide agency that promotes EE and helps reduce energy costs for residents. Measures offered through Efficiency Maine include heat pumps and CHP. ME just started counting unregulated fuel savings from fuel switching measures in the 2020 fiscal year.
Benefit/Cost Approach	ME uses the Total Resource Cost Test (TRC) for overall portfolio, total program, customer projects, and individual measure level screening, with exceptions for low-income programs, pilots, and new technologies. ME does not count total GHG costs.
Education & Training	Efficiency Maine emphasizes the certification and licensing requirements for trade allies affiliated with its programs. It also provides online and in-store training opportunities, scholarships, and other support for existing programs run by community colleges. Past programs include trainings for: home energy auditors, contractors learning about new mini-split heat pumps, sales staff at large retail chains who promote ENERGY STAR appliances, and large commercial contractors. The Trust has offered scholarships for advanced heat pump training

[97] The Efficiency Maine Trust Act is available at: http://www.mainelegislature.org/legis/statutes/35-a/title35-Asec10104.html

[98] Efficiency Maine (2015). "Triennial Plan for Fiscal Years 2017-2019." pp.61-62,118. Available at: https://neep.org/sites/default/files/resources/Triennial-Plan-III-as-filed-at-PUC.pdf

[99] These goals are described in Title 38 "Waters and Navigation," Chapter 3-A "Climate Change," Section 576, available at: http://www.mainelegislature.org/legis/statutes/38/title38sec576.html

	at community colleges to support the contractor community in adopting best practices for installing this relatively new technology. Efficiency Maine also plans to use social media and digital advertising to promote energy education and awareness.[100]
Key Findings	ME has high heat pump adoption, and administrators attribute the high adoption rate to the large cost savings that are available from fuel switching.[101]

F.3 Massachusetts

Enabling Policy	In 2008, the Green Communities Act (GCA) mandated that MA develop an EE plan every three years. These plans must align with state policy goals to decrease energy costs and increase reliability through reductions in winter and summer peak demand. In 2018, MA amended the Green Communities Act by the Clean Energy Future Act to include strategic electrification, "such as measures that are designed to result in cost-effective reductions in GHG emissions through the use of expanded electric consumption while minimizing ratepayer costs." This amendment also reframed utilities' electric efficiency plans as a broader "energy" efficiency plans, allowing electric utilities to claim savings of unregulated fuels.[102]
Supporting Policy	In 2008, the Global Warming Solutions Act set economy-wide GHG emission reduction goals for Massachusetts. These goals are reductions of between 10-25% below 1990 GHG emission levels by 2020, and 80% below 1990 levels by 2050.[103] The Residential Conservation Services statute (G.L. c. 164 App., §§2-1 to 2-10), signed into law in 1980, is the original MA EE law. The RCS statute provides a framework for in-home energy conservation services for residential customers.[104]
Current Measures	EE measures are managed through MassSave, a collaborative effort led by utilities in MA. Downstream customer incentives have been available for heat pumps and heat pump water heaters for several years. MA's 2019-2021 plan is the state's first plan to introduce energy optimization measures. To qualify for rebates on whole-home heat pump systems, customers are required to install integrated controls that link the operation of the customers' new heat pump system to their existing fuel-fired system.

[100] From Triennial Plan for Fiscal Year 2020-2022, https://www.efficiencymaine.com/docs/Proposed_Triennial_Plan_for_FY2020_2022_10_22_2018_PUC_Filing.pdf

[101] Source: ACEEE (2018). "Energy Savings, Consumer Economics, and Greenhouse Gas Emissions Reductions from Replacing Oil and Propane Furnaces, Boilers, and Water Heaters with Air-Source Heat Pumps." Available at: https://aceee.org/sites/default/files/publications/researchreports/a1803.pdf

[102] "An Act to Advance Clean Energy, Session Law - Acts of 2018 Chapter 227, H.4857." https://malegislature.gov/Laws/SessionLaws/Acts/2018/Chapter227

[103] "An Act Establishing the Global Warming Solutions Act, Session Law – Acts of 2008 Chapter 298." https://malegislature.gov/Laws/SessionLaws/Acts/2008/Chapter298

[104] Residential Conservation Services statute (M.G.L. ch. 164 App. §2). https://www.mass.gov/files/documents/2016/08/se/rcs-statute-electronic.pdf

	Separate from MassSave, the Massachusetts Clean Energy Center (MassCEC) offer rebates for heat pumps on a limited basis.
Benefit/Cost Approach	MA evaluates EE programs using the Total Resource Cost (TRC) test. Unregulated fuel savings are counted for customers switching from unregulated fuels to electricity, but not for customers switching to natural gas. Currently, utilities compare fuel and electric savings using a common MMBtu metric; electric savings are converted from kWh to MMBtu for comparison. This method may change, since the MA Dept. of Public Utilities ordered utilities to develop a better option that accounts for potential losses of electricity from generation to consumption. MA counts GHG emissions reductions using an avoided cost of $68 per short ton of CO_2-equivalent reductions. This is the AESC-reported value for New England marginal abatement cost, and it is based on a projection of future costs of offshore wind energy. MA uses this value instead of the global marginal abatement cost of $100/ton based on direction from the MA DPU.
Education & Training	MA is implementing educational programs for both installers and residents. MassCEC is training installers to install the appropriate number and size of ductless systems. Installers will also be trained to teach customers how to optimally heat their entire homes using their thermostats to adjust set points for each heat pump unit.
Key Findings	MassCEC is a third party that offers additional incentives outside of MA's regulated efficiency programs. Third parties such as MassCEC have more freedom than utilities to define savings requirements and goals. For example, MassCEC requires that participants receive an energy audit to qualify for rebates.

F.4 New York

Enabling Policy	The Public Service Law assigned the New York Public Utilities Commission the responsibility and authority to ensure that utilities carry out "their public service responsibilities with economy, efficiency, and care for the public safety, the preservation of environmental values and the conservation of natural resources." PSL §5(2); see also PSL §66(3). The New York Energy Law, including §§ 3-103 and 6-104, orders that the Commission considers actions to effectuate State energy policy and the New York State Energy Plan, which includes increased EE.[105]
Supporting Policy	The *New Efficiency: New York* report developed for NYSERDA in 2018 identifies strategies to reduce energy consumption across NY.[106] A follow-up report from

[105] Enabling policies as described on page 15 of the Order Adopting Accelerated Energy Efficiency Targets (Case 18-M-0084). Available at: https://drive.google.com/file/d/1jscrJ_1LlloFrwn0dM2dRpqhC1aZHzEY/view

[106] NYSERDA (2018). "New Efficiency: New York." p.43. Available at: https://www.nyserda.ny.gov/-/media/Files/Publications/New-Efficiency-New-York.pdf

	VEIC and NRDC examines the potential of electrification through heat pump technology to increase energy savings.[107] In 2018, the NY PUC responded to these reports with the Order Adopting Accelerated Energy Efficiency Targets (Case 18-M-0084). This order adopts several subsidiary targets for energy reduction, including a target that the state reduce energy consumption by 5 TBtu by 2025 through heat pump deployment.[108] In support of this target, the NY PSC observed that "In cases of conversion from oil or propane, heat pumps present a near-term benefit to non-participating customers by increasing the number of electricity sales units across which the utility revenue requirement is recovered," and suggested that "[i]ntegrating heat pump installations with thermal shell measures will mitigate potential winter-peaking concerns by reducing heating load and ensuring units are sized at the lowest level necessary."
Current Measures	NY utilities offer electric and gas efficiency measures, including measures for heat pumps and CHP. Potential future measures include ground source heat pumps and natural gas heat pumps. NY has plans to count unregulated fuel savings in the future. An updated report from the utilities on EE budgets, targets, heat pump technology, and low-income programs includes the proposal that all net onsite all-fuels energy savings, as contributing to the heat pump target, are accounted on a deemed basis for residential installations. So, while NY is not currently counting unregulated fuel savings, they plan to in the very near future.[109]
Benefit/Cost Approach	NY evaluates EE programs using the Societal Cost Test (SCT). The SCT considers how society is impacted, so a wide variety of costs and benefits are accounted. NY counts carbon emissions reductions using the societal cost of carbon of $27.41/MWh[110].
Education & Training	NY has studied the different equipment types that contractors offer and the barriers that may prevent them from offering particular equipment types. NYSERDA offers trainings with respect to the clean energy industry and trainings to teach contractors about high EE technology.[111] NYSERDA offers an incentive to participating installers for the installation of air source heat pumps (ASHPs) in order to accelerate the adoption of ASHPs. To become a participating installer, the contractor must obtain the ASHP Manufacturer-sponsored Installation Training Certificate or provide proof of comparable training.

[107] VEIC and NRDC (2018). "Ramping Up Heat Pump Adoption in New York State: Targets and Programs to Accelerate Savings." p.3. Available at: https://www.veic.org/documents/default-source/resources/reports/veic-ramping-up-heat-pump-adoption-in-new-york-state.pdf

[108] NY PUC (2018). "Case 18-M-0084 - In the Matter of a Comprehensive Energy Efficiency Initiative." https://drive.google.com/file/d/1jscrJ_1LIloFrwn0dM2dRpghC1aZHzEY/view

[109] Updated utilities report on Case 18-M-0084 – In the Matter of a Comprehensive Energy Efficiency Initiative. Available at: https://drive.google.com/file/d/1YsOXzGCrCYI3-iqp53QfmDoCg5e-FcBz/view

[110] New Efficiency: New York, P. 45: https://www.nyserda.ny.gov/About/Publications/New-Efficiency

[111] Training Opportunities available through NYSERDA: https://www.nyserda.ny.gov/Business-and-Industry/Training-Opportunities

Key Findings	Instead of setting reduction targets and leaving implementation options to the utilities, the NY PSC specifically set a goal for energy reduction using heat pump technology. NYSERDA is a third party that offers additional incentives outside of NY's regulated efficiency programs. Third parties such as NYSERDA have more freedom than utilities to define savings metrics and goals. For example, third parties can set targets in terms of market share or number of installations.

F.5 Rhode Island

Enabling Policy	The System Reliability and Least-Cost Procurement Statute, R.I. Gen. Laws § 39-1-27.7 states that least-cost procurement shall comprise system reliability, EE, conservation procurement. Additionally, least-cost procurement will include distinct activities with the goal of meeting electrical and natural gas needs in Rhode Island, while being optimally cost-effective, reliable, prudent, and environmentally responsible.[112] The Rhode Island EE programs operate under the Least Cost Procurement Standards, which were approved by the Rhode Island Public Utilities Commission in September 2018 (under Docket 4684). The Least Cost Procurement Standards specify that "EE plans should address new and emerging issues as they relate to Least Cost Procurement (e.g., CHP, strategic electrification, integration of grid modernization, gas service expansion, distributed generation and storage technologies, EE services for non-regulated fuels, etc.), as appropriate, including how they may meet State policy objectives and provide system, customer, environmental, and societal benefits."[113]
Supporting Policy	RI's Resilient Rhode Island Act (2014) set specific GHG emissions reduction targets.[114] It also established the Executive Climate Change Coordinating Council which is responsible for developing and tracking the implementation of a plan to achieve their GHG emissions reduction goals. The Resilient Rhode Island Act also incorporated the consideration of climate change impacts into the duties of all state agencies. In the Settlement Agreement for Docket Nos. 4770 and 4780, the RI PUC directed the utilities to include heat pump rebates, funded through the EE programs.[115] National Grid's Annual Energy Efficiency Plan for 2019 introduced a heat pump initiative with plans to expand the number of projects in following years.[116]

[112] As found in R.I. Gen. Laws § 39-1-27.7. System reliability and least-cost procurement. Available at: http://webserver.rilin.state.ri.us/Statutes/TITLE39/39-1/39-1-27.7.HTM

[113] As found on page 1 in section 1.2 of the Least Cost Procurement Standards. Available at: http://www.ripuc.org/eventsactions/docket/4684-LCP-Standards-FINAL.pdf

[114] Office of Energy Resources (2014). Resilient Rhode Island Act. Available at: http://www.energy.ri.gov/policies-programs/ri-energy-laws/resilient-rhode-island-act-2014.php

[115] National Grid (2018). "Settlement Agreement Docket Nos. 4770 and 4780." pp. 61 and 75. Available at: http://www.ripuc.org/eventsactions/docket/4770-4780-NGrid-SettlementAgreement-Signed(6-6-18).pdf

[116] National Grid (2018). "Annual Energy Efficiency Plan for 2019." pp.99-102 (Bates 29-32). Available at: http://www.ripuc.org/eventsactions/docket/4888-NGrid-EEPP2019(10-15-18).pdf

Current Measures	National Grid runs the only heat pump program in the state and provides downstream incentives to customers. Compared to other states, these downstream incentives are low, and NGrid does not offer upstream incentives. RI accounts for unregulated fuel savings for customers that switch to electric, but not for customers that switch to natural gas.
Benefit/Cost Approach	RI's EE programs are evaluated using the Rhode Island Test. All data and cost factors used in the test are specific to RI. The Rhode Island Test counts GHG emissions reductions using an avoided cost of $100/ton.
Education & Training	National Grid supports trainings for trade allies, vendors, and contractors. This includes a code training and in-field technical training for residential new construction, weatherization training, and technical training for HVAC specific contractors. National Grid also offers certifications for facility managers to learn energy efficient techniques to optimize energy management. The Community-Based Energy Efficiency initiative was developed to educate customers and increase EE program participation. This initiative includes a new website page for community recruitment and workforce trainings. RI also has the HVAC Electric Program's "Quality Installation Verification" training that ensures cold climate mini-split heat pump systems are sized and installed correctly, and that customers are educated on the proper use of the systems.[117]
Key Findings	Specially designed cost-benefit tests can make energy optimization measures more attractive. In the past, RI utility programs did not include fuel switching measures because these did not pass cost-benefit tests. The RI PUC developed a new Rhode Island (RI) Test, which includes social and environmental benefits. The new test has allowed fuel-switching programs to pass cost-benefit screening. Switching from electric resistance or delivered fuels to heat pumps is cost-effective under the programs but switching from natural gas to heat pumps is not.

F.6 Vermont

Enabling Policy	VT's Renewable Energy Standard (RES, Act 56) (2015) established three tiers of activity that contribute to the state's electrification.[118] Tier 1 aims to increase renewable electricity generation to 75% of utility sales by 2032; Tier 2 aims to increase distributed renewable electric generation with projects under 5 MW capacity; and Tier 3 aims to implement energy transformation projects that reduce customers' fossil fuel consumption. Tier 3 activities drive VT's electrification and energy optimization activities. Under Tier 3, major electric utilities have aggressive savings targets that ramp from 2% of electric sales in 2017 to 12% of sales in 2032; these goals reset annually and are not cumulative.[119]

[117] Customer awareness and workforce development discussed in the Annual Energy Efficiency Plan for 2019: http://www.ripuc.org/eventsactions/docket/4888-NGrid-EEPP2019(10-15-18).pdf

[118] The full text and summary of Act 56 are available at: https://legislature.vermont.gov/bill/status/2016/h.40

[119] As an example, VT's Green Mountain Power utility needed 2.0% of annual electric sales equivalent in savings in 2017 (~2M gallons of fuel oil). In 2018, GMP needs 2.67% (another 2.8M gallons). This ramps until 2032, when GMP needs 12% of savings (another 12.5M gallons).

	The Least-Cost Integrated Planning statute, 30 V.S.A. § 218c, requires that electric and gas utilities develop a least-cost integrated plan for meeting the public's energy service needs while addressing safety concerns, at the lowest present value life cycle cost, and including environmental and economic costs. Additionally, the statute requires that the plans make progress in meeting the state's GHG reduction goals and includes comprehensive EE programs.[120] Efficiency and energy optimization are also incorporated into transmission planning and regulation pursuant to 30 V.S.A. sec. 218c (d)(2) and the work of the Vermont System Planning Committee. The Jurisdiction statute, 30 V.S.A. § 209, provides for broad efficiency programs and measures, including combined heat and power. The statute also discusses building efficiency and independent efficiency entities. The statute also calls for a charge to realize all reasonably available, cost-effective EE savings.[121]
Supporting Policy	VT's 2016 Comprehensive Energy Plan identifies heat pumps as key component of a strategy to meet VT's goals for reducing fossil fuel consumption.[122]
Current Measures	Efficiency VT offers incentives for electric and natural gas efficiency without fuel switching. Individual utilities offer incentives for fuel switching and electrification under the Tier 3 program. Customers may combine incentives from these two sources. In addition to customer incentives, Efficiency VT provides midstream incentives to wholesale distributors of heat pump equipment, with a requirement that distributors pass these discounts on to contractors.
Benefit/Cost Approach	Efficiency VT evaluates EE programs using the Societal Cost Test (SCT). Efficiency VT uses both electric savings and fossil fuel savings in its cost–benefit calculation for heat pump measures that involve fuel switching. Savings are calculated across different fuel types using MWh-equivalent as a common metric, and fossil fuel savings are converted to an MWh-equivalent value. VT counts GHG emissions reductions using an avoided cost of $100/ton.
Education & Training	VT's Efficiency Excellence Network provides free technical training, enhanced support, and qualified leads to members who complete EE training with Efficiency VT. Contractors that complete professional education requirements can receive customer leads and referrals from the program's website.
Key Findings	While EE programs are unified throughout the state and provided by VEIC under the Efficiency VT brand, the fuel-switching energy transformation projects are driven by individual electric utilities. This gives utilities the flexibility to focus on measures that are most appropriate to their service areas. For example, Burlington Electric Department covers an urban area and can focus efforts on vehicle electrification, while Green Mountain Power and VT Electric Co-op can focus on custom C&I electrification. Our stakeholder interviews indicated that VT's Tier 3 programs have had a bumpy implementation. In some cases, the EE programs and the utilities measure their progress with different metrics and offer incentives with different

[120] As found in the Least-Cost Integrated Planning Statute (30 V.S.A. § 218c). Available at: https://legislature.vermont.gov/statutes/section/30/005/00218c

[121] As found in the Jurisdiction statute (30 V.S.A. § 209). Available at: https://legislature.vermont.gov/statutes/section/30/005/00209

[122] VT Dept. of Public Service (2016). "Comprehensive Energy Plan 2016." pp. 8-9. Available at: https://outside.vermont.gov/sov/webservices/Shared%20Documents/2016CEP_Final.pdf

	customer requirements. Some stakeholders claim that these different incentive options have led to confusion on the part of the customer. VT interviewees credit the state's success in heat pump deployment to its engagement of participants at different stages of the supply chain. Efficiency VT works in various capacities with manufacturers, wholesalers, and installers. These activities have included the development of marketing strategies, contractor training, and incentives.

F.7 Other States

California

California's climate goal targets 40% GHG reduction by 2030, and carbon neutrality by 2045. A recent study[123] jointly funded by state utilities recommends attaining these goals by electrifying multiple building end uses that are currently served by natural gas (HVAC, water heating, cooking, and laundry). Unlike New Hampshire and other Northeast states, a low proportion of California residents use delivered fuels for heating. California's fuel switching activities are focused on converting customers from natural gas to electricity.

CA has been encouraging customers to switch from natural gas to electric. One natural gas fuel switching program, the OFF Gas Program, was being develop by East Bay Community Energy in 2018. The program does not appear to be approved yet.[124] MCE Clean Energy and Sonoma Clean Power, both municipal utilities, are piloting $1,500 rebates to customers who switch out their natural gas heaters for heat pump electric models.[125]

California Public Utilities Commission (CPUC) requires fuel switching measures to undergo a three-prong test: fuel switching measures must not increase source BTU consumption, must be cost effective (TRC B/C ratio ≥ 1) and must not adversely impact the environment.[126]

California's investor-owned utilities are limited in promoting fuel switching programs. However, California municipal utilities currently offer electrification rebates. For example, Sacramento Municipal Utility District (SMUD), a community-owned electric utility, currently offers aggressive rebates as part of its Home Performance Program. SMUD offers individual rebates for customers that convert natural gas equipment to electric heat pumps,[127] as well as a whole-home electric conversion package to incentivize switching HVAC, water heating, and other end uses from natural gas to electric.[128]

[123] https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf

[124] To read more about EBCE's proposed OFF Gas Program, follow this link: https://ebce.org/wp-content/uploads/EBCE_Opportunities-for-Natural-Gas-Fuel-Switching_DRAFT.pdf

[125] As stated on page 23 of the draft of "Opportunities for Natural Gas Fuel Switching" for EBCE: https://ebce.org/wp-content/uploads/EBCE_Opportunities-for-Natural-Gas-Fuel-Switching_DRAFT.pdf

[126] http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M191/K912/191912228.PDF

[127] https://www.smud.org/en/Rebates-and-Savings-Tips/Rebates-for-My-Home/Home-Appliances-and-Electronics-Rebates

[128] https://www.smud.org/en/Rebates-and-Savings-Tips/Improve-Home-Efficiency

Washington

Washington is targeting 80 percent reduction in GHG emission levels by 2050. In support of this, the 2019 Biennial Energy Report[129] from the Department of Commerce proposed the following measures related to fuel switching:

- deep decarbonization pathways including very low or non-carbon electricity to meet energy needs for heating and cooling (high-efficiency heat pumps);
- electrification of transportation (EVs);
- substitution of biogas, synthetic natural gas and some hydrogen for fossil natural gas especially in buildings and industry.

[129] http://www.commerce.wa.gov/wp-content/uploads/2013/01/COMMERCE-Biennial-Energy.pdf

APPENDIX G. LITERATURE REVIEW OF IMPACT STUDIES (TASK 2)

Navigant reviewed and cataloged recent evaluations, reports, studies and scholarly articles on the topic of customer bill impacts and energy usage impacts associated with energy optimization through fuel switching, with a focus on switching to highly efficient electric end uses. The documents we reviewed generally fell into two categories. The first category, described in section G.1, includes studies that attempt to measure the impacts of energy optimization measures on energy consumption, operating costs, electric rates, and GHG emissions. The impact results vary based on customer and contractor education and behavior, which systems are installed, how the systems are configurated, and how systems are used (duct/system sizing, temperature setpoints, crossover points from heat pump to fuel-fired system). The second category, described in section G.2, includes studies focused on policies, strategies, and market analyses that do not include a rigorous independent study of impacts.

G.1 Impact Studies

The studies included in the table below attempted to measure the impacts of energy optimization measures on energy consumption, operating costs, and/or GHG emissions. All the studies included in the table measure the impacts of switching from a fuel-fired heating system to a heat pump. Our review does not include studies that only measured the impacts of switching from electric resistance heating to heat pumps. The studies cover different types of heat pumps, including central, ductless, mini-split, cold climate, air source, and ground source. For many of the studies, the baseline equipment includes oil and propane furnaces and boilers. About half the studies used metering while the other half used simulations. The studies found that the customer bill impacts are around $600 savings per year resulting from a switch from unregulated fuels to electric heat pumps. These savings are based on the customers' fuel/electricity prices at the time of the study. The studies also agree that heat pump installations in a fuel switching scenario lead to net energy savings. The energy savings ranged from 21.4 MMBtu of heating capacity during the winter to 62 MMBtu per year. Peak demand changes ranged from a summer demand savings of 0.11 kW per heat pump to a winter demand increase of 0.35 kW overall. The reported demand savings are less consistent: two of the studies found peak electric demand increases while one of the studies found summer demand savings.

Study	Location; Date	Scenario	Sample Size	Customer Bill Impacts	Energy Impacts
NYSERDA (2019)[130]	NY; 2019	Displace oil and resistance heating with ASHP, GSHP, and mini-split HP	N/A	N/A	7.5 TBtu of incremental site energy savings
E3 (2019)[131]	CA; 2018	Displace gas furnaces and A/C with HP	N/A	Savings of up to $600/year	N/A
Navigant (2018)[132]	MA; 2018	Partial displacement of oil- or propane-fueled equipment with HP or gas-fired equipment, resulting in a dual-fuel configuration	N/A	Oil furnace to CHP: $405/yr Propane furnace to CHP: $1,391/yr Oil boiler to DMSHP: $584/yr Propane boiler to DMSHP: $1,819/yr	Oil/propane furnace to CHP: net energy savings of ~51 MMBtu/yr Oil/propane boiler to DMSHP: net energy savings of ~62 MMBtu/yr
Cadmus (2017)[133]	VT; 2015-17	Displace various fuel furnaces/boilers with cold-climate HP	77	N/A	Displace 21.4 MMBtu of heating capacity during the heating season Summer demand savings: 0.11 kW per HP
Cadmus (2016)[134]	MA, RI; 2016	Displace oil furnaces/ boilers with ductless HP	152	N/A	Net energy savings: 2.2-4.7 MMBtu Peak demand increase: 0.21-0.25 kW

130 NYSERDA (2019). "New Efficiency: New York. Analysis of Residential Heat Pump Potential and Economics." Available at: https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/NYSERDA/18-44-HeatPump.pdf

131 https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf

132 Navigant (2018). "Energy Optimization Study (RES 21)." Report at: http://ma-eeac.org/wordpress/wp-content/uploads/RES21_Energy-Optimization-Study_09OCT2018.pdf and supporting spreadsheet at: http://ma-eeac.org/wordpress/wp-content/uploads/RES21_Task4_Final_Spreadsheet_Model_REVISED_2018-09-25_v4.xlsx

133 Cadmus (2017). "Evaluation of Cold Climate Heat Pumps in Vermont." Available at: https://publicservice.vermont.gov/sites/dps/files/documents/Energy_Efficiency/Reports/Evaluation%20of%20Cold%20Climate%20Heat%20Pumps%20in%20Vermont.pdf

134 Cadmus (2016). "Ductless Mini-Split Heat Pump Impact Evaluation." Available at: http://ma-eeac.org/wordpress/wp-content/uploads/Ductless-Mini-Split-Heat-Pump-Impact-Evaluation.pdf

Study	Location; Date	Scenario	Sample Size	Customer Bill Impacts	Energy Impacts
Williamson, U.S. DOE (2015)[135]	CT, MA, VT; 2013-14	Displace fuel-fired equipment with split ductless HP	7	Savings of $119 over oil and $341 over propane (only for 4-month monitoring period)	N/A
EMI Consulting (2014)[136]	ME; 2013-14	Displace oil furnaces/ boilers with HP	64	Savings of $598/year	Peak demand increase: 0.14 kW (summer) 0.35 kW (winter)
NEEP and ERS (2014)[137]	NH; 2013	Displace oil furnaces/ boilers with cold-climate HP	9	Savings of $613 per heating season (9/15-5/31)	Savings of 22.2 MMBtu per ton of heating capacity

[135] Williamson, James, and Robb Aldrich (2015) “Field Performance of Inverter-Driven Heat Pumps.” Available at: http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/inverter-driven-heat-pumps-cold.pdf

[136] EMI Consulting (2014). “Emera Maine Heat Pump Pilot Program.” Available at: http://www.emiconsulting.com/assets/Emera-Maine-Heat-Pump-Final-Report-2014.09.30.pdf

[137] NEEP (2014). “EM&V Forum: Primary Research – Ductless Heat Pumps.” Available at: https://neep.org/sites/default/files/resources/NEEP%20DHP%20Report%20Final%205-28-14%20and%20Appendices.pdf

G.2 Reports and Articles

The papers reviewed in this section focus on energy optimization measures, and some papers discuss the impacts of these measures. However, these studies do not include a rigorous independent study of the impacts of energy optimization measures or are not based on typical customer bill analysis. Broad findings from this review are that: (1) electrification of space heating is usually cost-effective for customers, (2) the energy and cost savings associated with electrification depend on climate and on the type of system being installed, and (3) from a program perspective, energy savings may be easier to obtain through custom C&I projects than through prescriptive residential measures. The findings of individual studies are summarized in the table below.

Study	Findings
RAP (2018)[138]	This study was not based on a typical customer bill analysis. Instead it calculated annual fuel cost savings for consumers switching from oil furnaces to air source heat pumps to be $556 in Georgia, $482 in Pennsylvania, $452 in Virginia. $439 in Missouri, $426 in New Jersey, $124 in New York, -$88 in Massachusetts and -$142 in Wisconsin.
ACEEE, (2018)[139]	This study was not based on a typical customer bill analysis. It instead presents representative average simple payback period for installing a heat pump at the time an existing oil or propane system needs to be replaced.
EFG (2018)[140]	An analysis of Vermont utility plans for 2018 found that the most common Tier 3 measures are commercial/industrial (C&I) custom fuel-switching projects, cold-climate residential heat pumps, and electric vehicles and chargers. EFG analyzed the potential rate savings that could result from new electric revenues that exceed the costs of providing electricity and promoting electrification measures. EFG estimated up to $7 million in rate savings over the lifetime of Tier 3/STEP measures installed in just 2018 and up to $300 million from measures installed over the 2018-2032 period.
NYSERDA (2019)[141]	Describes the "inverse cost shift" effect, which can result in heat pump customers paying for more than their fair share of fixed electric grid costs, reducing burdens on other ratepayers.

[138] Shipley, J., Lazar, J., Farnsworth, D., and Kadoch, C. (2018, November). Beneficial electrification of space heating. Montpelier, VT: Regulatory Assistance Project. https://www.raponline.org/wp-content/uploads/2018/11/rap-shipley-lazar-farnsworth-kadoch-beneficial-electrification-space-heating-2018-november.pdf

[139] ACEEE (2018), Nadel, S., Energy Savings, Consumer Economics, and Greenhouse Gas Emissions Reductions from Replacing Oil and Propane Furnaces, Boilers, and Water Heaters with Air-Source Heat Pumps, https://aceee.org/research-report/a1803

[140] EFG (2018). ""Tier 3"- Statewide Total Energy Program ('STEP") Beyond Fossil Fuels: An Overview, Analysis and projected Impacts for One of Vermont's Essential Climate Protection Strategies." Available at: http://www.energyfuturesgroup.com/wp-content/uploads/2018/10/Tier-3-White-Paper.pdf

[141] NYSERDA (2019). "New Efficiency: New York. Analysis of Residential Heat Pump Potential and Economics." Available at: https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/NYSERDA/18-44-HeatPump.pdf

Study	Findings
RMI (2018)[142]	• In most cases, electrification reduces costs over the lifetime of the appliances when compared with fossil fuels. • For homes currently heated with natural gas, electrification will increase costs when compared to replacing gas furnaces and water heaters with new gas devices. • Electrification is cost-effective for customers switching away from propane or heating oil, for those gas customers who would otherwise need to replace both a furnace and air conditioner simultaneously, for customers who bundle rooftop solar with electrification, and for most new home construction, especially when considering the avoided cost of gas mains, services, and meters not needed in all-electric neighborhoods. • Heat pump carbon emissions are lower than carbon emissions from natural gas equipment in Oakland, CA; Houston, TX; and Providence, RI. Chicago, IL has higher carbon emissions from heat pumps than natural gas equipment due to the use of a coal in the electric grid.
Synapse (2018)[143]	• An all-electric new home in Sacramento reduces GHG emissions by at least 67 percent relative to a gas baseline. • There is potential for both capital cost savings and bill savings from electrification in California.
NEEP (2017)[144]	• Presents regional savings estimates for ASHP adoption in existing homes (NEEP territory) when displacing oil, propane and electric resistance under different scenarios. • The study estimates $65.6/year energy savings per household when displacing oil heating with ASHPs, and $640.8/year energy savings when displacing propane heating with ASHPs.
GMP (2017)[145]	• A report by Green Mountain Power on its 2017 Tier 3 programs notes that it has proved much easier to obtain energy savings from custom C&I projects than from prescriptive residential programs (because savings from each C&I project are equal to the savings from many residential conversions) and that among residential conversion customers, only about 20% are taking advantage of GMP's installment purchase program.
ACEEE (2016)[146]	• Electric heat pumps use less energy in warm states if the heat pump is replacing both a furnace and central A/C. • In moderately cold states (like PA and MA), energy is saved if electricity comes from the highest-efficiency power plants. Life cycle costs are lower for gas furnaces than heat pumps. • Where heat pumps are less expensive than gas furnaces on a life cycle cost basis, the life cycle cost savings are typically $25–195 per year.

[142] Billimoria, Sherri, Leia Guccione, Mike Henchen, Leah Louis-prescott, Josh Castonguay, Green Mountain Power, David Chisholm, A O Smith, and Pierre Delforge. 2018. "The Economics of Electrifying Buildings: How Electric Space and Water Heating Supports Decarbonization of Residential Buildings." Retrieved from https://rmi.org/wp-content/uploads/2018/06/RMI_Economics_of_Electrifying_Buildings_2018.pdf

[143] Hopkins, Asa S., Kenji Takahashi, Devi Glick, and Melissa Whited. 2018. "Decarbonization of Heating Energy Use in California Buildings." Retrieved from https://www.synapse-energy.com/sites/default/files/Decarbonization-Heating-CA-Buildings-17-092-1.pdf

[144] NEEP (2017), Northeast/Mid-Atlantic Air-Source Heat Pump Market Strategies Report 2016 Update https://neep.org/sites/default/files/NEEP_ASHP_2016MTStrategy_Report_FINAL.pdf

[145] Green Mountain Power (GMP) (2017). "2018 Renewable Energy Standard Tier III Annual Plan." Available at: http://www.vpirg.org/wp-content/uploads/2017/12/2018-GMP-Tier-IIIFiling.pdf

[146] Deason et al., 2018. See also Nadel, S. (2016). Comparative energy use of residential furnaces and heat pumps (Report No. A1602). Washington, DC: American Council for an Energy-Efficient Economy. Retrieved from https://aceee.org/sites/default/files/publications/researchreports/a1602.pdf

Study	Findings
Ueno, U.S. DOE (2015)[147]	• Ductless mini-split heat pumps are a viable option as a single heat source. • Heat pump performance is affected by customer behavior. • Heat pumps perform best when operating at a constant setpoint as opposed to being turned off and on.
NEEP (2014)[148]	• Review of studies that address DHPs in the Pacific Northwest, mid-Atlantic, and New England. • When comparing the data from field monitoring studies of heat pumps with a modeled baseline of electric resistance heating, total annual heating savings were in the range of 1,200 to 4,500 equivalent kWh per ton.
NEEA (2014)[149]	• Market acceptance and technical viability of DHP technology as a retrofit resource for electrically heated customers in the Northwest. • Lab testing compared well with actual field measured coefficients of performance. • Billing analysis showed approximately 1,900 kWh/yr in energy savings. When supplemental fuels are excluded, energy savings are 2,700 kWh/yr. • Savings can vary widely depending on customer behavior.
Bonneville Power Administration (2012)[150]	• Use of ductless heat pumps as the primary heating source is the most effective use of electricity. • Displacing forced-air furnaces with ductless heat pumps can reduce energy usage by 5,500 kwh/yr.

[147] K. Ueno, H. Loomis. June 2015. "Long-Term Monitoring of Mini-Split Ductless Heat Pumps in the Northeast". Retrieved from https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/monitoring-mini-split-ductless-heatpumps.pdf

[148] Faesy, R., Grevatt, J., McCowan, B., and Champagne, K. (2014, November 13).
Ductless heat pump meta study. Lexington, MA: Northeast Energy Efficiency
Partnerships. Retrieved from https://neep.org/ductless-heat-pump-meta-study-2014

[149] Ecotope (2014) "Final Summary Report for the Ductless Heat Pump Impact and Process Evaluation." Retrieved from https://neea.org/img/uploads/e14-274-dhp-final-summary-report-final.pdf

[150] D. Baylon, B. Davis, K. Geraghty, L. Gilman. 2012. "Ductless Heat Pump Engineering Analysis: Single-Family and Manufactured Homes with Electric Forced-Air Furnaces" Retrieved from http://www.energyoutwest.org/Portals/0/assets/docs/presentation-and-docs/building-science/DHP-FAF-Dec-12.pdf